

An immature shell in the U.S. National Museum from "Doubtful Canyon", Peloncillo Mountains, seems to be the same.

The band at the shoulder is only faintly visible in a few shells, and in some entirely absent, leaving an ill-defined whitish zone.

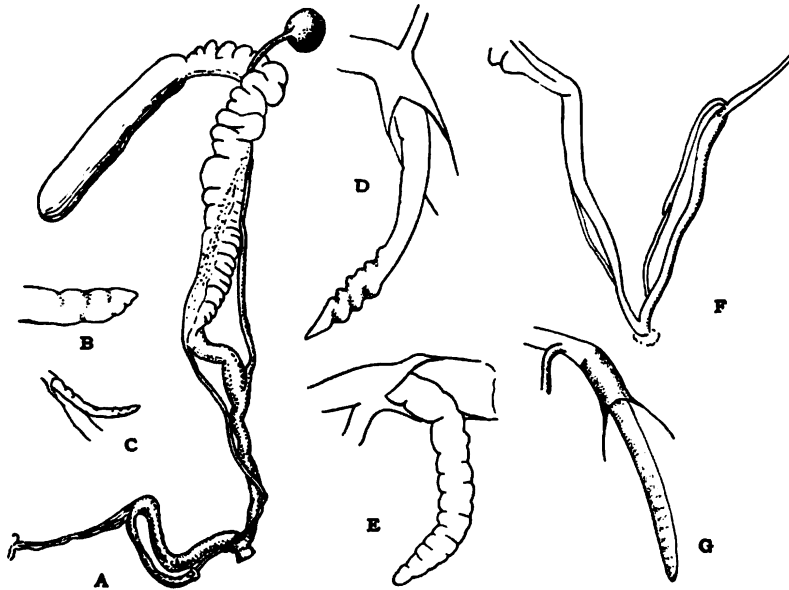


Fig. 146. A-E, *Sonorella hachitana peloncillensis*. A, genitalia; B, C, verge and end of same more enlarged; D, E, verges of two other individuals. F, G, *S. h. flora*, terminal ducts and verge.

***Sonorella hachitana orientis* Pilsbry**

Figs. 147, 148.

Sonorella hachitana, specimen from Filmore Canyon, Organ Mts., Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 257, pl. 17, figs. 7, 8 (shell), pl. 23, fig. 19 (jaw).

Sonorella hachitana orientis Pilsbry, 1936, Nautilus 49: 110.

The aperture is noticeably larger than in *S. hachitana*, its width 55 to 58 per cent of the diameter of the shell; the umbilicus is usually smaller, and the last whorl descends somewhat less deeply in front.

Height 13.4 mm., diameter 24.4 mm., width aperture 13.6 mm. Type.

Height 11.7 mm., diameter 21.3 mm., width aperture 11.6 mm. Topotype.

Height 13.3 mm., diameter 23.4 mm., aperture 12.8 mm. Ropes Spring.

Height 14 mm., diameter 25 mm., aperture 13.7 mm. Ropes Spring.

Height 13.8 mm., diameter 24 mm., aperture 13.6 mm. Filmore Canyon.

Genitalia (Fig. 148), much as in *S. hachitana*; measurements are given on page 275. Jaw with 8 narrow, equal ribs.

NEW MEXICO: Organ Mountains at Dripping Spring (Ferriss and Pilsbry), Type and paratypes 165931 A.N.S.P. Filmore Canyon (C.H.T. Townsend, 1897). Western foothills of the San Andreas Mountains in a ravine at Ropes Spring, about 30 miles northeast of Las Cruces (Ferriss and Pilsbry).

TEXAS: Sierra Blanca Peak, El Paso County (Ferriss, 1925).

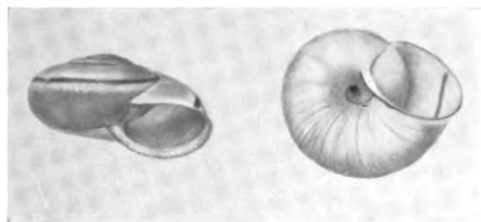


Fig. 147. *Sonorella hachitana orientis*, type and paratype.

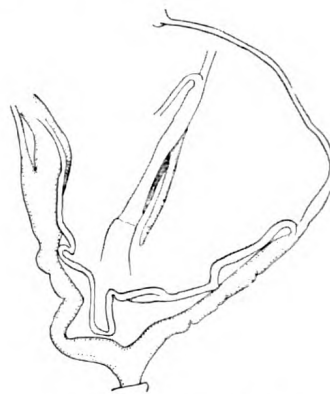


Fig. 148. Same, genitalia.

In shells from Dripping Spring the umbilicus is contained $6\frac{1}{2}$ times in the diameter; in those from Ropes Spring, 7 times. It is smallest in the single shell seen from Filmore Canyon, $7\frac{2}{3}$ times in diameter. In both localities the snails were found late in September aestivating rather deep under stones. This is the only *Sonorella* found east of the Rio Grande.

The shells from Sierra Blanca Peak, Texas, run from 22 to 24 mm. in diameter, and resemble those of the Organ Mountains closely in form. None have been dissected. This mountain, about a hundred miles southeast of the type locality of *orientis*, is the eastern outpost of *Sonorella*.

(*Orientis*, of the east.)

***Sonorella huachucana* Pilsbry**

Figs. 149, 150.

Sonorella virilis huachucana Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 267, pl. 17, fig. 24.

Sonorella huachucana Pilsbry & Ferriss, 1909, Proc. Acad. Nat. Sci. Phila., p. 498, pl. 19, figs. 16, 17.

Sonorella patagonica Pilsbry & Ferriss, 1919, Nautilus, 33: 20; 1923, Proc. Acad. Nat. Sci. Phila., 75: 67, pl. 1, figs. 7-10; pl. 4, figs. 2, 4, 6-8.

Shell less depressed than *S. hachitana*, with much smaller umbilicus contained slightly more than 8 times in the diameter; more elevated than *S. virilis*, which also is more widely umbilicate; glossy, thin; weakly striate; embryonic sculpture of the *hachitana* type; second and third whorls with weak traces of spaced papillae; the top of the last whorl shows numerous very weak spiral impressed lines. The supraperipheral band is rather wide and dark, with distinct white or whitish bands both above and below it. Above the upper white band the surface is pale reddish to the white sutural line. Below the lower white border the same reddish color prevails, but gradually fades on the base to whitish



Fig. 149. *Sonorella huachucana*, type.

around the umbilical region. The dark band runs about $2\frac{1}{2}$ whorls up the spire. Whorls $4\frac{3}{4}$, the last rather deeply descending in front. Aperture rounded-oval, the peristome thin, expanded, the dilated columellar end partially covering the umbilicus.

Height 12.7 mm., diameter 20.8 mm., alt. aperture 10 mm., width 11.7 mm.; width of umbilicus 2.4 mm.

ARIZONA: Brown Canyon,¹ Huachuca Mountains (J. H. Ferriss), Type 89225 A.N.S.P. Hill southeast of cave, Manila mine district, northwest foothills; also Patagonia mountains.

This species was collected by Mr. Ferriss in the course of a rapid trip in the winter of 1903-4; no soft parts were preserved. It was described as a subspecies of *S. virilis* on account of its faint spiral lines, but that Chiricahuan snail differs by its far more depressed and more widely umbilicate shell. On studying the type anew it appears that the shell is not distinguishable from that which was described later as *S. patagonica*. The latter is evidently a synonym. I am leaving as subspecies the local forms *aquacalientensis*, *mustang* and *cotis*. All seem closely related, and perhaps the recognition of local races was not required, though each is isolated by desert tracts.

The species as now understood contains rather capacious shells with small umbilicus, contained from nearly 7 to more than 8 times in the diameter, and often showing some impressed spiral lines on the upper part of the last whorl. The small, slender penis is somewhat enlarged anteriorly, and the anterior part of the vas deferens is noticeably enlarged, as in *S. walkeri*, often thicker than the epiphallus. It probably lives in a lower zone than other Huachuca species, and thus has been overlooked in most visits to that range.

In Bear Canyon, Huachuca Mountains, Mr. Ferriss found a few specimens somewhat similar to those from Brown Canyon, but noticeably more depressed, with a smaller mouth and obtuse lip. One measures, height 11.6, diameter 20.3, aperture 9.7 x 11 mm., umbilicus contained 7 times in the diameter. The shell is somewhat more solid, and the spiral lines are more distinct. In both forms they may be seen with a hand lens (Proc. Acad. Nat. Sci. Phila., 1909, pl. 19, fig. 16).

As this species seems to be most copiously developed in the Patagonia Mountains (whence it was described as *S. patagonica*), a further description of those shells follows.

The shell is rather capacious with umbilicus contained 8 times in the diameter; glossy, dilute pinkish-buff, fading to white or whitish on the base and in a broad band below, a narrower one above the chestnut-brown band above the periphery. Embryonic sculpture on the first half whorl of radial ripples, then becoming areolate, the second whorl with forwardly descending

¹ This is a short canyon between Tanner and Ramsey canyons, represented but not named on the Topographic Sheet, Hereford Quadrangle (1914).

threads on the outer part, and irregularly ascending on the inner, their intervals finely wrinkled. Traces of papillae are visible on the post-embryonic whorl or whorls; on the last whorl minute growth wrinkles, and under the microscope or a strong hand-lens weak, impressed spiral lines are visible on the upper surface (but are wanting in some examples). It descends rather steeply to the aperture. Peristome expanded, brown-edged.

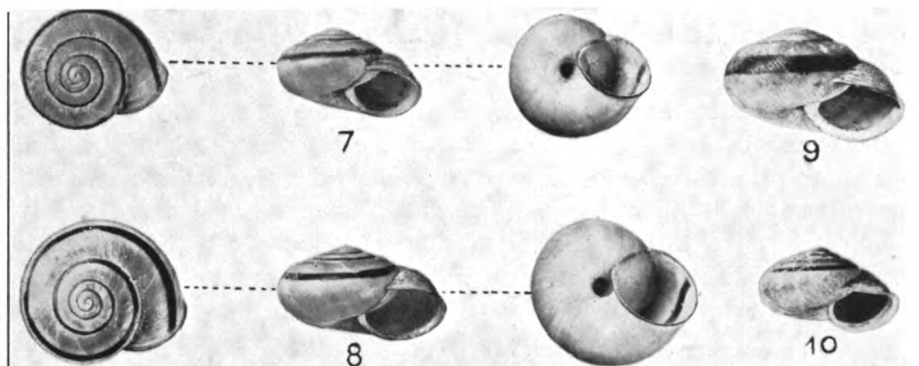


Fig. 150. *Sonorella huachucana*, Patagonia Mountains.

Height 12.7 mm., diameter 22 mm.; $4\frac{3}{4}$ whorls. Type of *patagonica*.

Height 15.3 mm., diameter 23.7 mm.; $4\frac{3}{4}$ whorls. Topotype.

Height 11.4 mm., diameter 18.5 mm.; $4\frac{1}{2}$ whorls. Topotype.

In one specimen (Fig. 150: 9), the dark band is nearly 3 mm. wide, the only case of such variation noticed in the genus.

Penis slender, nearly half the diameter of shell, with a basal sheath, and containing a slender, tapering verge which is usually more or less wrinkled in the alcoholic preparations. Lower part of the vas deferens is somewhat enlarged. Measurements of 7 specimens follow, the first column from the type specimen of *patagonica*.

Penis	8.7	9.3	8.5	7.0	7.0	6.5	6.5 mm.
Verge	6.0	6.3	...	5.0	5.5	...	5.5 mm.
Epiphallus	8.0	7.8	...	8.5	...	6.5	5.7 mm.
Flagellum	0.5	0.5	1.0	minute	...	0.7	1.0 mm.
Vagina	9.0	11.0	8.5	8.0	8.0	8.0	7.5 mm.

It is a common snail in the Patagonia Mountains around Washington and Duquesne, Santa Cruz County. The type of *S. patagonica* is 43722 A.N.S.P., from main canyon of Mt. Washington running west, under bowlders (Ferriss).

Sonorella huachucana cotis Pilsbry & Ferriss

Fig. 152.

Sonorella cotis Pilsbry & Ferriss, 1919, Nautilus, 33: 20; 1923, Proc. Acad. Nat. Sci. Phila., 75: 66, pl. 1, figs. 5, 6; pl. 4, figs. 3, 9.

The shell is dilute cinnamon-buff, fading on the base and on both sides of the chestnut-brown band; glossy. Embryonic whorls with weak

Fig. 151. 1, 1a, *Sonorella huachucana elizabethae*, Canelo Hills. 2, 4, 6-8, *S. huachucana*, Patagonia Mts. 3, 9, *S. h. cotis*, Whetstone Mts. 5, *S. h. mustang*, Mustang Mts. Scale lines = 1 mm.

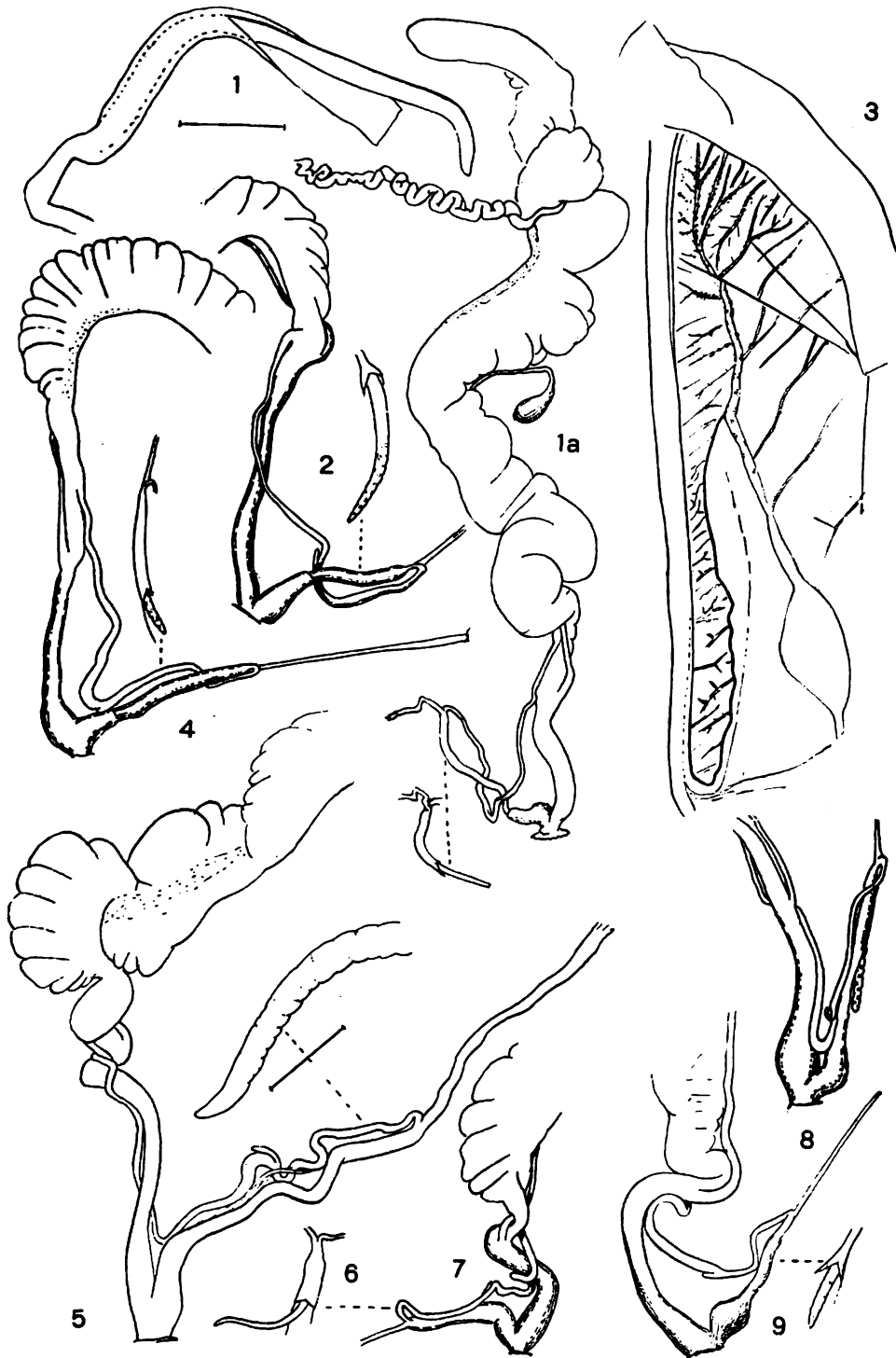


Fig. 151 (explanation on page 280).

protractive threads. The last whorl descends rather deeply in front. Umbilicus contained about $7\frac{1}{2}$ times in diameter. The peristome is expanded. Height 12.3 mm., diameter 20 mm.; $4\frac{1}{2}$ whorls.

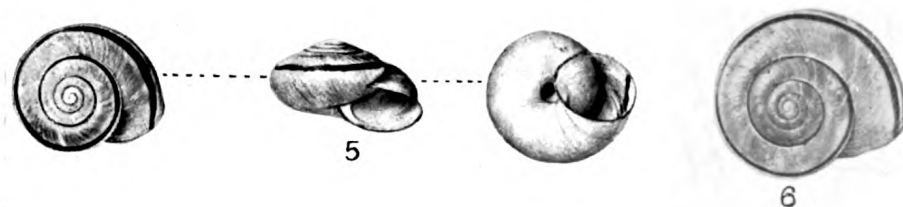


Fig. 152. *Sonorella huachucana cotis*.

In the genitalia (Fig. 151: 9, paratype) this form resembles *S. sabinoensis dispar*. The penis is smaller, slender, becoming abruptly swollen near the base, the swollen part containing several large pilasters. The verge is very slender, with slight traces of annulation. Vas deferens is enlarged in the lower part, as in *S. walkeri*. Length of penis 4.8 mm., verge 3 mm., epiphallus 7 mm., flagellum 0.5 mm., vagina 10.5 mm.

The pallial region (Fig. 151: 3) shows a kidney more than half as long as the lung the proportion being 15 to 26 mm. The pericardium is 4.5 mm. long. The veins of the anterior portion of the lung are sparsely bordered with brown dots.

ARIZONA: Whetstone Range, Cochise County (Ferriss and Daniels), Type 130994 A.N.S.P., from a mile up from the Ranger Station.

The last whorl descends more deeply in front than in *S. huachucana mustang*, and the umbilicus is narrower; otherwise there seems to be little difference in the shells. The typical lot of *S. huachucana cotis*, from the place mentioned above, measures 20 to 22 mm., in diameter, and was differentiated from *S. h. mustang* mainly by the shape and size of the penis. In 1919 further collections were made in the Whetstones (Proc. Acad. Nat. Sci. Phila., 1923, p. 61; Nautilus, 33: 42), and larger shells, up to 25 mm. in diameter were found (Fig. 152: 6), equal in size to *S. h. mustang*, but more narrowly umbilicate. Though fresh, none were alive.

(*Cotis*, of a whetstone.)

Sonorella huachucana elizabethae Pilsbry & Ferriss

Fig. 153: 1.

Sonorella elizabethae Pilsbry & Ferriss, 1919, Nautilus, 33: 20; 1923, Proc. Acad. Nat. Sci. Phila., 75: 65, pl. 1, fig. 1; pl. 4, figs. 1, 1a.

The shell is glossy, very dilute cinnamon-buff, fading to whitish on the base and in broad zones which border the very narrow ($\frac{1}{2}$ to $\frac{3}{4}$ mm.) chestnut-brown band. Embryonic whorls with *S. hachitana* sculpture; the following whorls microscopically lineolate-granulose when perfectly preserved; last whorl lightly striate, descending shortly in front. Peristome expanded, brown-edged.

Height 10.7 mm., diameter 19.3 mm.; $4\frac{1}{2}$ whorls. Type.

Height 10.3 mm., diameter 16.8 mm.; $4\frac{1}{3}$ whorls.

Genitalia (Fig. 151: 1, 1a). The penis is decidedly over one-third the diameter of shell and longer than the vagina (in *hachitana* between one-third and one-fourth the diameter of the shell, and shorter than vagina). It is very slender, with a short, stout basal sheath. Verge slender, tapering, over half the length of penis. Flagellum minute. Lower part of the vas deferens very little enlarged, narrower than the epiphallus. Length of penis 8 mm., verge 5 mm., epiphallus 5.5 to 6 mm., vagina 6 mm.; practically the same in three specimens.

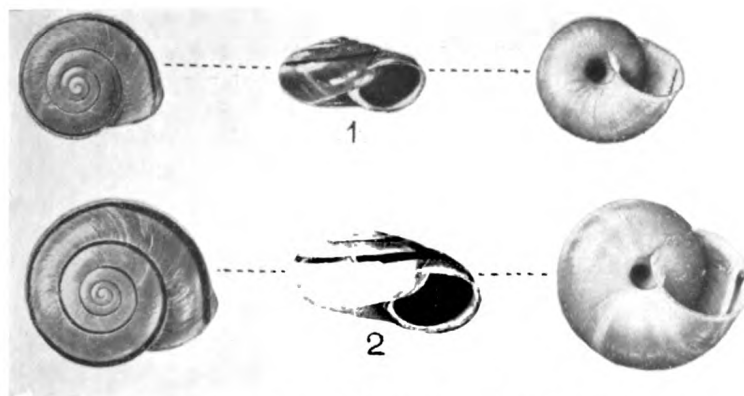


Fig. 153. 1, *Sonorella huachucana elizabethae*. 2, *S. huachucana mustang*.

ARIZONA: Northwestern slope of Mt. Hughes, northern end of the Canelo Hills, Santa Cruz County, at about 5000 feet (J. H. Ferriss and Elizabeth Pilsbry), Type 120991 A.N.S.P.

The shells vary in diameter from 16.3 to 21. mm. It is smaller than *S. hachitana* with differently proportioned terminal male ducts and a very narrow brown band with broad white borders. The brown ground color is extremely pale. The photograph reproduced here is very much too dark. On account of the slender vas deferens I considered this a distinct species; unfortunately, I have now no material to confirm this point, and am ranking the form as a subspecies of *S. huachucana*.

Sonorella huachucana mustang Pilsbry & Ferriss

Fig. 153: 2.

Sonorella mustang Pilsbry & Ferriss, 1919, Nautilus, 33: 20; 1923, Proc. Acad. Nat. Sci. Phila., 75: 65, pl. 1, fig. 2; pl. 4, fig. 5.

The shell resembles *S. hachitana* closely, differing by being slightly less depressed, the umbilicus somewhat smaller, contained nearly 7 times in the diameter; the last whorl descending less in front, and the aperture larger and less oblique. It is glossy, light pinkish cinnamon, fading to whitish around the umbilicus and on both sides of the chestnut-brown band above the periphery, which is visible above the suture on $1\frac{1}{2}$ to 2 whorls. The first

whorl has minute, irregular, radial wrinkles partly anastomosing on the first half whorl, then very fine, forwardly-descending threads over them, about as in *S. hachitana*.

Height 15.3 mm., diameter 26.5 mm.; barely 5 whorls. Station 332. Type.

Height 15.5 mm., diameter 25.7 mm.; 5 whorls. Station 153.

Height 13 mm., diameter 25 mm.; $4\frac{2}{3}$ whorls. Station 153.

Genitalia (Fig. 151: 5) of the *hachitana* type, but characterized by the much greater length of all of the male organs, which are decidedly longer than in *S. h. flora*, which has a shell at least as large as *S. mustang*. The penis is slender, having a sheath which is thick and muscular near the base. Its verge is about two-thirds the length of penis, tapering and slender. The flagellum is unusually long; beyond the flagellum the vas deferens is somewhat enlarged, as in the related forms. The lengths of the organs are as follows: penis 15.5 mm., penial retractor 11.5 mm., verge 10.5 mm., epiphallus 8.0 mm., flagellum 2.0 mm., vagina 13.5 mm., A.N.S.P. No. 44048. Station 286.

The jaw has 6 strong ribs.

ARIZONA: Mustang Mountains, Santa Cruz County (J. H. Ferriss), Type 130992 A.N.S.P.

While not conspicuously unlike *S. huachucana*, the differences are constant in a large number of shells compared. It appears to be distinct from *cotis* anatomically, by the longer penis, which is about three times as long as in *S. cotis*, while the epiphallus is about equal. The umbilicus is wider than in *cotis*, *patagonica* or *huachucana*. *S. h. mustang* seems better characterized than the other races of *huachucana*.

This snail is common throughout the Mustang range. The type was from the main canyon of the north slope of the largest mountain west of Dan Mathews' ranch, but the greatest number of living specimens were taken from the north side of the "tower" of the east peak of the range. A few albino shells were found. A deposit of fossil, or at least long dead shells, in this place, consists of rather small examples, between 19 and 22 mm. in diameter, 4 to $4\frac{2}{3}$ whorls.

Sonorella huachucana aguacalientensis Pilsbry & Ferriss

Fig. 154.

Sonorella walkeri aguacalientensis Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 396, pl. 9, figs. 5-6b, text-fig. 5.

The shell is similar to *S. walkeri* except that the ill-defined light bands bordering the chestnut band, and the middle region of the base, are only slightly paler than the light brown ground color (not nearly white, as in *S. walkeri*).

Height 13.8 mm., diameter 24 mm.; $4\frac{2}{3}$ whorls, or smaller, down to 19 mm. diameter.

Genitalia (Fig. 155) characterized by the length of the male ducts, much greater than in *S. walkeri*, but practically the same as *huachucana*. Length

of penis about 9 mm., verge 5.5 mm., epiphallus 8.5 mm.,¹ vagina 8 mm. There is no flagellum, and no penial retractor was seen.



Fig. 154. *Sonorella huachucana aguacalientensis*, upper figures, type; lower figures, from lowest station.

ARIZONA: Western foot of Santa Rita Mountains in the mouth of Agua Caliente Canyon, from about 3800 to 4200 feet (Ferriss, Pilsbry and Daniels), Type and paratypes 112162 A.N.S.P.

Our Station 1 is in rocks on the bank of the wash running out of the canyon, immediately southeast of the fine spring of tepid water which gives this canyon its name. This is the lowest station for any snail found in these mountains, the elevation being about 3,800 feet. The shells measure 19 to 24 mm. in diameter and live in crevices or under fragments of a friable, shale-like rhyolite, of a dark vinaceous-drab color. See Figure 154, lower figures.

Station 2, the type locality, is at the base of bluffs southeast of Station 1 and at 4,100 to 4,200 feet (Figs. 154, upper). The diameter runs from 22.3 to 24 mm.

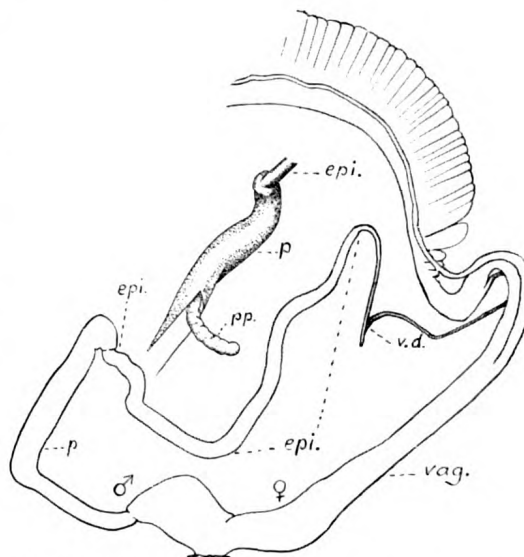


Fig 155. Genitalia of *S. h. aguacalientensis*, type, with detail of verge (*pp.*). *epi.*, epiphallus; *p.*, penis; *vag.*, vagina; *v.d.*, vas deferens.

¹ Perhaps part of the duct measured as epiphallus is really an enlarged portion of the vas deferens, as in *huachucana*. A vestigial flagellum may be present, bound into the integument with the beginning of the vas deferens, to be revealed by sections.

Sonorella walkeri Pilsbry & Ferriss

Fig. 156.

Sonorella walkeri Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 394, pl. 9, figs. 4-4b.

Sonorella montana Pilsbry & Ferriss, 1919, Nautilus, 33: 19.

Sonorella walkeri montana Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 68, pl. 1, fig. 11; text-fig. 1.

Sonorella walkeri aguacalientensis Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 68.

The shell is umbilicate (the width of umbilicus contained about 9 times in the diameter of the shell), rather solid, pale cinnamon, fading to white around the umbilicus and on both sides of the chestnut-brown shoulder band. The surface is glossy, lightly marked with growth lines, and under a strong lens showing impressed spiral lines on the upper surface of the last whorl (lacking, however, in many individuals). Initial $\frac{1}{3}$ whorl radially

Fig. 156. *Sonorella walkeri*.

rippled, granulation then beginning, the last $\frac{2}{3}$ whorl of the embryonic shell having close ascending spiral threads, the intervals densely wrinkled radially. Spire very low conic. Whorls $4\frac{2}{3}$, the last descending in front. The aperture is rounded oval; peristome narrowly expanding, inconspicuously brown-edged, slightly thickened within, the margins converging, joined by a thin, brownish-edged parietal callus.

Height 14 mm., diameter 23 mm.; umbilicus 2.6 mm.; aperture 12 x 13 mm.

Genitalia (Fig. 157: 1-3, 5, 5a). The penis is small and slender, at the base enclosed in a short but thick sheath. Verge cylindric, more than half the length of penis, tapering distally to a blunt or a somewhat pointed end. Retractor muscle inserted on the epiphallus near its base. Epiphallus as long as the penis or somewhat longer, terminating in a minute, bud-like flagellum. Lower part of the vas deferens large, its diameter equal to or exceeding that of the epiphallus. Vagina usually about twice the length of the penis. Six specimens from 4 localities measure:

Penis	4.7	5	4	4.3	4	7 mm.
Verge	2.3	3	2.3	2.8	3	5 mm.
Epiphallus	5	5	6	7.3	6.5	6.7 mm.
Flagellum	1	minute	minute	minute	0.7	minute
Vagina	8	7	10	10	7.5	7 mm.

ARIZONA: Santa Rita Mountains, the type from Walnut Branch of Agua Caliente Canyon, at about 6000 feet, Type 112164 A.N.S.P. (Ferriss, Daniels and Pilsbry, 1910). Also taken in "Soldier Canyon," at about

Fig. 157. 1-3, 5, 5a, *Sonorella walkeri*. 4, 6, 7, *S. clappi*. epi., epiphallus; fl., flagellum; pp., verge; p.r., penial retractor; v.d., vas deferens.

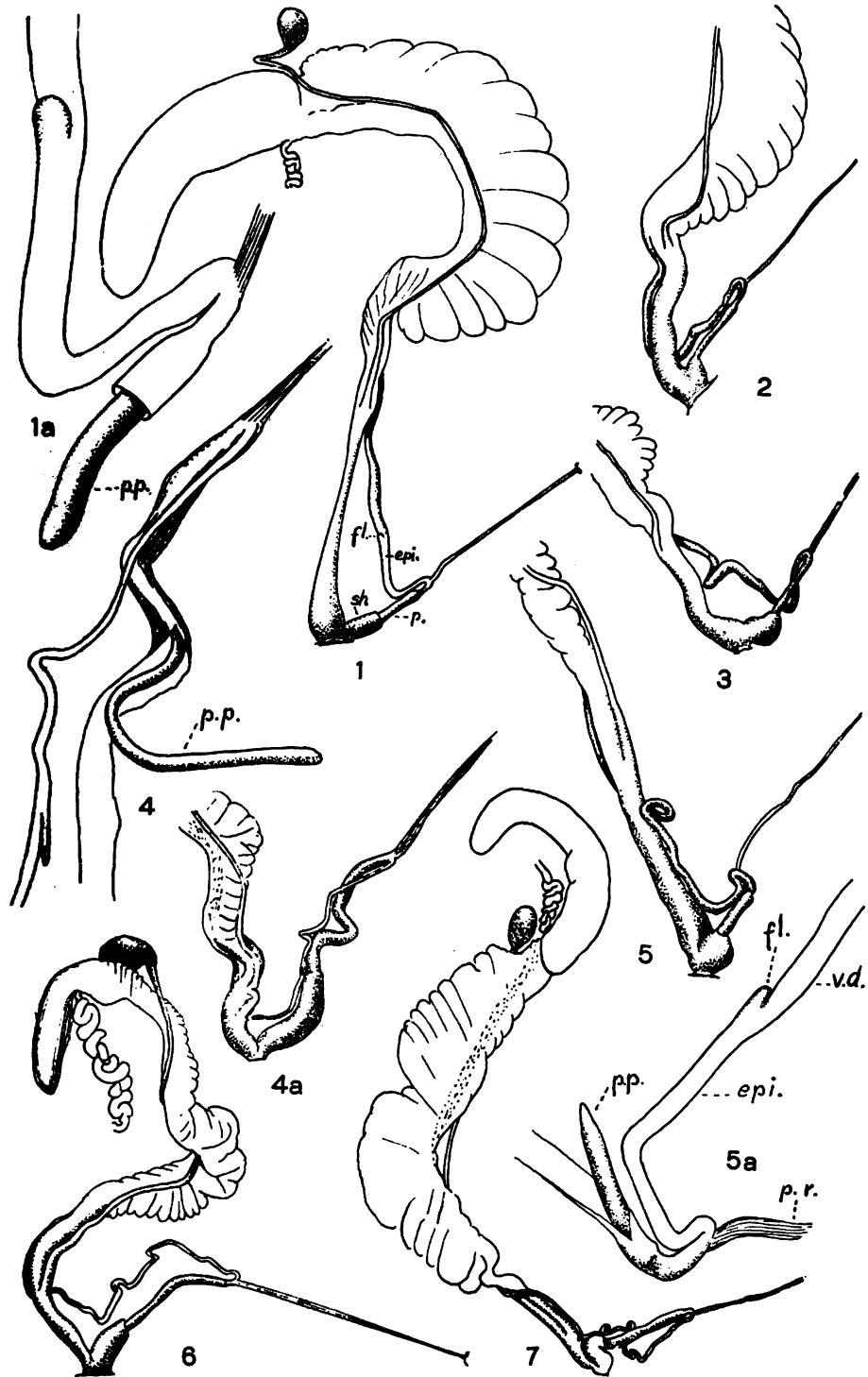


Fig. 157 (explanation on opposite page).

4500 feet,¹ and in Madera Canyon. Also in the southwestern Santa Ritas and the Pajaritos.



Fig. 158. *Sonorella walkeri* (type of *S. montana* P. & F.).

This fine snail is not uncommon in the Santa Ritas, though less generally distributed than *S. santaritana*. The type locality, Walnut Canyon, is humid, and well shaded with deciduous trees. *S. walkeri* lives in piles of granitic rock with *S. santaritana* and *S. clappi*, sometimes all under the same rock, sometimes in separate rock piles. The smallest specimens, topotypes, measure 20 mm. in diameter; the largest, from Madera canyon, 24.3 mm.

Many specimens have been dissected. The slender, short penis, with a short, thick basal sheath, and the enlarged free vas deferens are conspicuous characters. The smaller umbilicus and less depressed contour separate it from *S. santaritana*, which also differs more fundamentally by its genitalia. *S. walkeri* is very much like *S. clappi* in soft anatomy, but the shells are quite distinct. It is closely related to *S. huachucana*, perhaps to be united with that as a subspecies, the most tangible difference being that the penis is smaller. In the Santa Ritas it inhabits higher and much more humid places than *huachucana*.

In the "Allen Mountains", Station 206 (1919), a small group of hills in Josephine Canyon, in the southwestern foothills of the Santa Ritas towards the San Cayetanos, fine, large specimens, about 25.5 mm. in diameter, were taken by Ferriss and Hinkley. Length of penis 2.5, verge 1.3, epiphallus 5, vagina 12 mm.; the flagellum is vestigial, penial retractor long. I have not been able to locate these "mountains" on the map.

¹ Soldier Canyon is a small canyon running in north of the mouth of Agua Caliente, opening to the mesa between two high crags. The rock is a coarse granite, and shells are not numerous. A single giant cactus growing here is further east than we have seen the species elsewhere.



Fig. 159. *Sonorella walkeri* (*montana*). p. penis; pr., penial retractor; sp.d., duct of spermatheca.

In the Pajarito Mountains, which extend over the Mexican border west of Nogales, Ferriss and A. A. Hinkley found a *Sonorella* which we named *montana*. The shell is not distinguishable from *S. h. walkeri* or *S. h. patagonica*, in different specimens. The male organs are a little smaller than in *walkeri*, but I think not significantly different. The penis is extremely small, having a short, stout basal sheath and long retractor muscle. The flagellum is reduced to a mere bud; beyond it the vas deferens is enlarged. The base of the vagina is enlarged. Length of penis 2.5 mm., verge 1.3 mm., epiphallus 5 mm., vagina 9.4 mm. (Fig. 159). The preserved animal is nearly white. The shells were taken on Montana Peak, near the mine of the same name, in Bear Canyon in Bear Valley, and in the pass, on the highway to Oro Blanco. The type of *montana* is 43724 A.N.S.P., from the first locality.

(Named for Dr. Bryant Walker.)

***Sonorella marmorarius* Pilsbry & Ferriss**

Fig. 160 a-c.

Sonorella marmorarius Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila. for 1918, p. 294, pl. 3, figs. 9-9b; text-fig. 6.

Sonorella marmorarius imula Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila. for 1918, p. 297, pl. 3, figs. 7, 7a, 8-8b.

The shell is depressed, rather solid, umbilicate, the width of umbilicus contained about 7 times in that of the shell, suddenly widening at the last whorl; light pinkish cinnamon, paler around the umbilicus, and whitish on both sides of the chestnut-brown band above the periphery. The surface is glossy. Embryonic shell of $1\frac{1}{2}$ whorls, the last of which is densely, irregularly granular, with indistinct protractive and retractive threads (when unworn), subsequent whorls delicately marked with growth-lines, and under the lens showing some weak spiral impressed lines in places on the upper surface of the last whorl. The suture descends rather deeply in front. Aperture is quite oblique, oval. Peristome expanded throughout, with a gray edge, somewhat thickened within, the margins generally connected by a roughened callous ridge in fully adult shells.

Height 13.7 mm., diameter 25 mm.; 4 $\frac{3}{4}$ whorls.

Genitalia (Fig. 161 A-G). The penis is thin-walled, very weakly or usually not noticeably enlarged near the atrium, containing a slender tapering, corrugated verge, half to two-thirds or more the length of penis. Epiphallus somewhat shorter than penis, typically terminating in a little flagellum, but this is often rudimentary or wanting. Penial retractor long, inserted on apex of penis and base of epiphallus. The vagina is but little shorter than the penis. Lengths of the organs in mm. follow, the specimens all from stations on Marble Peak:

Mus. No.	Penis	Verge	Epiphallus	Flagellum	Retractor	Vagina	Fig.
109,078	12.5	7.3	8	—1	....	10	161 G
109,077	12	8	10	1	8	11	161 A
109,039	9	6	7.3	1	12	8.5	161 D
109,040	10	8.5	7	0.5	....	9.5	....
109,074	11.5	10	9	1	....	9	....
109,083	8.5	7	....	0.5	....	7	161 E
109,084	9	7	....	0	11	5.5	161 F
109,080	12.5	6	....	0	....	7	....
109,071	11.5	6	7.3	0	....	6	161 B, C

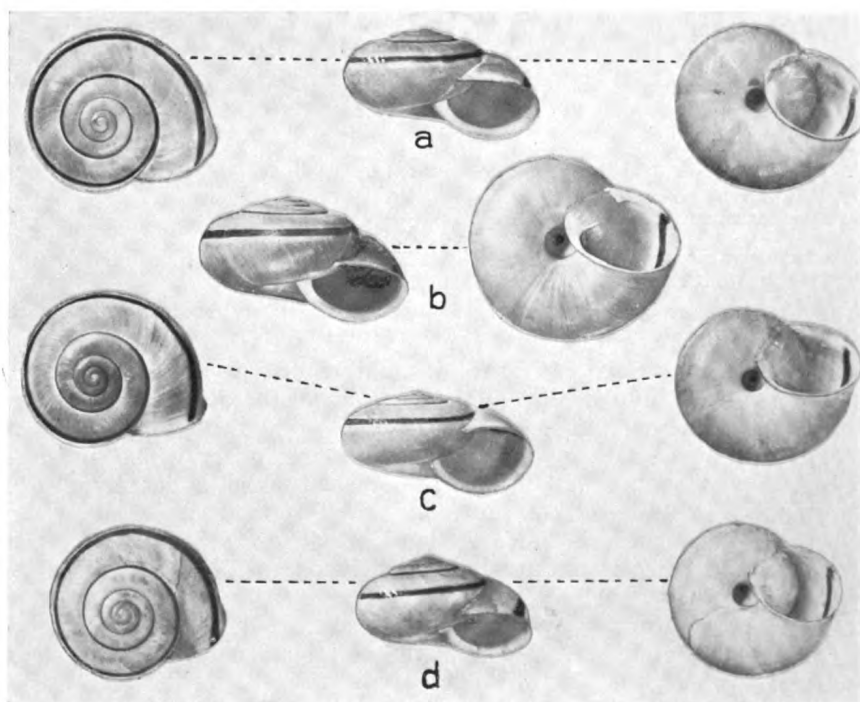


Fig. 160. a, *Sonorella marmorarius*. b, c, form *imula*. d, *S. marmorarius limifontis*.

ARIZONA: Marble Peak, Santa Catalina Mountains; Type 109078 A.N.S.P., from Station 26, a quartzite slide on Marble Peak. Also found at many other places on the same mountain, at about 6-7000 feet, and northward to the foothills (J. H. Ferriss).

The only comparable species of the Santa Catalinas is *S. sabinoensis*, which is far less depressed than *marmorarius*, with a smaller umbilicus and a larger aperture. In form and embryonic sculpture it agrees well with *S. hachitana*, but in that species the verge is constantly shorter. *S. compar* is a thinner shell, and the penis tapers to a slender tube towards the base.

Other specimens of the original lot from the type locality measure:

Height 15 mm., diameter 26.3 mm. Height 13.8 mm., diameter 24 mm.
Height 15.3 mm., diameter 24.6 mm. Height 13.8 mm., diameter 23 mm.
Height 13 mm., diameter 23.6 mm. Height 12.5 mm., diameter 22 mm.

The largest examples were taken at Station 3, two measuring:

Height 16.4 mm., diameter 28.2 mm.; 5 whorls.
Height 17 mm., diameter 28 mm.; 5 whorls.

Marble Peak and Apache Camp have oak, juniper and sycamore wood on the lower slopes; the crest of the ridge, the head of the main slide, is in the pine belt.

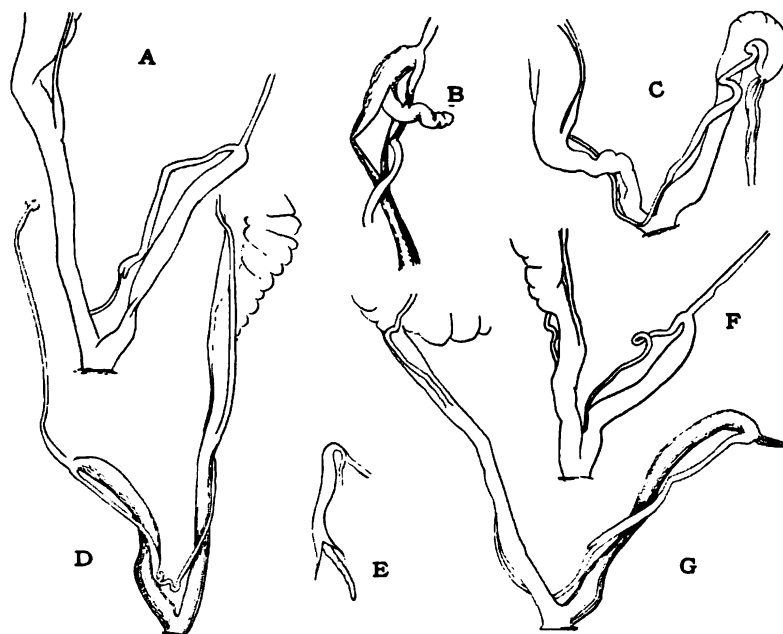


Fig. 161. Genitalia of *Sonorella marmorarius*, A, No. 109,077; B, C, No. 109,071; D, No. 109,039; E, No. 109,083; F, No. 109,084; G, No. 109,078.

The name *imula* (Figs. 160 b, c) was given to specimens from a limestone hill 6 miles west of Brush Corral Ranger Station, north of Alder Springs, in the northern foothills of the Santa Catalinas. They differ from *marmorarius* by the somewhat darker color, and by having about a half whorl more in shells of the same diameter. The type (Fig. 160 b), is the largest shell seen; it measures height 15.6 mm., diameter 26.7 mm.; $5\frac{1}{2}$ whorls. In 84 adult shells from one station the diameters run from 22.3 mm. to 26.5 mm.; 41 are from 24 to 25 mm. A specimen having the umbilicus exceptionally narrow is illustrated in Figure 160 c; diameter 24.4 mm., $4\frac{1}{2}$ whorls. On going over the whole series again, it appears that the

differences are too slight and inconstant to call for separation from typical *marmorarius*.

(*Marmorarius*, a worker in marble.)

Sonorella marmorarius limifontis Pilsbry & Ferriss

Fig. 160 d.

Sonorella marmorarius limifontis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 296, pl. 3, figs. 5-5b.

The shell is depressed, openly umbilicate, the width of umbilicus contained slightly over 6 times in that of the shell; whitish, faintly buff near the suture and on the spire, having the usual chestnut-brown band. Last whorl wide, very deeply descending in front. Surface glossy, weakly marked with growth-lines as in related species of the *hachitana* group, and showing weak traces of impressed spiral lines on the upper surface of the last whorl. The last whorl descends deeply and abruptly in front. The aperture is very oblique, rounded-oval. Peristome somewhat expanded, slightly thickened within.

Height 13.3 mm., diameter 22.5 mm.; 5 whorls. Type.

Height 15.5 mm., diameter 26.5 mm.; 5 whorls (exceptionally large).

ARIZONA: Santa Catalina Mountains, bluffs near Mud Springs, in Pine Canyon (J. H. Ferriss), Type 109500 A.N.S.P.

The last whorl descends more than in *S. marmorarius*, the aperture is more oblique, and the color of adults is paler. The immature shells have more of a cinnamon tint than the adults.

The spiral lines mentioned in the description are usually very faint, often scarcely discernible, but in the largest example they are quite distinct. The umbilicus sometimes varies to somewhat smaller than in the type specimens, $6\frac{2}{3}$ times in the diameter.

Mud Springs, in Pine Canyon, a branch of Sabino above Sabino Basin, is a walled hole in the mud. It is on the trail from Sabino Basin to Soldier's Camp, the elevation about 7,000 feet. It is in the pine zone. The *Sonorella* was found in the first rocks east of the spring along the trail. Also at the foot of a high cliff, in stratified "porphyry," in a ravine heavily wooded with ypress (*Cupressus arizonica*), about a mile southeast of the springs.

(*Limifontis*, of a mud spring.)

Sonorella tortillita Pilsbry & Ferriss

Fig. 162.

Sonorella tortillita Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, 70: 299, pl. 5, figs. 4-4b; text-fig. 8.

The shell is umbilicate, width of umbilicus contained nearly 8 times in that of the shell, pinkish buff, fading to white around the umbilicus and paler near the chestnut-brown band which revolves above the periphery of the last whorl and shows very narrowly above the suture on most of the penult whorl. The surface is glossy; embryonic shell about $1\frac{1}{2}$ whorls, the first half whorl having some radial wrinkles, the rest of the embryonic portion closely irregularly granulose, and having fine, often rather indistinct,

forwardly descending threads, often visible only near the suture. Subsequent whorls have the usual fine growth-lines. The spire is rather small. The whorls increase slowly at first, the last one very wide, suture descending slightly in front. The aperture is rounded oval-lunate. Peristome is well expanded.



Fig. 162. *Sonorella tortillita*, type.

Height 15.3 mm., diameter 27.3 mm.; aperture alt. 14.7, width 15.9 mm.; $4\frac{2}{3}$ whorls.

Genitalia (Fig. 163). The penis is very long and rather slender, with muscular walls, containing a long, slender, corrugated, tapering verge. The epiphallus is shorter than the penis, without a distinct flagellum, though there seems to be a rudimentary one concealed in the integument. The penial retractor is long. Length of vagina is about equal to the penis. Length of penis 18, verge 8, epiphallus 11, vagina 17 mm.

ARIZONA: Tortillita Mountains, Pinal County (J. H. Ferriss), Type 118053 A.N.S.P., from east side of Hog Canyon; also found on the west side of same canyon near the cement dam, and south slope of mountains east of Hog Canyon.

By the long penis and vagina this species resembles *S. rinconensis*, but in that snail these organs are far longer. *S. santaritana* is even more like *S. tortillita* in genitalia, but the shell is flatter, the whorls of smaller caliber. None of the Santa Catalina species has the vagina and penis nearly so long as in *S. tortillita*. The larger shells referred to *S. sabinoensis occidentalis* are closely similar, but the threads of the embryonic whorl are better developed, the spire is wider, and the penis is only about half as long and differs by its swollen base.

The embryonic sculpture described is in large part effaced in the fully adult shells found. The color, too, is somewhat faded. In the young and barely full-grown examples it is decidedly darker than described. The largest specimen from the type locality measures 17.2 x 28.6 mm.; the

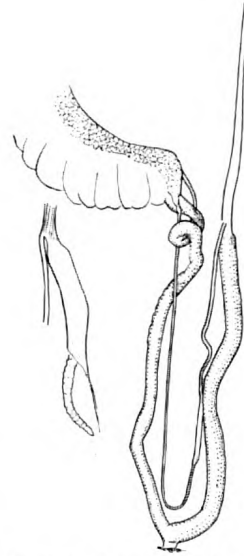


Fig. 163. Genitalia of *Sonorella tortillita*, with detail of the verge.

smallest, 12.5 x 23.2 mm.; very few are under 25 mm. diameter. The largest shell in the lot from the west side of Hog Canyon measures 17.5 x 30 mm. A strongly depressed shell measures 15.3 x 29 mm.

The Tortillitas are a short range about ten miles northwest of the Santa Catalinas. They are arid mountains without forest.

Sonorella sabinoensis Pilsbry & Ferriss

Fig. 164 a-e'.

Sonorella sabinoensis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, 70: 289, pl. 4, figs. 1-5d; text-fig. 3.

The shell is rather narrowly umbilicate, width of umbilicus contained nearly 8 times in that of shell in the type specimen, rather solid; cinnamon-buff, broadly zoned with white (or whitish) on both sides of the chestnut-brown band above the periphery. The surface is glossy; embryonic whorls when unworn with a smooth tip, followed by radial wrinkles and some granulation, then spirally descending threads with radially corrugated intervals, and with some interrupted ascending spirals near the upper suture. Subsequent whorls delicately marked with growth-lines. Suture descends moderately in front. The aperture is large, oblique, rotund-oval. Peristome narrowly expanded, dilated at the umbilical insertion.

Height 12.7 mm., diameter 21.3 mm.; aperture 12 x 13 mm.; 4½ whorls.

Genitalia (Fig. 165 a, b) resembling those organs in *S. marmorarius*. The penis is thin, not swollen basally. The verge is slender and corrugated, as in the other species, and nearly as long as the penis (Fig. 165 a). The flagellum is either minute or wanting. Five measure:

Penis	Verge	Epiphallus	Flagellum	Vagina	Diam. shell
10	7	8	0	9	21.3, type
9.5	8	7	0	7.3	22.8
10.5	10	9	-1	9	26.7
9	7	6	0.3	8.5	24.0
8.5	8	6.5	0.5	6.5	23.2

ARIZONA: Santa Catalina Mountains in Sabino Canyon (Ferriss), Type 109097, Station 16, 1913, and its tributaries, Sycamore Canyon and Mt. Lemon Fork, from about 3000 to 6000 feet elevation. Also Rock and Vantana canyons, west of Sabino, and Bear Canyon eastward.

It is a species of the dry, sun-baked rock-slides, living ones found only deep in the crevices, in the lower levels with desert vegetation. The Sabino Basin, Sycamore and Bear Canyon localities are below the pine belt, in arid country, with some oak, juniper and sycamore. The species is not known to occur in the humid upper forest.

The smallest shells, 19 mm. in diameter, were found low in Sabino Canyon (about 4,000 ft.); but others up to 25 mm. in diameter occur in the same place. The largest, 27 mm. in diameter, are from the bluffs opposite. One of this lot is figured, Figs. 164 d.

The degree of depression is variable in the same lot. Specimens selected from a station on Vantana canyon measure:

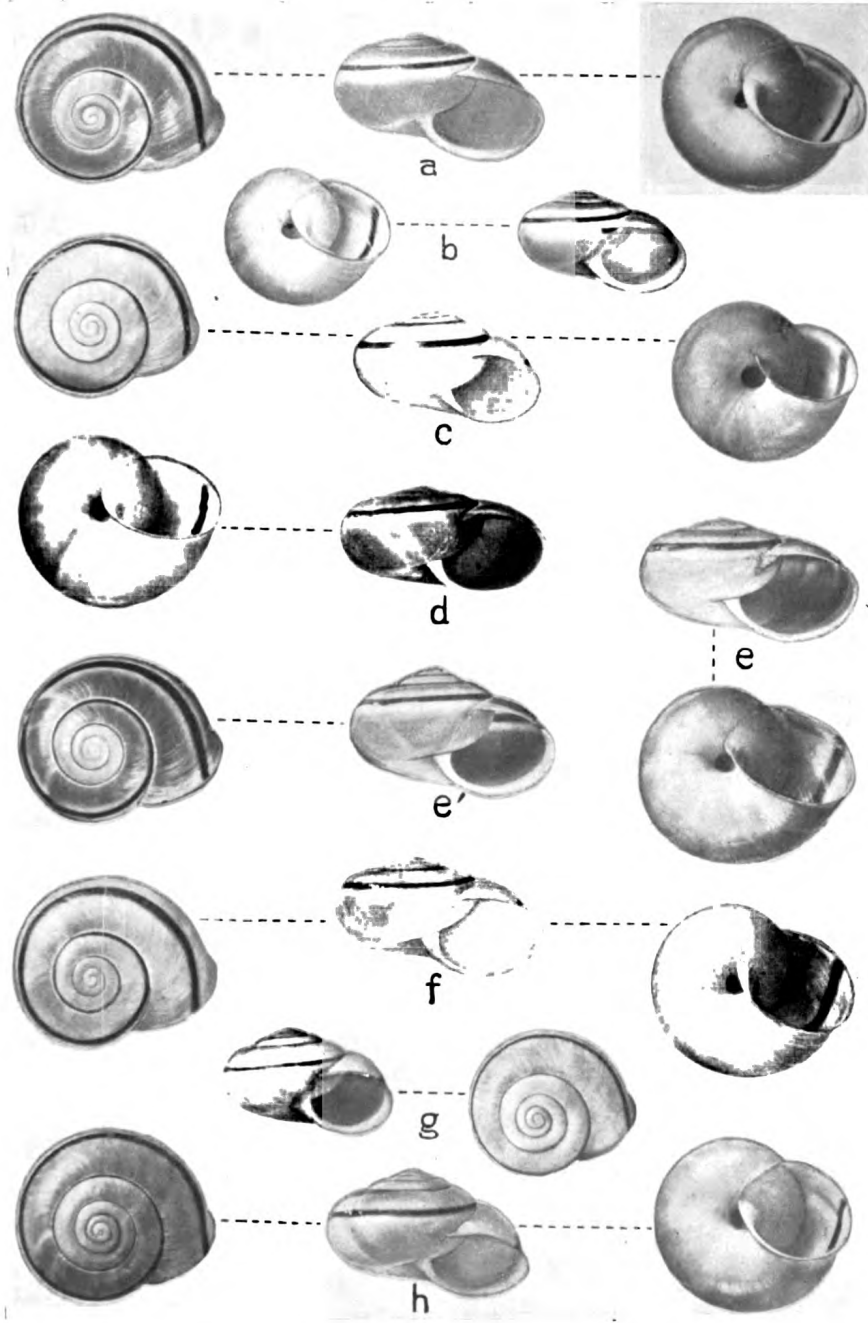


Fig. 164. a-d, *Sonorella sabinoensis*, Sabino Canyon, b the type; e, e', Bear Canyon. f, *S. sabinoensis dispar*, type. g, h, *S. sabinoensis buchmanensis*, h the type.

Height 14.5 mm., diameter 26 mm. Largest.
 Height 13.2 mm., diameter 25 mm. Most depressed.
 Height 16.4 mm., diameter 24.8 mm. Most elevated.
 Height 12.2 mm., 20 mm. Smallest.

Figures 164 e and e' are depressed and elevated shells from Bear Canyon.

Shells from the type station measure from 20 to 24 mm. diameter. The relative size of the aperture also varies within rather wide limits. In the type specimen (Fig. 164 b) the width of aperture is contained about 1.63 times in that of the shell, and in another locotype (Fig. 164 c) it is contained nearly 1.8 times. In the small-mouthed individuals the umbilicus is somewhat larger and less covered, and the last whorl, viewed from above, is not so wide. Nearly every station supplied individuals with large, intermediate and small apertures.

The specimens from low in Sabino Canyon usually have more solid, thicker shells than those from higher; but this is not always the case.

Sonorella sabinoensis buehmanensis Pilsbry & Ferriss

Fig. 164 g, h.

Sonorella sabinoensis buehmanensis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. for Phila., for 1918, p. 292, pl. 5, figs. 2-3b; text-fig. 5.

Typically the shell differs from *S. sabinoensis* by being more solid and more elevated, only very slightly paler near the shoulder band, and with nearly one whorl more in examples of the same diameter. Umbilicus contained 8 times in the diameter. Penis rather slender throughout (Fig. 165 c, d).

Height 16.4 mm., diameter 25.8 mm.; 5½ whorls. Type (Fig. 164 h).
 Height 17 mm., diameter 25.2 mm.; 5½ whorls. Topotype.
 Height 15.7 mm., diameter 23 mm.; 5+ whorls. Topotype.
 Height 17.7 mm., diameter 25.8 mm.; 5 whorls. Station 43.
 Height 13.7 mm., diameter 21.5 mm.; 4¾ whorls. Station 43.
 Height 13 mm., diameter 21 mm.; 4¾ whorls. Station 43.

ARIZONA: Buehman Canyon, in the eastern part of the Santa Catalina Mountains, the Type 109198 A.N.S.P., from Station 44 (1913), near the Korn Kobb mine. Also at Stations 41, head of Sycamore Gulch, tributary to Buehman Canyon, 42, Buehman Canyon at the Brush Corral, and Station 43, Buehman Canyon a mile below the Brush Corral Ranger Station (J. H. Ferriss).

There is considerable variation in the shells from Buehman Canyon, in size, degree of elevation and number of whorls. Specimens from the head of Sycamore Gulch have the umbilicus slightly more open than in typical *buehmanensis*, and the borders of the shoulder-band are paler; thus approaching the larger forms of *S. sabinoensis*. In Stations 42 and 43 the size varies widely, and the smaller specimens have only a fraction of a whorl more than *sabinoensis*, from which they differ by the smaller aperture.

One figured (Fig. 164 g) measures: height 13.7, diameter 21 mm. In the same lots the larger shells have a diameter of 25 mm. or slightly more.

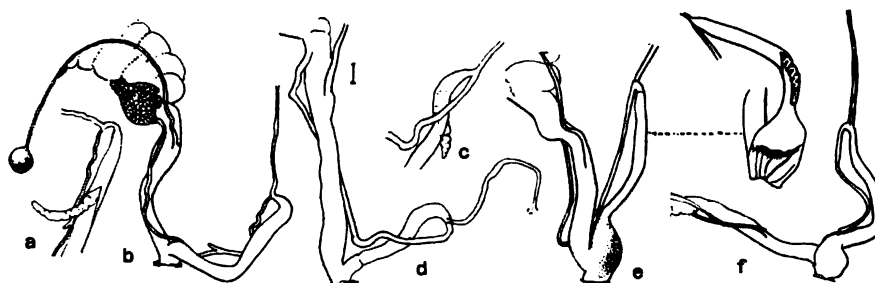


Fig. 165. Genitalia of: a, b, *Sonorella sabinoensis*; c, d, *S. sabinoensis buehmanensis*; e, f, *S. sabinoensis dispar*.

Like other species of the dry lower mountains, living snails are rare. In one rock slide in Buehman Canyon, 360 fairly good "bones" were found, and only 8 living snails.

***Sonorella sabinoensis dispar* new name**

Fig. 164 f.

Sonorella sabinoensis occidentalis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 291, pl. 5, figs. 1-1b; text-fig. 4. Not *S. granulatissima occidentalis* Pilsbry & Ferriss, 1915.

The shell appears indistinguishable from *S. sabinoensis*.

Height 16.3 mm., diameter 28 mm.; 5 whorls.

Height 17.3 mm., diameter 26.8 mm.; 5 whorls. Type (Fig. 164 f).

Height 15.3 mm., diameter 26.5 mm.; 4½ whorls.

Height 15 mm., diameter 23.4 mm.; 4¾ whorls.

Genitalia (Fig. 165 e, f). The penis is slender except at the base where it is suddenly dilated. Internally there is a short, sinuous fleshy fold and several minor folds in the dilated part of the penis where it passes into the atrium, which also contains several fleshy ridges. The verge is long, slender and corrugated. Penial retractor is terminal and enveloping base of the epiphallus, as usual. The epiphallus is nearly as long as penis, with a slight distal swelling (or a minute flagellum). The vagina is shorter than the penis. Measurements in mm. follow:

Penis	Verge	Epiphallus	Flagellum	Vagina	Spermatheca and duct	Locality
10	8	8	0	6	32	Type
8.5	6	7.5	minute	4	23	Sta. 37
9	6.5	7.5	minute	6	..	" 45

The head and back are hair brown, fading to drab on the sides, the tail and entire sole being dull chamois to dull cream-buff.

ARIZONA: Western end of the Santa Catalinas (J. H. Ferriss), Type 119491 A.N.S.P., from Station 36, east side of Pima Canyon. Also on the west side, Station 37 (Pusch Ridge); Station 43 (1917), northeast of Sutherland's Ranch, in the foothills; Station 45, in the large canyon north of Romero Canyon (eastward from Sutherland's).

This form is separated from *S. sabinoensis* solely on account of the difference in the penis, which is enlarged at the base in *dispar*, slender in *sabinoensis*. While the Pima Canyon shells are distinguishable from the large-mouthed typical forms of *sabinoensis*, we can find no difference in the *sabinoensis* with slightly smaller aperture, such as those from Sabino Canyon Station 9 (which agree in genitalia with the type of *sabinoensis*). No specimens with the penis swollen basally were found among the numerous Sabino Canyon individuals opened.

The series of 60 specimens from Pima Canyon consist chiefly of dead shells. The average size appears to be slightly less in the specimens from the western side of the canyon, forming the eastern slope of Pusch Ridge.

There are three "dead" specimens from "Pusa Ridge" (? = Pusch Ridge) in the U. S. National Museum, No. 271011, collected by Barber. The diameter is about 22 mm.

The specimens from the canyon north of Romero (opening northward), Station 45 (1917), have the same range of variation noted in Sabino canyon *S. sabinoensis*. There are depressed, more openly umbilicate shells, together with smaller, usually less depressed shells with relatively larger aperture and smaller umbilicus, $\frac{1}{3}$ to $\frac{1}{2}$ covered by the expansion of the columellar lip; also a few specimens transitional in these characters. 14 examined.

Height 15.4 mm., diameter 27.3 mm.; $4\frac{3}{4}$ whorls. Largest.

Height 15.6 mm., diameter 23 mm.; $4\frac{1}{2}$ whorls.

Height 14.3 mm., diameter 22 mm. Smallest.

The genitalia do not differ from Pima Canyon shells.

Seven shells from Station 43 (1917) measure from 21 to 24.4 mm. in diameter.

All of the localities for *dispar* are in the arid lower zone of the range. (*Dispar*, different.)

***Sonorella sabinoensis hesterna* Pilsbry & Ferriss**

Fig. 166.

Sonorella hesterna Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 294, pl. 4, figs. 6-6b.

The shell resembles *S. sabinoensis*. It is rather solid, glossy, of the same dilute brown color, with distinct whitish bands on either side of the chestnut-brown band. Umbilicus 7 to $8\frac{1}{2}$ times in the diameter. Embryonic whorls with some radial rugosity, distinct below the suture, the threads interrupted into a fine, irregular and broken network, not recognizable as descending or ascending threads; this being the only definite difference from some forms of *sabinoensis*. Soft anatomy unknown, as only dead shells have been collected.

Height 14 mm., diameter 22.6 mm., aperture 11.5 x 12.6 mm.; $4\frac{1}{2}$ whorls
Type.

A larger topotype measures, height 15.7 mm., diameter 25.7 mm., aperture 13.2 x 15 mm., $4\frac{3}{4}$ whorls. Other topotypes are from 20.2 to 26 mm. diameter.



Fig. 166. *Sonorella sabinoensis hesterna*, type.

ARIZONA: Southern foothills of the Rincon Mountains south of the Tucson-Benson highway, at Shaw's goat ranch, near the cave (J. H. Ferriss), Type 119489 A.N.S.P.

This form was evidently abundant, as Ferriss sent me 61 "bones", only a few in good condition, none alive. The station is an extremely arid one. Its place in the series remains uncertain.

(*Hesternus*, of yesterday.)

***Sonorella sabinoensis tucsonica* Pilsbry & Ferriss**

Fig. 167 a-c.

Sonorella sabinoensis tucsonica Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 69, text-fig. 2a, c-e.

Sonorella sabinoensis deflecta Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 71, text-fig. 2b.

The shell is similar to *S. sabinoensis* except that the umbilicus is a little larger in specimens of equal size; as in that species, the last whorl, seen from above, is quite wide. It differs from *S. papagorum* by the sculpture of the embryonic whorls, which is distinct, as in *sabinoensis*, while in *papagorum* it is extremely weak, the surface appearing more polished. The color is distinctly darker than *papagorum*, wood-brown or almost fawn color, with a usually broad chestnut-brown band with pale borders. The last whorl descends very little in front.

Height 16 mm., diameter 27.3 mm.; $4\frac{3}{4}$ whorls. Type. Station 81.

Height 13 mm., diameter 20.8 mm.; $4\frac{1}{2}$ whorls. Station 64.

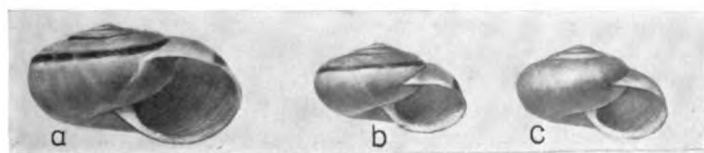


Fig. 167. a, *Sonorella sabinoensis tucsonica*, type. b, c, form *deflecta*.

The genitalia are similar to *S. sabinoensis*, characterized by a rather long penis, in those measured from slightly over $\frac{1}{3}$ to nearly $\frac{1}{2}$ the diameter of shell. The slender, slightly tapering verge is also long, generally wrinkled

somewhat, but in one specimen (Station 64) it was smooth. The flagellum is small, or in a specimen from Station 57, wanting. The penis and vagina are longer than in *S. papagorum*, but of the same type.

Penis	9.5	10	9	9.5	9	7.5	7 mm.
Verge	6	7	8	7.5	6	4	4.5 mm.
Epiphallus	6	8	7.5	....	7	4	6.5 mm.
Flagellum	-1	-1	1	0	1	....	1 mm.
Vagina	7	11	9.5	....	6	5	5.5 mm.
Diam. of shell...	27.3	23.5	21	25	21.4	21	19.6 mm.
Station	81	54	64	57	72	79	59

ARIZONA: Tucson Range (J. H. Ferriss), Type 118070 A.N.S.P. A common species, generally distributed.

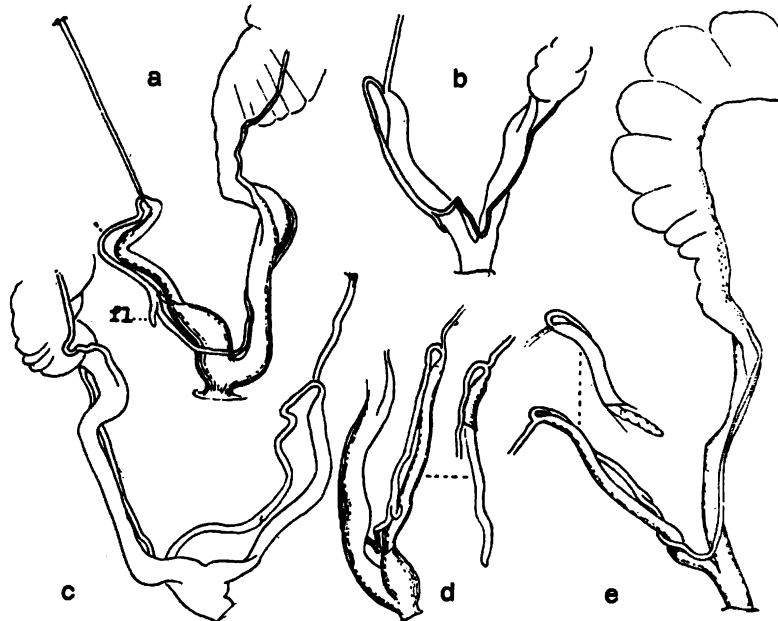


Fig. 168. *Sonorella sabinoensis tusconica*. Lower ducts of the genitalia, a, No. 118067, station 72. b, *S. s. defecta*, No. 118050, station 59. c, *S. s. tusconica*, No. 118047, station 54. d, 118063, station 64. e, 118070, station 81. fl., flagellum. All in the Tucson Range.

The shell is highly variable in size and in degree of depression of the spire. The largest specimens, from Station 81, were found less than half a mile from the smallest measured above, Station 64, in the same valley.

At the north end of the Tucson Range, Stations 72, 73, 79, all of the specimens are small and dark, diameter 20 to 21.5 mm. In the genitalia they do not differ from the smaller examples from "Wild Pig Amphitheatre." Measurements are given above.

In No. 118070 and 118047 the basal sheath of penis is but little larger than the distal part of the penis. In 118063, 118067 and 118049 it is quite thick, as in *S. sabinoensis dispar*.

We gave the name *deflecta* (Figs. 167 b, c), to a small form, 18 to 20 mm. in diameter, taken in several places about 5 miles north of "Mountain Sheep Camp", in a quartzite outlier west of the Tucson Range. The shells are lighter colored than typical *tucsonica*, and in some, but not all, the suture descends rather deeply in front. However, this feature is equalled in some undoubted *tucsonica*; and I now regard its characters as due to an exceptionally dry station, and not racial. The genitalia are drawn in Figure 168 b, measurements in table, Station 59. One specimen in the long series seen lacks the dark shoulder band.

A shell (119331 A.N.S.P.) not distinguishable from "*deflecta*" was picked up by J. C. Blumer at the base of the Santa Catalina mountains 6 miles west of the mouth of Sabino Canyon. This was probably at about 3000 feet. It measures 11 x 20.5 mm. Perhaps it is a dry country dwarfed form of *sabinoensis* rather than a direct relative of "*deflecta*".

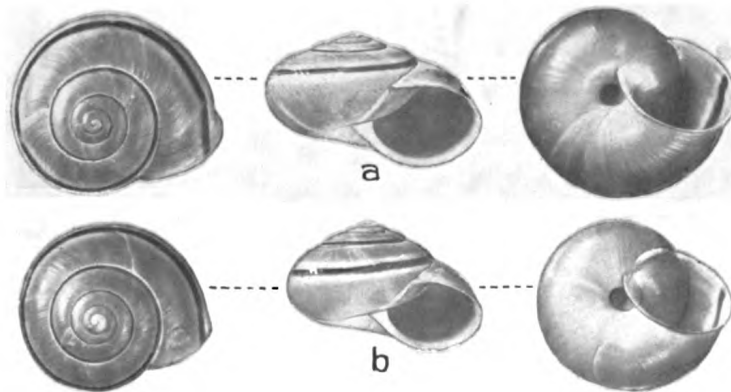


Fig. 169. *Sonorella galiurensis*; a, type, and b, topotype.

***Sonorella galiurensis* Pilsbry & Ferriss**

Fig. 169.

Sonorella galiurensis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 298, pl. 5, figs. 5-6b; text-fig. 7.

The shell is umbilicate, the width of umbilicus contained about $7\frac{1}{2}$ times in that of the shell, between cinnamon-brown and sayal-brown in color, fading on the base, and much paler on both sides of the broad chestnut-brown band above the periphery; glossy. Embryonic whorls closely wrinkled-granulate, with close, forwardly descending threads on peripheral half of last embryonic whorl (often lost by wear in adult shells). Subsequent whorls lightly marked with irregular growth-lines, and sometimes weak impressed spiral lines below the last turn of the suture. The

last whorl is wide and descends somewhat in front. The peristome is narrowly expanded. The parietal callus usually has a thickened edge in fully adult shells.

Height 16.7 mm., diameter 27.5 mm.; nearly 5 whorls. Type (Fig. 169 a).

Height 16.3 mm., diameter 25.2 mm.; 5 whorls. Topotype (Fig. 169 b).

Genitalia (Fig. 170). The general proportions are as in *S. marmorarius*. The penis has a long, very thin sheath about the basal part, not seen in *marmorarius*; its lower portion is somewhat swollen and has several small longitudinal folds within. Retractor muscle long. Verge weakly annulate, about half as long as the penis. There is the usual short flagellum. The vagina about equals the penis in length. Length of penis 10 mm., verge 5, epiphallus 7, flagellum 1.5, vagina 9 mm.

ARIZONA: Galiuro Mountains, Graham County, on the southern slope of the mountains at John Rhodes' Ranch and Rhodes Canyon; Whitlock Ranch; Copper Creek to Table Mountain. Type 119493 A.N.S.P., from a porphyry slide $1\frac{1}{2}$ miles south of Copper Creek mining camp. Also in Gila and Pinal Counties (J. H. Ferriss).

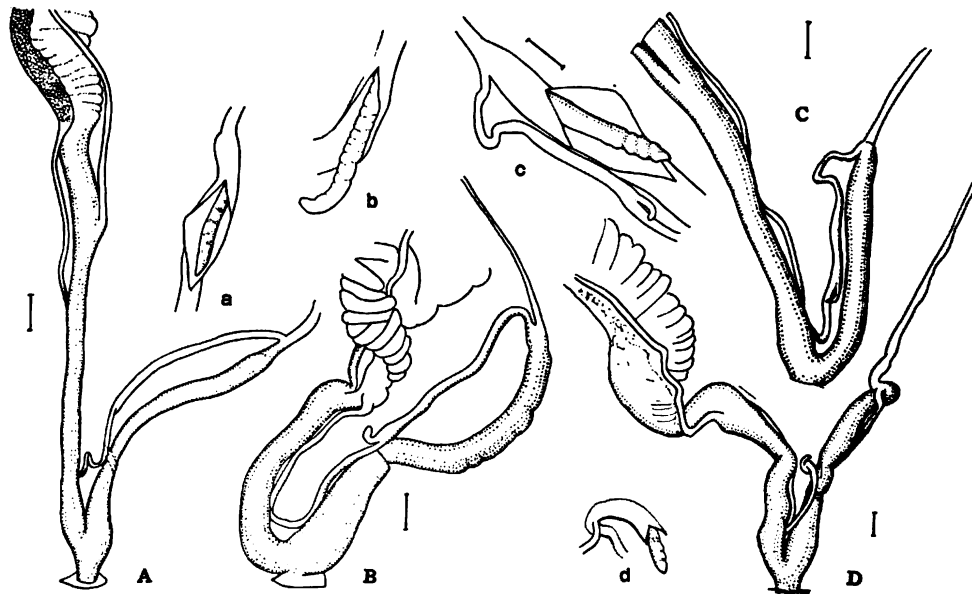


Fig. 170. A, a, *Sonorella galiurensis*, Nantes Mts. b, b, *S. galiurensis superioris*. c, c, *S. galiurensis*, Picket Post Mt. d, d, Galiuro Mts. Scale lines = 1 mm.

This form is much like *S. marmorarius*, but the shell is decidedly more capacious and darker colored, with a larger aperture and a smaller umbilicus. Its habitat is at a lower elevation and separated from that of *marmorarius*

by the valley of the San Pedro River. It seems very closely related to *S. caerulifluminis* except in form of the verge, which is stouter.

20 living specimens from Station 30, all taken, measure as follows:

Diameters in mm.	25	25.5	26	26.5	27	27.5	28	29
No. specimens	1	1	2	2	3	2	8	1

17 specimens from Station 24, a southern slope:

Diameters	24	24.5	25	26	26.5	27	28	28.5	30.5
No. specimens ..	1	2	3	2	4	1	2	1	1

S. galiurensis was taken on Picket Post Mountain, southwest of Superior, Pinal County, the shells from 24.7 to 28 mm. diameter, with the embryonic whorls differing slightly, increasing a little more rapidly; umbilicus contained $7\frac{2}{3}$ times in the diameter. The penis has a sheath of loose strands only, near the base. The verge has strong circular corrugations near the end. Length of penis 8, verge 4, epiphallus 6, vagina 10 mm. (Fig. 170 c, e).

One specimen from "Nantes Mts. 10 miles north of Rice", Gila County, has a narrow umbilicus, contained 10 times in the diameter, as in *S. g. superioris*, but the proportions of the genitalia (Fig. 170 A, a) are as in *S. galiurensis* except that the flagellum is very short. Length of penis 8, verge 4, epiphallus 6.5, flagellum 0.3, vagina 10 mm.

A specimen was taken by Dr. G. H. Horn at or near old Fort Grant, at the western base of the Graham (Pinaleno) Mountains, Graham County, about 1864, and recorded as "*H. strigosa* Gld." by W. M. Gabb (Amer. Journ. Conch., 2: 330, 1866).

***Sonorella galiurensis superioris* new subspecies**

Fig. 171 d, e.

The shell differs from *S. galiurensis* by its narrower umbilicus, contained $8\frac{1}{2}$ to 12 times in the diameter; embryonic whorls similar, being profusely wrinkle-granulose following smooth and radially rippled stages, with irregular, forwardly descending threads on the peripheral half.

Height 16.2 mm., diameter 25.8 mm.; $4\frac{2}{3}$ whorls.

Paratypes measure 14.6 x 24 mm. and 16.6 x 27.8 mm.

The genitalia (Fig. 170 B, b) are characterized by the greater length of the penis compared with that of *galiurensis*, about 60 percent of the diameter of the shell; it has a strong sheath around the slender anterior third. The base of epiphallus is enlarged by union with the penial retractor for a distance of about 1 mm. The verge is transversely wrinkled. Flagellum well developed. Length of penis 16, verge 7, epiphallus 7, vagina 8 mm.

ARIZONA: Near the highway tunnel 4 miles east of Superior, Pinal County (J. H. Ferriss), Type 166682 A.N.S.P. Also in the same county at Ray (from G. H. Clapp), and at Kelvin (Barber).

As in *S. galiurensis*, the degree of depression of the spire varies. The smallest shell seen has a diameter of 21.6 mm. At Kelvin, 271012 U.S.N.M., the diameter is from 24 to 24.7 mm.

Sonorella verdensis new species

Fig. 171 a, b, c.

The shell resembles *S. ambigua* and *S. galiurensis* in form and coloration, but the chestnut-brown band above the periphery is without the white borders which are quite conspicuous in *S. galiurensis*, though the ground color may be slightly paler there. After the minute smooth initial tip the embryonic whorls have close, fine radial wrinkling, more or less interrupted or anastomosing, but no diagonally descending threads as in the *hachitana* group. The first neanic whorl is not papillose. The umbilicus is larger than in *S. galiurensis superioris*.

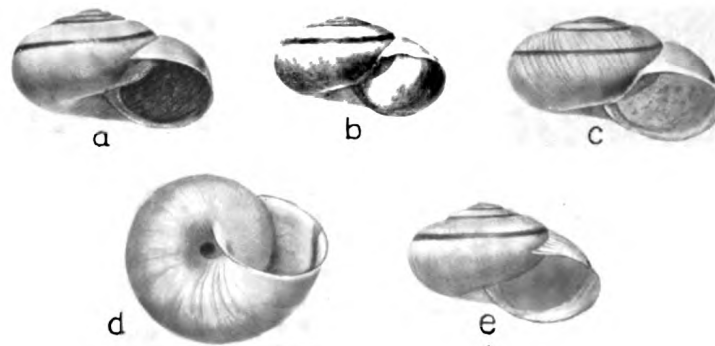


Fig. 171. *Sonorella verdensis*; a, type; b, c, Pine creek. d, e, *Sonorella galiurensis superioris*, type and paratype.

Height 16 mm., diameter 27 mm., aperture 13 x 14.6 mm.; 5 whorls.

Genitalia (Fig. 172). The penis is very long, nearly equaling the diameter of shell, with a short basal sheath; containing a large, cylindric verge with blunt end (and in the type, longitudinally wrinkled near the end, left figure). Epiphallus enlarged in the basal 3 mm., where penial retractor attaches. Flagellum moderately developed. Vagina not quite as long as penis. The hermaphrodite duct is large and strongly convoluted. Length of penis 25, verge 17, epiphallus 14, flagellum 0.8, vagina 19 mm.

ARIZONA: Mazatzal Mountains, Gila County, on the Maricopa County border (J. H. Ferriss), Type 130859 A.N.S.P. Pine Creek Natural Bridge, Gila County (Ferriss and Hand).

By the shell alone this species is separable from *S. galiurensis* by the absence of diagonal threads on the embryonic whorls

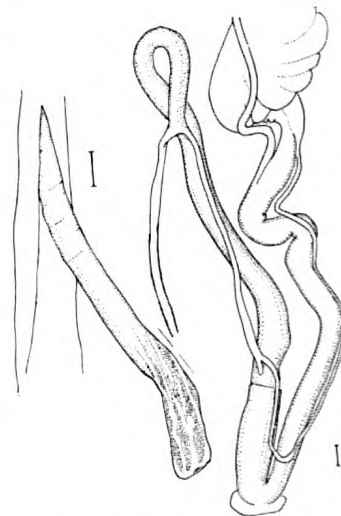


Fig. 172. *S. verdensis*.

and of papillae on the next whorl. The much larger penis, its length nearly equal to the diameter of the shell, and the long, club-shaped verge, differentiate *verdensis* from other species of central Arizona. These characters, as well as the lack of diagonal threads mentioned, ally this snail to *S. ambigua*, which is widely spread in the mountains of the desert region a hundred miles south. Almost nothing is known of the shells of this hundred miles between the Mazatzal and the Silverbell ranges west of Superior and Ray, and the mountains around Phoenix are equally unknown. Perhaps *S. verdensis* is a northern outlier of *S. ambigua*, or a derivative of *galiurensis* which has lost part of the embryonic sculpture; but until further collections are made, no definite opinion can be formed. *S. ashmuni* has a narrower umbilicus.

At Pine Creek Natural Bridge, about 15 miles north of the Mazatzal range, Ferriss collected a long series of similar shells, none alive. These shells vary from 13.5 x 23 mm. to 17 x 28.5 mm.; $4\frac{3}{4}$ whorls (Fig. 171 b, c).

(Named for the Verde River valley, in which the localities lie.)

Sonorella optata Pilsbry & Ferriss

Fig. 173.

Sonorella optata Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 60, pl. 1, figs. 6-12, 17-19; pl. 4, figs. 1-4, 7; text-fig. 4 (" *S. optima* " by error, l. c. p. 58).

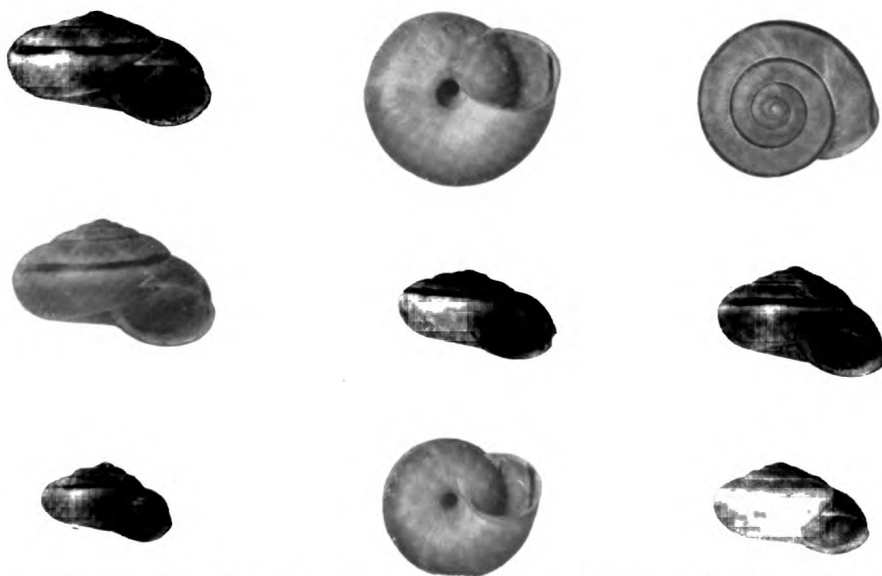


Fig. 173. *Sonorella optata*. Upper, type and paratypes; middle left, cleft at fork of Emigrant Canyon; lower left, head Emigrant Canyon; other figures, west side of Rough Mountain.

The shell is umbilicate, umbilicus contained 6 times in the diameter; similar to *S. hachitana*. Pale brown, fading to whitish around the umbilicus,

encircled by a rather wide dark chestnut band above the periphery, bordered above and below with whitish bands. The spire is low conic. Whorls 5½, slowly increasing to the last, which is much wider, and descends rather deeply in front. The embryonic shell consists of 1½ whorls. The first half whorl has radial wrinkles, and begins in a smooth tip; then a small areolate area follows, after which there are curved, forwardly descending delicate threads reaching the suture below, but weak or obsolete on the summit of the whorl, which is irregularly roughened; there are also some forwardly ascending threads in places. The first neanic whorl has sculpture of slight growth ripples and an indistinct roughening or punctation. Subsequent whorls are lightly marked with growth-lines only. The aperture is very oblique, subcircular; peristome thin, a little expanded, narrowly reflexed below, the columellar margin dilated.

Height 15.2, diameter 25 mm.; aperture 11.7 x 13 mm.

Penis small, usually shorter than the vagina, and less than one-third as long as the spermatheca and duct. Epiphallus short, the flagellum apparently absent or reduced to a very minute adnate coecum (Fig. 174). Radula with 35, 1, 35 (summit of Cross J Mt.) to 38, 1, 38 teeth, about 14 laterals, an ectocone appearing on the 11th to 13th. The entocone is bifid on the outer 15 to 18 marginals, and the ectocone occasionally so on some teeth, though generally simple. Six radulae from 5 stations examined. The jaw has 5 ribs in two, 6 and 7 in two other examples. The crop and oesophagus as far as the stomach are conspicuously sulcate or corrugated longitudinally.

ARIZONA: Emigrant Canyon, Chiricahua Range, from about 4500 to 7000 feet¹ (Pilsbry and Ferriss), Type 99784 A.N.S.P., from about 2 miles north of west of Rough Mountain, at about 6000 feet.

This handsome snail has a far wider umbilicus than *S. bicipitis*. It is much like *S. hachitana*, but differs by the shape of the verge and the

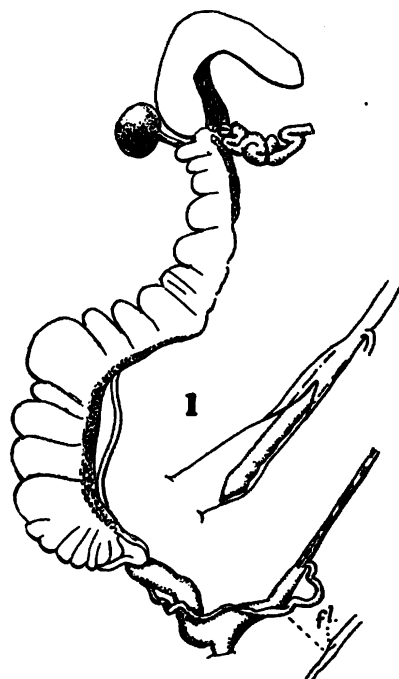


Fig. 174. *S. optata*. fl., flagellum.

¹ These mountains had not been mapped at the time Ferriss and the author collected there. In our paper of 1910, p. 121, a rough map from the author's notebook shows the locations of our collecting stations. Our "Cross J Mt." (l. c. p. 87, fig. 12) and "Big Emigrant Mt." (local names obtained from ranchers), are Wood Mt. and Rough Mt. of the U. S. G. S. topographic map.

vestigial or wanting flagellum. Neighboring *Sonorellas* southward in the Chiricahuas differ by their apical sculpture and genitalia.

In the type lot the diameter varies from 22.8 to 26 mm. In a colony from Rough Mountain the size runs from 15.5 to 20.5 mm. A small shell from near the type locality measures 9.8 x 16.3 mm., 4½ whorls (Fig. 173, lower left).

The shells from Rough Mountain and Wood Mountain usually show numerous spiral striae on the upper surface of the last whorl, but this character is variable; in some shells of each lot no spiral striae can be made out.

Measurements of the genitalia of specimens from 5 localities follow:

Penis	5	7	4.5	5	4.6 mm.
Verge	7	4	4	2.6	2.6 mm.
Epiphallus	4.5	3.5	5	5	2.7 mm.
Vagina	8	8	6	5	7 mm.
Spermatheca .....	..	26	24	20	.. mm.
Shell, diam.	25	25.5	18.5	19.5	20 mm.

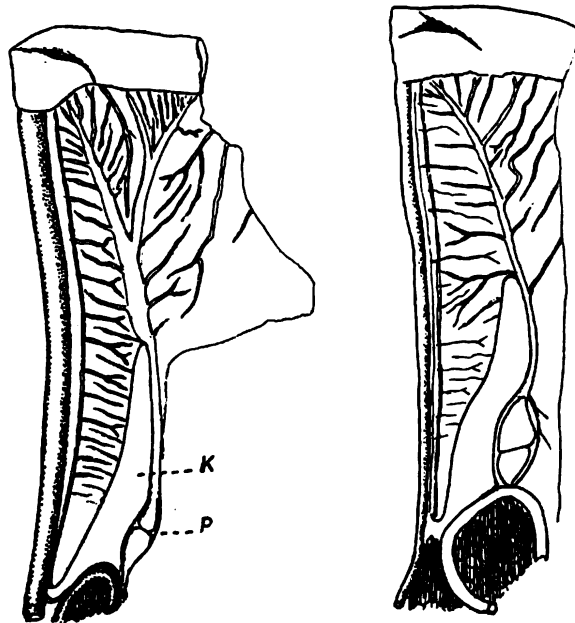


Fig. 175. Pallial region of *Sonorella optata*, two individuals. *k*, kidney; *p*, pericardium.

The lung (Fig. 175, right fig.) has venation much as in *S. compar*. The secondary ureter is open throughout, being defined by a thread-like ridge only. Length of lung 26, of kidney 14, of pericardium 5 mm. In one of several examined the pulmonary vein has a large branch on the cardiac side,

where the venation is otherwise very faint. Length of lung 27, of kidney 14, of pericardium 4.5 mm. (Fig. 175, left fig.).

S. optata occurs in numerous colonies throughout Emigrant Canyon, except on slopes with southern exposure. It is a rather arid canyon with some cover of scrub oak on the slopes and pinyons in the upper part. The snails were found under stones. The prevalent rock is limestone.

(*Optatus*, desirable.)

Sonorella bicipitis Pilsbry & Ferriss

Fig. 176.

Sonorella bicipitis Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 55, pl. 1, figs. 1-5; pl. 3, figs. 1-4, 6, 7.

Shell of the group of *S. hachitana*; the umbilicus contained about 9 times in the diameter, and one-third covered by the dilated columellar lip; brown, fading to white around the umbilicus, encircled above the periphery with a dark chestnut band bordered above and below with white bands of about the same width; the brown band visible on about two whorls of the spire, the upper white band visible also on the penultimate whorl. Whorls $4\frac{3}{4}$ to 5, rather slowly increasing at first, the penultimate and last whorls rapidly widening. Surface nearly smooth to the eye, glossy. Embryonic shell consisting of $1\frac{1}{2}$ whorls. The first half whorl has distinct radial ripples; the next whorl has close, fine wrinkles in the direction of growth-lines, and

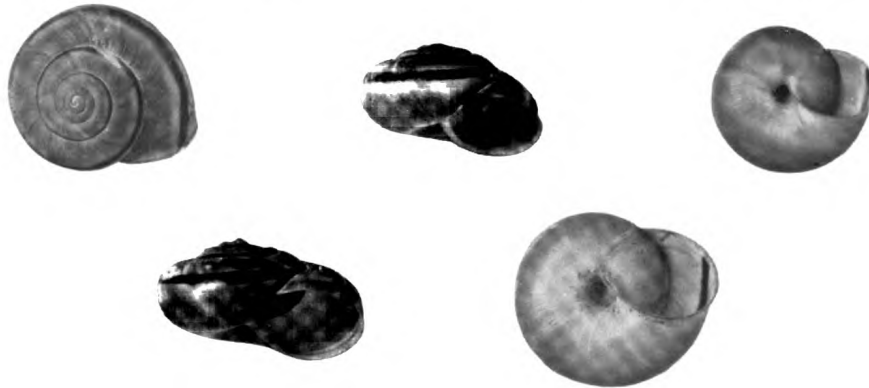


Fig. 176. *Sonorella bicipitis*. Above, type and paratypes from Buckeye Canyon; below, Nine-mile Creek.

interrupted by delicate, spirally descending threads. The third whorl shows some very sparse punctation. Later whorls are marked with fine growth-ripples, and usually show, under a strong lens, some excessively faint spiral lines above the periphery. The last whorl descends moderately in front, and is well rounded on periphery and base, as usual. The aperture is large, oblique, rounded, nearly as high as wide. Peristome thin, narrowly expanded outwardly, the basal margin a trifle reflexed, columellar margin dilated in a curved triangular plate over about one-third of the umbilicus.

Height 14 mm., diameter 23 mm.; aperture, 12.2 x 13 mm.

Fig. 177. 1-4, 6, 7, *Sonorella bicipitis*; 1, 4, 7, Buckeye Canyon; 2, 3, 6, Nine-mile Creek; 5, *S. binneyi*.

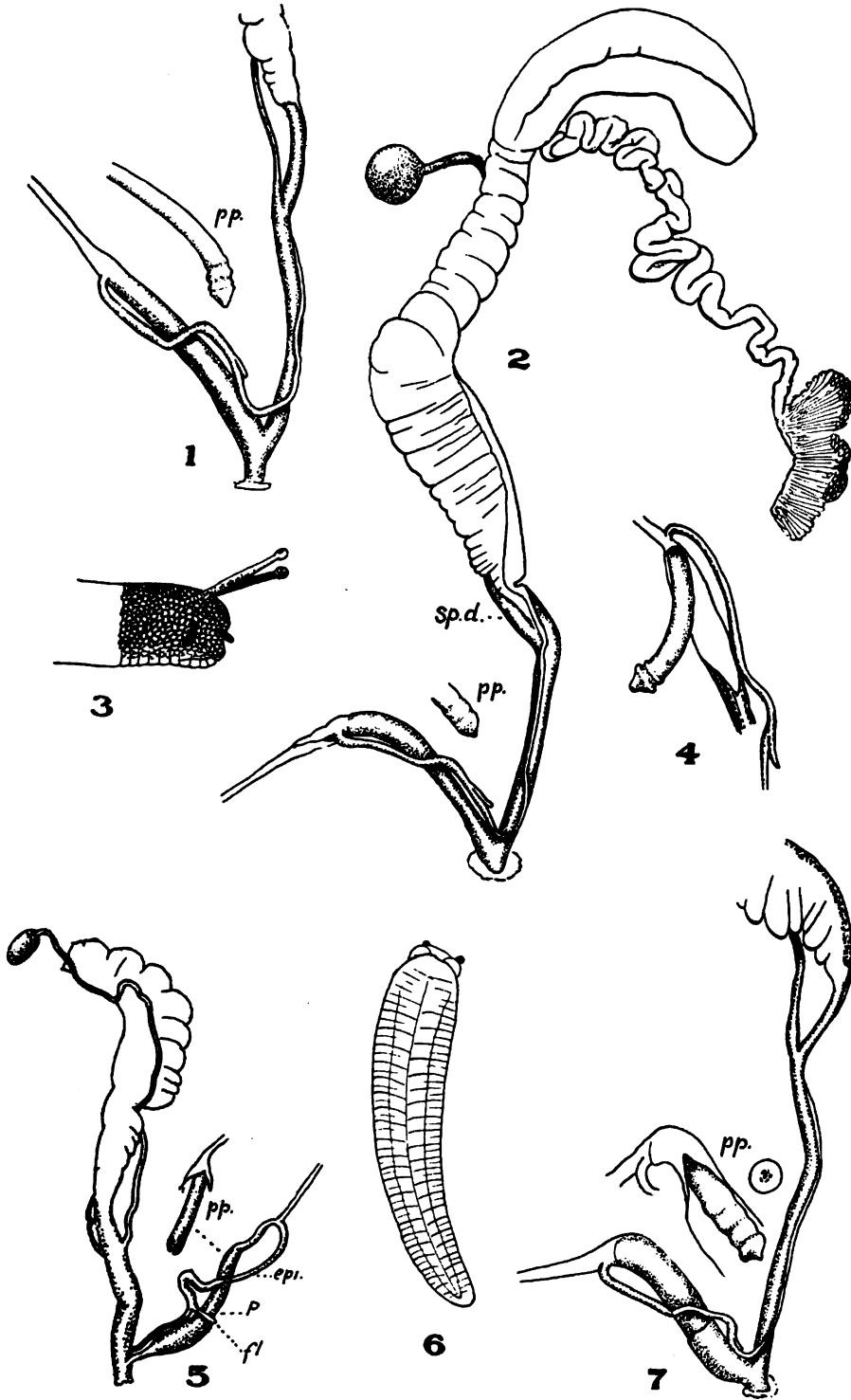


Fig. 177 (explanation on opposite page).

Genitalia (Fig. 177: 1, 2, 4, 7). Penis of moderate length, somewhat less than one-third the length of spermatheca and duct, with a long retractor muscle and a sheath around the basal third to half. The verge (*pp.*) is cylindrical, annulated distally, with conic tip. Epiphallus somewhat shorter than penis. Vagina generally not much longer than the penis. Sole (in alcohol) ochre or dirty white, uniform or with slightly darker sides. Back gray, the flanks and tail very pale.

Jaw with 6 to 8 ribs, grouped in the median half. Radula with 26,12,1,12,26 to 27,13,1,13,27 teeth, centrals and laterals without ectocones; some of the marginals with both cusps bifid.

ARIZONA: Dos Cabezas Mountains (a northwestern extension of the Chiricahua Range) (Ferriss & Pilsbry), Type 94328 A.N.S.P., from Buckeye Canyon; also found southeastward to Nine-mile Water-hole or "Creek".

This species has the same apical sculpture as *S. bowiensis* and *S. optata*. It differs from *optata* in the shape of the penis-papilla or verge, the presence of a flagellum, the shorter inner cusp of the marginal teeth, the larger aperture and narrower umbilicus. *S. hachitana* from the Big Hatchet Mountains has a decidedly smaller aperture. In shell characters *S. bicipitis* stands nearest *S. huachucana*, but the apical sculpture of the latter is much less distinct, without the oblique threads on the last embryonic whorl which are characteristic of *S. bicipitis* and related forms.

All of the radulae examined agree in having decidedly fewer teeth in a transverse row than *S. hachitana flora* or *S. optata*.

Figure	Penis	Verge	Epiphallus and flagellum	Flagellum	Vagina	Spermatheca and duct	Penis retractor	Diameter of shell	Museum No.
7	8	4.5	6.5	0.6	14.5	29	long	23	94.328
1	9.5	6	8	0.7	9.5	..	"	21	94.326
4	7	6	7	0.6	...	..	....	19	94.325
2	9	4.3	7	0.6	10	29	14	26	94.324

In the alcoholic specimen from Nine-mile, the sole is tripartite by faint longitudinal impressed lines, with a median groove due to partial folding of the foot. There are transverse lines as shown in Fig. 177: 6. In the specimens from other stations no longitudinal impressed lines could be traced on the sole.

In the type locality the diameter is from 18 to 24 mm. Other lots are within these dimensions except at Nine-mile Water-hole, where two larger adults were found, one measuring, height 15.3, diameter 26.3 mm.

It ranges throughout Buckeye and Happy Camp Canyons, and at Nine-mile Water-hole, living deep under stones and rocks. Buckeye Canyon is the first from the northern end of the range. Its upper branches drain the eastern flanks of Dos Cabezas Peak. The country rock of these canyons is

mainly metamorphic, but in part granitic. All the stations are on steep well-drained slopes facing northward, the earth very dry (in November), even under a couple of feet of rock, and scantily protected by low scrub oak brush. Nine-mile Water-hole is a shallow amphitheatre open eastward to the mesa, its slopes covered with great weathered boulders of coarse-grained light gray granite, among which ferns grow luxuriantly. A tiny stream trickles among the rocks, collecting into a stagnant pool at the base. A man can make his way in the interstices between and under the rocks, in some places, but as very few of them are movable it is almost impossible to obtain the shells.

(*Bicipitis*, of Dos Cabezas.)

Sonorella caerulifuminis Pilsbry & Ferriss

Fig. 178.

Sonorella caerulifuminis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila. for 1918, 70: 315, pl. 6, figs. 1-4; text-figs. 11, 12a.

The shell is depressed, umbilicate, the umbilicus contained about 8 times in the diameter; somewhat translucent, nearly isabella color, having a chestnut-brown band at the shoulder, showing above the suture on the penult and usually half of the next earlier whorl, and without white bordering bands, though the shell may be slightly paler there. It is somewhat

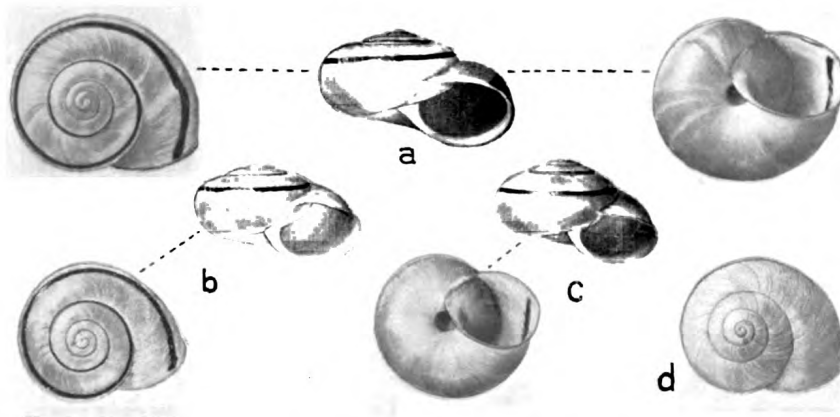


Fig. 178. *Sonorella caerulifuminis*. a, type; b, c, and d (an albino), Blue River, at mouth of Pigeon Creek.

translucent throughout. Surface glossy. Embryonic $1\frac{1}{2}$ whorls, at first with some radial ripples, then irregularly pitted-granulose, with weak uneven, mostly interrupted threads or stippling, never regular as in some others of the *S. hachitana* group. First post-embryonic whorl is weakly striate and minutely papillose; later whorls with sculpture of delicate, irregular growth-lines only. The whorls are moderately convex, the last

descending slowly in front. The aperture is rounded oval-lunate, large. Peristome expands a little and is dilated at the columellar insertion.

Height 14.6 mm., diameter 25 mm., aperture 12.3 x 14.6 mm.; $4\frac{1}{2}$ whorls.

The head and back are blackish brown, fading downward and backward to dark grayish brown, the tail paler. The sole has lateral bands somewhat darker than the central field (No. 119048).

Genitalia (Fig. 179) generally similar to *S. hachitana*. The penis is very slender, its retractor muscle longer; verge slender, smooth, with tapering end. A short flagellum is present. The epiphallus is nearly as long as the penis. The vagina is generally longer than the penis.

ARIZONA: Blue and San Francisco Rivers, Greenlee County (Ferriss), the Type 119048 A.N.S.P., from San Francisco River 6 miles above its confluence with the Blue River. Also from Ash Canyon, 6 miles above Clifton, to the mouth of Sardine Creek on the Blue River (Ferriss). The higher colonies are at little more than 4000 feet.

The size of the shell is rather variable, the extremes of diameter in a series from Station 17 being 20 and 24.6 mm. The largest specimen noticed measures 26.4 mm. An individual without a dark band is photographed in Fig. 178 d. It is from Station 19, Blue River, at the mouth of Pigeon Creek. Two other shells from this station are illustrated in Figs. 178 b and c.

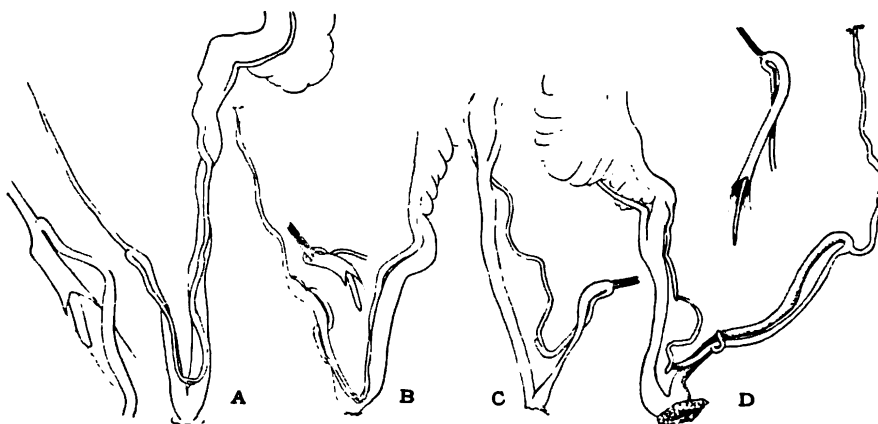


Fig. 179. Genitalia of *Sonorella caerulifuminis*.

While belonging to the group of *S. hachitana*, it differs from all New Mexican species by the absence of white bands bordering the shoulder-band, and of a white umbilical area, by the suture descending less deeply and not so abruptly in front; the umbilicus is smaller and the aperture decidedly larger. It is smaller than *S. galiurensis*, in the average, and the apical sculpture is more irregular, and the brown band is not white-bordered, but I doubt whether it is specifically distinct.

Measurements of genitalia of *S. caerulifuminis* from four localities:

Penis	8.5	7.5	7	12 mm.
Verge	3	3.5	4	11 mm.
Epiphallus	8	6	7	8.7 mm.
Flagellum	0.6	0.7	0.5	2 mm.
Retractor .....	...	...	10	13 mm.
Vagina	15	14	8	9.5 mm.
Museum No.	119.048	119.042	119.046	119.047

In one specimen dissected, Station 20 (fourth column of measurements, Fig. 179 D), the penis is about a third longer, the verge very long, three times the usual length or more. The flagellum also is much longer. Such differences would usually be thought specific, yet I have not found any differences in the shells from this locality.

(*Caerulifuminis*, of the Blue River.)

Sonorella ashmuni Bartsch

Fig. 180.

Sonorella ashmuni Bartsch, 1904, Smiths. Misc. Coll., 47: 190, pl. 31, fig. 5.

“Shell like *S. hachitana* Dall, but larger in every way. General coloration light isabelline above and whitish below; a broad chestnut band, bordered on each side by a light zone, encircles the whorls somewhat above the periphery and may be seen above the suture on all the ephobic whorls; the band gradually diminishes in breadth from the aperture toward the apex. The nepionic¹ stage embraces the first half turn, is somewhat flattened and slopes outward; it is marked by a few transverse wrinkles, and passes without distinct separation into the neanic stage, which is described in the definition of the group [marked by wrinkled growth lines over which pass threads obliquely downward and forward, etc.; *hachitana* sculpture]. The neanic¹ portion consists of 1¼ turns; its termination is marked by several strong transverse wrinkles. The ephobic stage consists of 3¼ moderately rounded, polished whorls which are marked by numerous lines of growth and here and there by a few obsolete, very distantly and irregularly scattered rounded papillae. Last whorl considerably deflected at the aperture, which is large and oblique and has the outer edge expanded and somewhat reflected; columella broadly expanded at base, reflected only slightly over the umbilicus, which is moderately large and open to the very apex; parietal wall covered by a thin callus. Alt. 16.9 mm., maj. lat. 28.2 mm., min. lat. 23.2 mm.; aperture 13 x 15.2 mm.; width of umbilicus about 4 mm.” (Bartsch.)

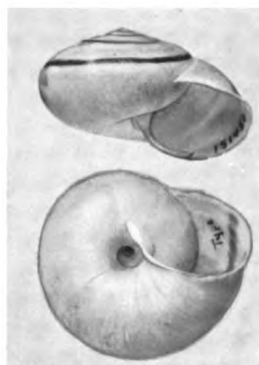


Fig. 180. *S. ashmuni*, type.

ARIZONA: Richinbar, about 30 miles southeast of Prescott, at 3500 feet (Rev. E. H. Ashmun), Type 151450 U.S.N.M. Also reported from Jerome (Ashmun).

¹ The terms nepionic and neanic, as used in this description, are together equivalent to what is called the embryonic stage in this work.

One of the largest sonorellas, with a rather thin and capacious shell. The anatomy is unknown. The type specimen scarcely shows the *hachitana* group sculpture at the apex, being slightly worn. I cannot see the papillae mentioned above as present on the post-embryonic whorls.

Sonorella ashmuni capax Pilsbry & Ferriss

Fig. 181.

Sonorella ashmuni capax Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 410, pl. 10, figs. 7-7b.

The shell is umbilicate, the umbilicus very narrow within, but in the last half-whorl widening to about three times its former width, oblong, contained about $7\frac{2}{3}$ times in the diameter of the shell. Avellaneous in color, paler around the umbilicus and slightly so on both sides of the chestnut-brown shoulder band. Surface glossy, lightly striate, the embryonic shell of $1\frac{2}{3}$ whorls with *S. hachitana* sculpture, of moderately spaced and irregular, forwardly descending threads, their intervals radially rugose. Whorls 5, slowly widening to the last, which is broad and capacious, rather steeply descending to the aperture. The aperture is very large, oblique, the peristome well expanded except near the upper termination; margins converging, joined by a thin callus.



Fig. 181. *Sonorella ashmuni capax*.

Height 16.3 mm., diameter 28.5 mm.; umbilicus 3.7 mm.; aperture 14.5 x 16.9 mm.

ARIZONA: Cobabi Mountains (about 75 miles west of Tucson) (Frank Cole). Type 112253 A.N.S.P.

This is one of the largest species, much resembling *S. ashmuni* Bartsch, from Richinbar, Yavapai County, which is thinner, a little less depressed, with a slightly smaller aperture. As the localities are about 150 miles apart and separated by the depression of the Gila River, the shells will probably turn out to be distinct when the genitalia of both are examined; but as no differences which can be depended on as specific appear in a comparison of the types, we rank the southern form as a subspecies. Some smaller shells down to 24 mm. diameter, found with the type of *capax*, may or may not be conspecific. They are much like a globose form of *S. ambigua* found in the Coyote Mountains (Fig. 228: 1).

Sonorella compar Pilsbry

Fig. 182.

Sonorella hachitana, specimens from Purtyman's, Oak Creek, Pilsbry, 1900, Proc. Acad. Nat. Sci. Phila., p. 557, pl. 21, figs. 1-5 (anatomy). Not *Epiphragmophora hachitana* Dall.

Sonorella hachitana ashmuni Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 259, pl. 17, figs. 9-14; pl. 20, fig. 15. Not *S. ashmuni* Bartsch.

Sonorella compar Pilsbry, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 296, footnote 3.

The shell is moderately depressed, umbilicus contained slightly more than 6 times in the diameter; very pale brown, fading to whitish around the umbilicus and on both sides of the chestnut-brown band. Whorls increasing slowly to the last which is much wider and descends rather steeply in front. Embryonic $1\frac{1}{2}$ whorls with the usual initial smooth stage, followed by papillae near the upper suture and forwardly descending threads over the rest of the whorl, or there may be ascending threads also in the upper zone, the intervals rather weakly rugose radially. The last whorl has weak wrinkles of growth and is rather glossy. The aperture is very shortly oval; peristome weakly expanding, with a dull brown edge in old shells, the thin parietal callus also with a rusty brown edge.

Height 13 mm., diameter 23.4 mm.; aperture 11 x 12.7 mm.; $4\frac{3}{4}$ whorls.



Fig. 182. *Sonorella compar*. Middle and left lower figures are three views of the type.

Genitalia (Fig. 183), with slender penis with terminal retractor embracing the base of the epiphallus; verge slender and tapering, flagellum minute (Fig. 183 b). Length of penis 10, verge 8, epiphallus 7, flagellum 0.7, vagina 8, spermatheca 35 mm.

Pallial tract: Lung reticulation almost wholly confined to the intestinal side, where the venation is transverse and branching. Cardiac side almost plain, with only a few faint branches, except toward the anterior extremity. Pulmonary vein simple and direct, with no large branches.

Kidney half the length of the lung, three times that of the pericardium, narrow and band-like. Ureter reflexed, as usual.

Jaw (183 c) with five or six strong ribs a little wider than their intervals, and grouped in the median portion, denticulating both margins.

Teeth 37, 1, 37; 13 laterals. Rachidian with the cusp shorter than the basal plate, laterals with it longer, the side cusps obsolete. Marginals with the cusps split.

Salivary glands long and irregular, con crescent above the crop by several bands and filaments; separate below. Crop long and tapering. Stomach thick. Folds of the intestine mostly exposed on the lower (inner) face of the left lobe of the liver, part of *G* 3 only immersed.

ARIZONA: Purtyman's Ranch, on Oak Creek, near the eastern edge of Yavapai County, about 40 miles from Jerome (E. H. Ashmun), Type and paratypes 80707 A.N.S.P.

This snail is remarkably similar to *S. hachitana*, with which it was formerly united, but the shell is a little less depressed and has a perceptibly larger aperture; the jaw has fewer ribs, and the penis and verge are somewhat longer. *S. ashmuni*, its nearest neighbor, is larger and more capacious, but until dissected nothing definite can be said of its relation to *compar*.

Three shells out of 350 collected by Mr. Ashmun lack the brown band. One of these is represented in the right hand figures.

A *Sonorella* which appears closely related to *S. compar* has been found in the Salt River Mountains 9 miles south of Phoenix, Arizona, at 800 feet (98313 A.N.S.P., received from Wm. G. Mazyck). The shells are smaller than *compar*, diameter 20.7 to 22 mm., with a somewhat narrower umbilicus. They are bleached and have lost the apical sculpture. These may be from the same lot noticed by Henry Prime (1882, *American Naturalist*, 16: 909) as *Ampelita rowelli* Newcomb.

(*Compar*, a companion, from its resemblance to *S. hachitana*.)

SONORELLA BINNEYI GROUP

The shell is generally more globose than in other groups, but in some species is of the usual depressed form; apical sculpture with diagonal threads more or less developed. Penis short, usually not far from half the shell diameter, the retractor inserted near base of epiphallus.

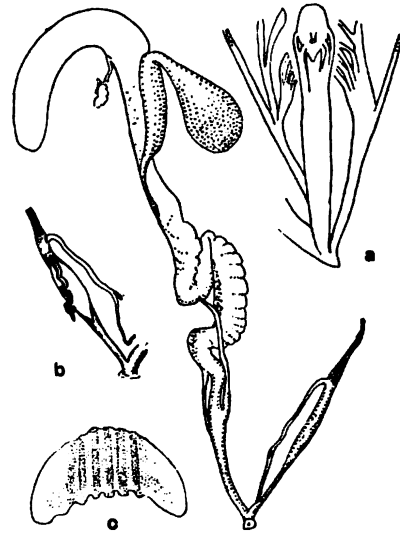


Fig. 183. *Sonorella compar*. a, free retractor muscles (diagrammatic); b, penis opened; c, jaw.

Sonorella bowiensis Pilsbry

Fig. 184.

Sonorella hachitana bowiensis Pils., 1905, Proc. Acad. Nat. Sci. Phila., p. 260, pl. 18, figs. 29-32; pl. 20, figs. 10, 11; pl. 23, fig. 22.

Sonorella bowiensis Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 65, pl. 1, figs. 13-16; pl. 4, fig. 6.

The shell is umbilicate, umbilicus contained nearly 6 times in the diameter; thin, somewhat transparent, pale corneous-brown becoming lighter almost corneous-whitish near the umbilicus. There are usually one or two obliquely radial whitish streaks on the last whorl. The chestnut band above the periphery is about one millimeter wide, is visible on $2\frac{1}{2}$ to 3 whorls, and has a very faint paler border below, hardly visible; no noticeable pale border above the band. Whorls $4\frac{1}{2}$, rather slowly widening to the

Fig. 184. *Sonorella bowiensis*.

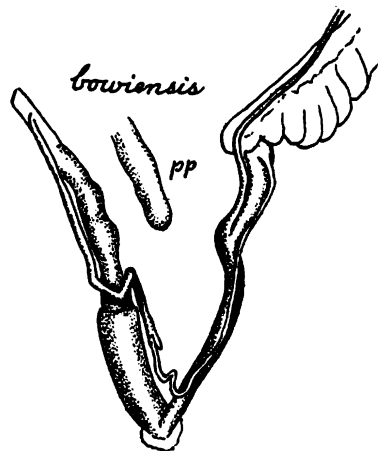
last, which is nearly double the width of the preceding, and well rounded peripherally. The embryonic shell consists of $1\frac{1}{2}$ whorls; the apex is smoothish; then a radially wrinkled area follows to the end of the first half whorl; the next whorl has forwardly descending delicate threads on its outer or peripheral half, the inner half being irregularly, shallowly pitted and roughened. The succeeding neanic whorls are lightly striate obliquely and very slightly, minutely roughened. The last whorl descends rather deeply in front. The aperture is very oblique, peristome expanded, the ends strongly converging, the columellar end dilated, slightly impinging on the umbilicus.

Height 9.7 mm., diameter 17.8 mm.; $4\frac{1}{2}$ whorls.

Genitalia (fig. 185). The well-developed penis has a long basal sheath, the lower part of the penis itself being quite slender. The verge is cylindrical, somewhat more than one-third the length of the penis, with a blunt, rounded end. The penis retractor is long. The organs measure as follows: length of penis 12 mm.; of verge 4.4 mm.; epiphallus and flagellum 12; flagellum 0.6; vagina 10; spermatheca and duct 21.5 mm. The atrium is extremely short.

The jaw has four low, wide, unequal ribs and some minor riblets.

The living animal is slate color on head and back, sides of foot pale blue, borders of the foot orange; liver brown. In alcohol the back is slate,

Fig. 185. *S. bowiensis*.

sides, tail and sole whitish. The sole has slightly darker lateral areas marked off with faint grooves. The crop is long and smooth.

ARIZONA: Chiricahua Mountains, on "Quartzite Hill," back of Dixon's place, about a mile south of Old Fort Bowie (Ferriss and Pilsbry), Type 86497 A.N.S.P.

S. bowiensis differs from *S. bicipitis* by its smaller size and the faintness or absence of white bands bordering the chestnut zone; the embryonic sculpture is like that of *S. bicipitis*, but the spirally protractive threads are more numerous and closer. In anatomy it differs by the rounded end of the verge and the actually and comparatively longer penis, over half the length of spermatheca and duct, though the shell is smaller. *S. binneyi* differs from *S. bowiensis* by the very much smaller penis, only half the length of that of *S. bowiensis* in a larger shell; by the different shape of the verge, and the absence or very minute size of the flagellum. The shell also is invariably larger than *S. bowiensis*.

In a lot of 69 which I collected in 1906, the diameter ranges from 15 to 18 mm., 84 per cent of the shells from 16 to 17 mm. The smaller shells have $4\frac{3}{4}$ whorls.

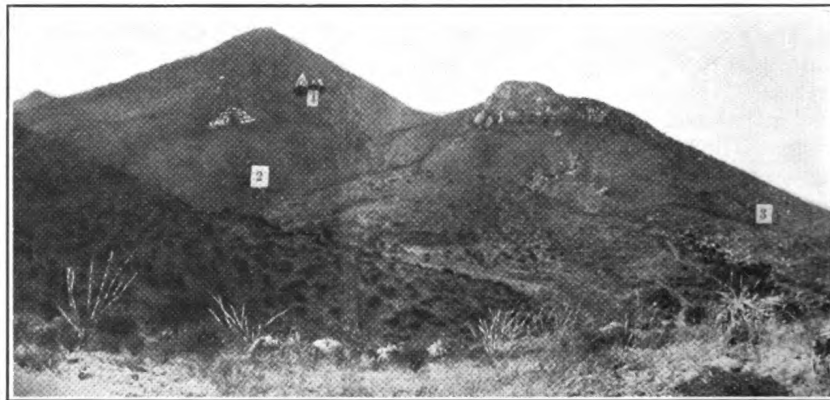


Fig. 186. Quartzite Peak and Bull Hill, from the ridge on east side of the creek, looking across Dixon's place, showing type localities of *Sonorella bowiensis* and *Ashmunella proxima* (1), and *Holospira cionella* (2); at (3) another colony of *H. cionella*.

Sonorella bowiensis was found only in one colony very limited in extent but prolific in individuals, but it may be expected to occur on Bowie Mt. and Helen's Dome, which have not been explored. The type colony, on a northeastern slope, is in a small thicket of long-leaved scrub-oaks with some underbrush of service berries (*Amelanchier* sp.) under a low cliff, somewhat more than half way to the summit of Quartzite Hill, back of Dixon's place, shown at (1) in the photographic reproduction above. The snails were under small stones and dead leaves.

Sonorella tryoniana Pilsbry & Ferriss

Fig. 187, upper figs.

Sonorella rowelli (Newc.), Pilsbry, 1902, Nautilus, 16: 32; 1903, Proc. Acad. Nat. Sci. Phila. for 1902, p. 511; 1905, Proc. Acad. Nat. Sci. Phila., p. 261, pl. 18, figs. 33-35; pl. 20, figs. 13, 14, 20; pl. 22, fig. 18. Not *Helix rowelli* Newcomb.

Sonorella tryoniana Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 86, pl. 8, fig. 6.

The shell is moderately depressed; umbilicus contained $6\frac{1}{3}$ to $6\frac{2}{3}$ times in the diameter; pale brown, subtranslucent, fading to whitish around the umbilicus, at the apex and in narrow belts on both sides of the chestnut-brown suprapерipheral band. The surface is glossy, embryonic whorls radially weakly wrinkled after the smooth apex; later whorls with fine, delicate growth lines only. The whorls increase slowly to the last which is very wide, and descends slowly in front. The aperture approaches

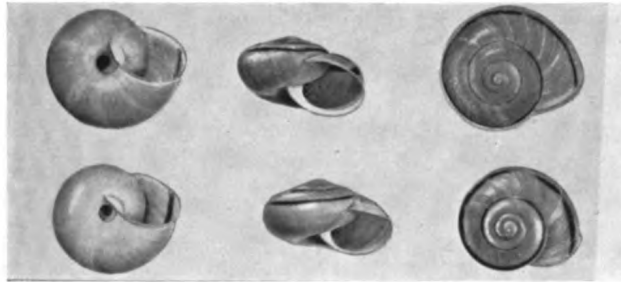


Fig. 187. Upper: *Sonorella tryoniana*. Lower: *S. imperatrix*.

circular; peristome narrowly expanded in outer and upper margins, rather widely so at base, dilated a little over the umbilicus. Parietal callus thin.

Height 9.8 mm., diameter 17.4 mm.; aperture 8.8 x 9.7 mm.; $4\frac{1}{2}$ whorls.

Height 9.4 mm., diameter 16.8 mm. Paratype.

Height 8.4 mm., diameter 14.4 mm.; $4\frac{1}{4}$ whorls. Patagonia Mts.

Genitalia (188 a). The penis is short, containing a short, cylindric, obtuse verge. The free portion of the epiphallus is about equal to the penis in length. The flagellum is reduced to a mere tubercle. The vagina is about as long as the penis, and the spermatheca and its duct are about four times as long.

The jaw has 6 or 7 narrow ribs.

The radula has 41.144 teeth, like those of *S. granulatissima*. The eleventh and twelfth are transitional.

ARIZONA: Sanford, Santa Cruz County, on the bank of Sonoita Creek under leaves and logs, near the water (Ferriss), Type 83273 A.N.S.P. Also eastward in the northern end of the Patagonia Mountains (Ferriss and Ashmun).

The aperture is larger and the umbilicus smaller than in *S. bowiensis*. Both penis and vagina are decidedly shorter, though their proportionate

lengths do not differ materially. Both species have the verge short and obtuse; but in *S. tryoniana* the flagellum is reduced to a minute vestige, or in a specimen from the Patagonia Mountains, it is wholly wanting.

In the Patagonia Mountains, 6 or 8 miles eastward from Sanford, the species was collected by Mr. Ferriss, and also by Mr. Ashmun. The shells are smaller, 13.4 to 15.7 mm. in diameter.

(Named for George W. Tryon, Jr.)

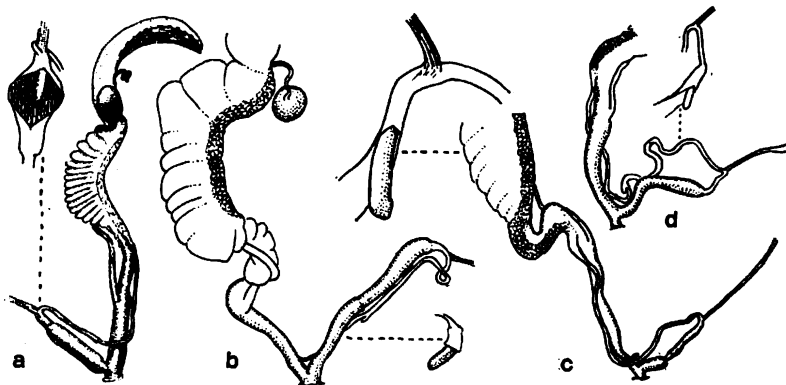


Fig. 188. a, *Sonorella tryoniana*. b, *S. binneyi imperialis*. c, *S. delicata*. d, *S. franciscana*.

***Sonorella imperatrix* new species**

Fig. 187, lower figs.

Sonorella tryoniana, specimens from the Empire Mts., Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 86, pl. 8, fig. 6.

The size and figure are almost exactly as in *S. tryoniana*, but the aperture is not quite so round, and the last half whorl of the embryonic shell has very close radial wrinkles between rather widely spaced obliquely spiral threads, which trend upward over most of the surface, downward near the lower (outer) suture. This sculpture, quite distinct in adult fresh shells, is much like that of *S. binneyi imperialis* of the same mountains, and quite unlike the obsolescent embryonic sculpture of *S. tryoniana*. The umbilicus is relatively wider than in *S. baboquivariensis depressa*, the aperture is smaller, the apical sculpture more pronounced. The shell resembles *S. binneyi imperialis* in color and texture, but it is smaller, the last whorl is not so wide, the umbilicus is decidedly larger (contained $6\frac{1}{2}$ times in the diameter), and the aperture is relatively smaller, though of similar shape. Surface very glossy, lightly striate, without spiral lines or granulation.

Height 9.3 mm., diameter 15.9 mm.; aperture 8.3 x 9.3 mm.; $4\frac{1}{2}$ whorls.

A specimen received dry and soaked up gave the measurements: length of penis 3.5, verge 1.5, vagina 4 mm. The verge is cylindric, with blunt, rounded end.

ARIZONA: Empire Mountains (J. H. Ferriss), the Type, 143829 A.N.S.P., from north side of a large peak $1\frac{1}{2}$ miles north of the Total Wreck mine.

Most of the shells taken were dead. The extremes of diameter are 15 and 16.4 mm. In about 100 shells of *S. b. imperialis* from different places in the Empire range, none approaching this species were found. The former reference to *S. tryoniana* was certainly wrong, though the superficial similarity is great.

S. imperatrix resembles *S. tumamocensis* rather closely, but it differs by having the columellar end of the lip carried forward in the manner of *S. b. imperialis*; also the apical sculpture is somewhat more distinctly developed.

(*Imperatrix*, empress, from its occurrence in the Empire Range.)

Sonorella xanthenes Pilsbry & Ferriss

Fig. 189.

Sonorella xanthenes Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 72, pl. 1, fig. 13; pl. 7, fig. 11.

The shell is rather thin, has a moderately raised spire and rather small umbilicus contained about $8\frac{3}{4}$ times in the diameter; it is dilute cinnamon-buff, paler on the base, with a narrow chestnut-brown band above the periphery. Surface smooth except for light growth lines, having little gloss. The first half whorl has radial ripples; remainder of the embryonic shell with radial wrinkling very weak or subobsolete; no descending spiral threads seen. The last whorl descends moderately in front. The peristome is thin, narrowly expanded, dilated at the columellar insertion and impinging slightly on the umbilicus. Parietal callus very thin.

Height 8.5 mm., diameter 13.6 mm.; $4\frac{1}{4}$ whorls. Type. Largest shell 16 mm. diameter; smallest 7.5 x 13 mm.

The penis contains a relatively long, smooth, slightly tapering verge, acute at the end. The epiphallus is very slender, much longer than the penis, is a little swollen near the end and bears no flagellum. The penial retractor inserts on the epiphallus some distance from the penis. The vagina is decidedly shorter than the penis. Length of penis 4.7 mm., verge 3 mm., epiphallus 8 mm., vagina 2 mm.

ARIZONA: Near the top of Kitt's Peak, Pima County, in a humid situation at foot of cliffs near the head of stream, under scattered rocks among sticks and leaves in oak brush, elevation about 5500 feet (J. H. Ferriss, 1918), Type 118094 A.N.S.P.

This is one of the smallest species of *Sonorella*, about the size of the smallest specimens of *S. coloradoensis*. It differs from the latter in the slender, acute verge and long epiphallus, among other characters. *S. sitiens*, *S. tumamocensis* and *S. arida* differ from *xanthenes* by the larger umbilicus. The aperture of this snail is shaped much as in the *binneyi* group, but the verge and the embryonic sculpture differ. Its affinities are doubtful. The locality is at the northern end of the Baboquivari Range.

(*Xanthenes*, a precious stone of an amber color.)



Fig. 189. *Sonorella xanthenes*.

Sonorella animasensis new species

Figs. 190, 191.

The shell is umbilicate, umbilicus contained about 7 times in the diameter; thin but moderately strong, dilute cinnamon-buff, fading to whitish on the base, having above the periphery a carob brown band with very inconspicuous or hardly noticeable light borders. Surface somewhat glossy,

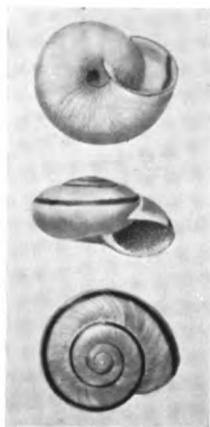


Fig. 190. *Sonorella animasensis*.

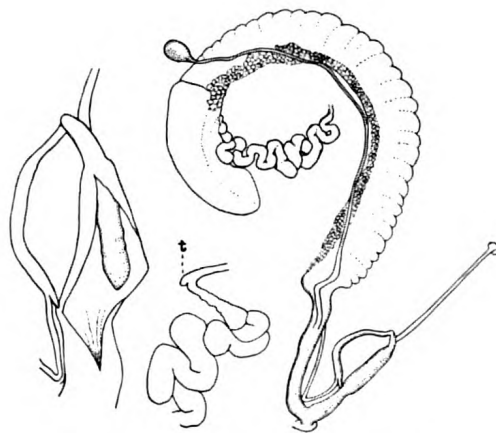


Fig. 191. Genitalia of same. t, talon.

the first $1\frac{1}{2}$ whorls papillose near the suture and covered with a close pattern of minute wrinkles with some short, spirally ascending threads, chiefly in the peripheral portion. In some shells some fine wrinkling and papillae can be seen as far as the third whorl. Last whorl moderately descending in front, lightly marked with lines of growth. The aperture is shortly oval; the peristome very slightly expanded with a yellowish edge. Parietal callus thin, short, yellow-edged in old shells.

Height 11 mm., diameter 18.9 mm., aperture 8.7 x 10 mm.; $4\frac{1}{2}$ whorls.

Genitalia (Fig. 191) with penis length about one-fourth the diameter of shell, containing a cylindric verge about half as long as the penis, with conic end. Epiphallus about equal to penis in length, the penial retractor inserted on it. Flagellum minute. Hermaphrodite duct of unusually large size, strongly convoluted. Talon (t) minute, 0.12 mm. long, buried in albumen gland. The jaw has 8 unequal, irregularly spaced ribs.

NEW MEXICO: Animas Range, Hidalgo County, above Black Bill Spring (Pilsbry and Cyril H. Harvey), Type and paratype 166153 A.N.S.P.

The smallest adult measures 17 mm. in diameter. The sculpture of the embryonic shell is more pronounced than in related species. By the shape of the verge it resembles *S. delicata* P. & F., but that species has a larger aperture and nearly smooth embryonic shell, and it differs in measurements of the genitalia.

It occurs in deciduous forest on the steep sides of the canyon above the spring, under volcanic rock (andesite?), at from 6500 to 7000 feet, the forest above that being pine.

Sonorella delicata Pilsbry & Ferriss

Fig. 192.

Sonorella delicata Pilsbry & Ferriss, 1918, Proc. Acad. Nat. Sci. Phila., 70: 314, pl. 6, figs. 6-6b, text-fig. 10.

The shell is umbilicate (umbilicus contained seven times in diameter of shell), thin, somewhat translucent, light ochraceous-buff with several pale or whitish oblique streaks on the last whorl, and a cinnamon-brown band above the periphery. Glossy, having the usual weak irregular growth-lines. The embryonic whorls are nearly smooth, but short, protractive



Fig. 192. *Sonorella delicata*.

threads may be seen near the suture. The last whorl is wide and descends rather slowly in front. The aperture is strongly oblique, rounded-oval. Peristome thin, expanded, with a dull brown edge.

Height 10.5 mm., diameter 18.3 mm.; $4\frac{1}{2}$ whorls.

Genitalia (Fig. 188 c) remarkable for the small size of the male organs. The length of penis is about one-fifth the diameter of the shell, very slender, having a stout basal sheath, and containing a short, cylindric verge. The epiphallus is longer than the penis, terminating in a short flagellum. Length of penis 3.5 mm., verge 1.2 mm., epiphallus 4.5 mm., flagellum 0.4 mm., vagina 5.5 mm.

ARIZONA: Northern end of the Peloncillo Range, about 6 miles south of the Gila River, on the road between Solomonsville and Clifton, Graham County, in a "malpais" rock slide, about 4,800 feet elevation (J. H. Ferriss), Type 109110 A.N.S.P.

The shell recalls *S. bowiensis* Pils., differing by the wider last whorl, smaller aperture and somewhat smaller umbilicus; also much less distinct sculpture of the embryonic whorls. By the decidedly larger umbilicus and smaller aperture it differs from *S. binneyi franciscana*. The genitalia, examined in several individuals, differ by the very small size of the male organs, relatively even smaller than in *S. hachitana* and its immediate relatives. It differs from these by the cylindric verge with bluntly conic end. The genitalia of *S. walkeri* P. & F., of the Santa Ritas, have considerable similarity.

The living animal has an odor like *S. odorata* in the Santa Catalinas.
(*Delicatus*, dainty, delicate.)

Sonorella binneyi Pilsbry & Ferriss

Fig. 193.

Sonorella binneyi Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 68, pl. 2, figs. 13-18; pl. 3, fig. 5.

The shell is depressed globose, narrowly umbilicate, umbilicus contained about $10\frac{1}{2}$ times in the diameter; quite thin but moderately strong; pale brown with some whitish oblique streaks, and fading to opaque white around the umbilicus, encircled with a narrow chestnut band at the shoulder, narrowly showing above the suture on the penultimate whorl. Surface slightly shining, marked with fine, rather sharp growth-striae. Whorls $4\frac{1}{2}$, convex, the first minutely roughened radially, and with widely spaced oblique threads on the second half whorl (obsolete in adult shells). The last whorl is very wide (viewed from above), inflated, rounded peripherally, very convex beneath. It descends in front. The aperture is very large, strongly oblique, elliptical, the ends of the lip converging. Peristome thin, very slightly expanded throughout, dilated at the columellar insertion.

Height 12.8 mm., diameter 20.2 mm., aperture 12.8 x 11.2; width of umbilicus 1.9 mm.

Height 9 mm., diameter 13.3 mm.; smallest shell seen.



Fig. 193. *Sonorella binneyi*; left figure the type.

The genitalia (Fig. 177: 5). The penis is somewhat longer than the vagina. It contracts into a narrow neck at the base, and contains a cylindrical verge (*pp*), obtuse at the free end, and from one-sixth to about one-third the length of the penis. Penial retractor inserted on the epiphallus about 2.3 mm. beyond apex of penis. Epiphallus not very unlike the penis in length. Flagellum as usual in the genus. The vagina is short. Spermatheca oval, on a long duct. Length of penis 8, verge 3, epiphallus 9, flagellum 1, vagina 6, spermatheca 22 mm. In another the lengths are: penis 11.5, verge 2.5, epiphallus 8 mm.

The jaw has five ribs. The pericardium is about half as long as the kidney.

ARIZONA: Southeastern Chiricahua Mountains, in Horseshoe Canyon about two miles up, type location, and near the "red box" (J. H. Ferriss). Type 99793 A.N.S.P.

The aperture is smaller than in *S. baboquivariensis*, and the margins of the lip are not carried so far forward. There are also anatomical differences. In its soft anatomy this species resembles *S. bowiensis* and *S. tryoniana*, but differs from the latter by having a distinct flagellum. The shell is more like *S. tryoniana*, but differs from both species by its more inflated contour, very large aperture and smaller umbilicus. In conchological characters the species is, for a *Sonorella*, very distinct, and unlike other known Chiricahuan snails. Its localities are between 5000 and 5500 feet.

(Named in memory of William G. Binney.)

Sonorella binneyi franciscana Pilsbry & Ferriss

Fig. 194.

Sonorella binneyi franciscana Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila. for 1918, p. 318, pl. 6, figs. 5-5b; text-fig. 12b.



Fig. 194. *Sonorella binneyi franciscana*.

The shell is noticeably more depressed than *S. binneyi*, the umbilicus somewhat wider, contained 8 to 8½ times in the diameter. The second half of the embryonic shell has similar close radial wrinkles between widely spaced spirally descending threads (weak or wanting on most adult shells).

Height 12.1 mm., diameter 19.6 mm.; 4½ whorls. Type.

Height 10 mm., diameter 17.1 mm.; 4 whorls. Smallest shell.

The head and back are dark grayish brown shading into dark vinaceous drab downward and backward, the tail light colored.

Genitalia (Fig. 188 d). The penis contains a cylindrical verge with blunt, rounded end. The epiphallus is about twice as long as the penis, and bears a small flagellum. The penial retractor inserts on the epiphallus some distance above the penis. The vagina is nearly or about as long as the penis. Measurements of 3 individuals follow:

Length of penis	5	6	7 mm.
Length of verge	2	2.3	3.5 mm.
Length of epiphallus	10.5	10	10.5 mm.
Length of flagellum	0.5	0.7	....
Length of vagina	4.7	5	5.5 mm.

ARIZONA: Along the east side of San Francisco River, from about 2 miles above the Harper ranch to above the entrance of Sardine Creek (J. H. Ferriss), Type 119052 A.N.S.P.

Perhaps too much like *binneyi* for subspecific distinction, but the localities of this race lie about 100 miles north of the *binneyi* area, much of the intervening country being desert wholly barren of snails. The localities are not far from the 4000-foot contour.

Sonorella binneyi imperialis Pilsbry & Ferriss

Fig. 195: 12.

Sonorella binneyi imperialis Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 85, pl. 2, fig. 12; pl. 7, fig. 1.

The shell is decidedly more depressed than *S. binneyi*, narrowly umbilicate, umbilicus about ten times in the diameter, thin, dilute cinnamon above, shading into white beneath, with a chestnut-brown band rather indistinctly whitish-bordered. There are some narrow whitish growth-rest

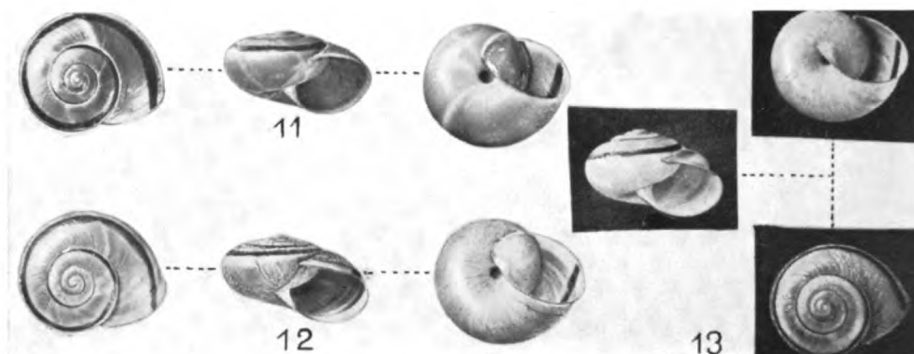


Fig. 195. 11, *Sonorella baboquivariensis depressa*, Tucson Range. 12, *S. binneyi imperialis*. 13, *S. baboquivariensis berryi*.

streaks. Surface glossy, with light, fine growth lines. Embryonic shell, after the smooth initial part, radially anastomosing-crinkled, then with slowly protractive threads over fine radial crinkling, and on the last part of the first whorl, retractive threads. The spire is small. The last whorl increases very rapidly and is unusually wide, as viewed from above. In front it descends a little and slowly. The aperture is large, its width decidedly more than half the diameter. Lip thin, very slightly expanded, outwardly and basally, dilated at the columellar insertion, partly covering the umbilicus.

Height 11.3 mm., diameter 19.5 mm.; $4\frac{1}{2}$ whorls.

ARIZONA: Empire Mountains, southeastern part of Pima County (Ferriss), Type 131000 A.N.S.P.

S. b. imperialis, lives about 90 miles northwest of the locality of *S. binneyi*, several intervening ranges which we have explored being without species of this group. The few living ones and numerous "bones" show very little variation in size, nearly all being from 19 to 20 mm. in diameter. It has a more depressed shell than *S. binneyi*, and the verge is slightly thicker. Genitalia are drawn in Figure 188 b.

(Named for its occurrence in the Empire Range.)

Sonorella baboquivariensis Pilsbry & Ferriss

Fig. 196.

Sonorella baboquivariensis Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 415, pl. 10, figs. 1-2b; pl. 13, fig. 1; 1923, Proc. Acad. Nat. Sci. Phila., 75: 81, pl. 2, figs. 9, 10; pl. 7, figs. 2, 3, 12, 13.

The shell is very narrowly umbilicate, umbilicus contained about 14 to 15 times in the diameter; globose-depressed, thin, glossy, cinnamon or sayal brown, fading or whitish around the umbilicus and on both sides of the broad chestnut-brown shoulder band. First third of a whorl smooth, the following whorl with sculpture of irregular radial wrinkles, over which run spiral, slowly descending, irregular or interrupted threads; later whorls marked with fine growth lines as usual. Whorls $4\frac{1}{2}$, the last very wide, its last fourth slowly and rather deeply descending. The aperture is very large, strongly oblique. Peristome narrowly expanding throughout, the



Fig. 196. *Sonorella baboquivariensis*. Upper, type and paratypes; lower, Oro Fino Canyon.

columellar margin brown-edged, broadly dilated and reflexed half over the umbilicus, its upper and lower margins carried forward. The parietal callus has an opaque, pale brown edge.

Height 13.3 mm., diameter 21.3 mm.; aperture 12.1 x 14 mm.

Genitalia (Fig. 197 a, b, c). The penis is long, the distal fourth enlarged, the rest slender. The basal third or less is sheathed, the sheath composed of firm, circular muscles. The verge (Fig. 197 a) is cylindrical, with a conic, glandiform end. The retractor muscle is inserted on the epiphallus, which is nearly as long as the penis, and bears a short flagellum. The vagina is about three-fourths as long as the penis. Length of penis 12, verge 3, epiphallus 11, flagellum 0.75, vagina 9 mm., diameter shell 21 mm. Another specimen: penis 10, verge 2.7, epiphallus 8.5, flagellum 0.75, vagina 8.2 mm., diameter of shell 19 mm.

ARIZONA: Eastern slope of the Baboquivari Mountains, Pima County, from Oro Fino Canyon north to the rincon between the Baboquivari and the Coyote Mountains; Type 111549 A.N.S.P., from ridge at head of Thomas Canyon about half a mile south of Baboquivari Peak (Pilsbry and Daniels). A variety in the Sierrita Mountains.

This is the common species of the Baboquivaris throughout the part of the range which we explored. It is distinguished by having a larger aperture than any other *Sonorella* known. The rather long penis with a strong basal sheath and a verge of characteristic shape are diagnostic of the soft anatomy, and confirmed in a number of individuals from several stations.

In Oro Fino Canyon it was taken at the foot of the cliffs on north side of Mount Mildred, a conspicuous butte at the southern side of the mouth of the canyon; the shells are small, 16.8 to 18 mm. in diameter (Fig. 196, below), the genitalia typical but small (Fig. 197 c, verge). Equally small shells were collected in many places, often without ecologic conditions obviously differing from places where larger shells occurred, the diameters for two such lots being respectively 16.5 to 18.5 mm., and 18 to 23 mm.

A form of *S. baboquivariensis* was taken at Station 117 (1918), in the rincon of Chief Pablo, in the cliffs of the creek near a cow camp, formerly the Sycamore Forest Ranger station. The shells vary in size from 16.4 to 20.7 mm. diameter. There are 5 instead of 4½ whorls. The umbilicus is generally slightly wider than in typical *S. baboquivariensis*, but there is no constant difference.

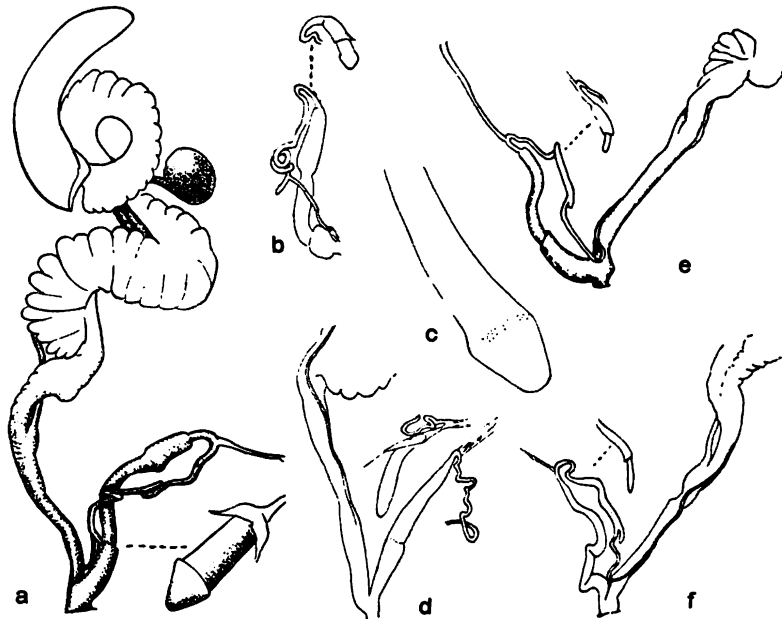


Fig. 197. a, *S. baboquivariensis*, type; b, Sycamore Canyon; c, Mt. Mildred, verge; d, var. from rincon of Chief Pablo. e, *S. b. depressa*, Tucson Range; f, Sycamore Canyon.

The genitalia (Fig. 197 d) differ chiefly by the absence of an enlargement of the end of the verge, which is rather thick as in *baboquivariensis*, but slightly longer. The verge is shaped as in *S. b. depressa* but is much larger, especially thicker. The epiphallus is very slender and long, but was not gotten out entire, the specimens being very hard. Vagina is short. Three specimens of no. 118085 were dissected. The organs of two measure: length of penis 6.2, verge 4.3, vagina 3.7 mm.; and penis 6, verge 4, vagina 5 mm.

Sonorella baboquivariensis berryi Pilsbry & Ferriss Figs. 195: 13; 198.

Sonorella berryi Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 86, pl. 2, fig. 13; pl. 5, fig. 11.

The shell is depressed-globose, thin, narrowly and half-covered umbilicate, translucent, white, with a chestnut-brown band above the periphery and narrowly showing on the penult whorl, and a pinkish-buff band below the suture, spreading nearly half way to the chestnut band. Surface rather



Fig. 198. *Sonorella baboquivariensis berryi*, type.

glossy, smooth except for very fine growth lines. Embryonic shell smooth at the tip, then finely radially rugose towards the end of the first whorl (showing a few widely spaced protractive threads in some, especially young, examples). The last whorl is very wide and descends a little and slowly in front. The aperture is very large. Peristome thin, expanded, reflected half over the umbilicus. Parietal callus thin.

Height 12.3 mm., diameter 18.3 mm.; aperture 11 x 12.3 mm.; 4½ whorls. Type.

Genitalia as in *S. binneyi* P. & F., so far as can be judged from a dried specimen, soaked up. Length of penis 6.7 mm.; length of papilla 2.5 mm.; length of vagina 7.5 mm.

ARIZONA: East side of the Roskrige Range in malpais slides on a small hill north of the road, near the forks (J. H. Ferriss), Type 131001 A.N.S.P.

The largest and smallest shells measure 15.7 and 19.4 mm. in diameter, most of the lot being between 17 and 18 mm. No material variation in color was noted in about 60 living specimens collected.

It is similar in form and very small umbilicus to *S. baboquivariensis* but differs in coloration; the margins of the lip are not carried so far forward as in typical *baboquivariensis*. It differs from *S. b. depressa* by its color, the less depressed shape and smaller umbilicus. In the genitalia it resembles *S. binneyi franciscana* in having the epiphallus longer than in Tucson

Range specimens of *depressa*. Unfortunately the single animal saved became dry and had to be soaked up, hence the measurements may require revision when fresh ones are obtained.

The Roskrige Mountains lie north of the Baboquivaris, the Coyote Range between them. The great uniformity of this race, and absence of intermediate specimens caused us to give specific rank, but it may better be regarded as a local race of the widely spread *baboquivariensis* circle.

(Named for Dr. S. Stillman Berry.)

***Sonorella baboquivariensis depressa* Pilsby & Ferriss** Figs. 195: 11; 199.

Sonorella baboquivariensis depressa Pilsby & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 417, pl. 10, figs. 3-3b; 1923, Proc. Acad. Nat. Sci. Phila., p. 82, pl. 2, fig. 11; pl. 7, figs. 4, 5, 7-10.



Fig. 199. *Sonorella baboquivariensis depressa*, type.

The shell is more depressed than typical *S. baboquivariensis*, with the aperture smaller and the umbilicus decidedly wider, contained 8 times in the diameter.

Height 10 mm., diameter 17.8 mm.; aperture 9.6 x 10.7 mm.; $4\frac{1}{2}$ whorls.

In all of the lots dissected the verge differs from that of typical *baboquivariensis* by its far more slender shape, with a bluntly tapering end, not at all enlarged and glandiform as it is in *baboquivariensis*. This may indicate that the form defined as *depressa* is specifically distinct; yet as the shell characters appear to intergrade, we leave this form as a subspecies (Fig. 197 f, Type, 197 e, Tucson Range). Measurements of the genitalia in mm. follow:

	Baboquivari Mountains				Tucson Mountains	
Penis	7	6	5	8	7.3	8
Verge	3.3	3	2	3.5	2	3
Epiphallus	7	7.3	6	9	8	7.5
Flagellum	long	2	..	1	..	..
Vagina	8	6.5	5	..	6.7	5

ARIZONA: Baboquivari Mountains, in upper Sycamore Canyon and Otero Canyon (Pilsbry), Type 111559 A.N.S.P. Also in the Tucson Range, and a form in the Sierrita Mountains (Ferriss).

In the Sierrita Mountains collections were made in a canyon facing east, at about 4500 feet, and on the south side of a mountain facing Harris ranch, at about 6000 feet more or less. The shells resemble *baboquivariensis* in some examples, *depressa* in others, the umbilicus being somewhat variable; but the genitalia, particularly the form of the slender verge, are identical with *depressa* in two dissected. Length of penis 6.3, verge 1.7, epiphallus 8, flagellum 1, vagina 7 mm.

In the Tucson Range (Fig. 195: 11) this race was found in three collecting stations, the shells not materially differing from those of the Baboquivaris. Genitalia (Fig. 197 e) characterized by the rather slender penis with stout basal sheath, and containing a rather short, smooth, slender, blunt-ended verge, contained 3 times, more or less, in the length of penis. Flagellum short. The vagina is slightly shorter than the penis in specimens dissected.

The question arises whether *depressa* is really distinct from *S. binneyi imperialis*. The shells look much alike. It is a case for further consideration; but I am disposed to retain them apart for the present. On comparing numerous specimens it appears that the embryonic shell of *imperialis* has distinct, forwardly descending threads on the outer part of the embryonic whorl, ascending threads on the inner part, the two series meeting <-like near the middle. *S. b. depressa* has some irregular forwardly descending threads, but above them no regular ascending series, that being replaced by long tubercles, spirally arranged, or often subobsolete.

(*Depressus*, flattened down.)

Sonorella arizcnensis (Dall)

Fig. 200.

Epiphragmophora arizonensis Dall, 1895, Proc. U. S. Nat. Mus., 18: 1; 1896, Proc. U. S. Nat. Mus., 19: 337-339, pl. 31, figs. 11, 12.

Sonorella arizonensis (Dall), Bartsch, 1904, Smiths. Misc. Coll., 47: 198, pl. 33, fig. 6.



Fig. 200. *Sonorella arizonensis*, type.

"Shell small, moderately elevated; light brown, with a narrow brown band just above the periphery, mostly concealed by the suture, but visible internally in the aperture on the outer side; whorls four and a half, of which one and a half are nepionic and punctate, the remainder with rather well-marked incremental lines and microscopic vermicular markings, of which the longer axes are subparallel to the lines of growth; suture distinct, whorls full and rounded, but with the periphery slightly above the middle, the last whorl descending a little near the aperture; base full and rounded; umbilicus narrow, deep; aperture expanded, the pillar lip reflected, but the outer lip not so." (Dall.)

"Height 11.3 mm., greater diameter 17.2 mm., lesser 14.1 mm.; aperture 8.6 x 9.5 mm.; umbilicus about 1.7 mm." (Bartsch.)

ARIZONA: Banks of the Santa Cruz River, near Tucson (Maj. E. A. Mearns, U. S. A.), Type 130002 U.S.N.M.

The type is a bleached specimen which no doubt drifted down the Santa Cruz River from above. As no *Sonorella* lives at or near the river level, it must have been washed down from some mountain or rocky hill in the river valley, where it will eventually be found again. Great quantities of the drift débris of the Santa Cruz which Ferriss and the author looked over did not produce another specimen, though minute shells were abundant. It is a lost species.

As Bartsch has stated, "the nuclear whorls of the type and only specimen are too much worn to enable a determination of the systematic position of this species in the genus"; but from the subglobose shape and small umbilicus it may be presumed to belong to the group of *S. binneyi*. The aperture is smaller than in *S. baboquivariensis* and its races, and *S. binneyi imperialis*, which are the only forms of the region with an umbilicus so small.

Sonorella superstitionis new species

Fig. 201.

The moderately depressed shell is narrowly umbilicate, the umbilicus contained about 13 times in the diameter. The whorls increase rather slowly to the last, which is very wide and descends a little in front. Color avellaneous, fading to whitish on the base and towards the apex, and with



Fig. 201. *Sonorella superstitionis*.

whitish bands above and below the chestnut-brown shoulder band. The apical whorls are without sculpture in adult shells. Last whorl has very weak wrinkles of growth only. The aperture is rounded oval. Peristome narrowly expanded, straightened and dilated towards the columellar insertion, where the margin extends well beyond the umbilicus. Parietal callus is thin and transparent.

Height 11 mm., diameter 19.3 mm.; aperture 11 mm. high, 12.3 wide; $4\frac{2}{3}$ whorls.

ARIZONA: Superstition Range, in northern Pinal County (Earl Sanders), Type and paratype 167771 A.N.S.P.

It is closely similar to *S. binneyi imperialis*, but somewhat less depressed, and the columellar margin projects farther beyond the umbilicus. *S. baboquivariensis depressa* is more openly umbilicate than *superstitionis*, and *S. arizonensis* is less depressed.

Sonorella micromphala new species

Fig. 202.

The depressed-globose shell is perforate, the perforation contained 15 to 19 times in the diameter, half covered by the dilated columellar lip. Color cinnamon buff to pinkish buff with a narrow chestnut-brown band.



Fig. 202. *Sonorella micromphala*; a, b, type; c, paratype.

Surface varying from rather glossy to matt. Embryonic $1\frac{1}{2}$ whorls with radial ripples after the small, smooth apical area; then covered with fine, close, irregular and more or less interrupted radial wrinkles and granules; over them, in the peripheral half, very irregular, oblique interrupted threads, in places forming a loose, torn network; towards the inner suture broken into short, separated fragments. The first post-embryonic whorl has indistinct papillae on a microscopically wrinkled surface; these papillae disappearing on later whorls, which are very lightly marked with growth lines only. The last whorl is very wide and descends moderately to rather deeply in front. The aperture is ample, rotund-lunate. Peristome narrowly expanded.

Height 13 mm., diameter 19.3 mm., aperture 11 x 12 mm.; $4\frac{3}{4}$ whorls. Type.

Topotypes measure from 11 x 17 mm. to 13.7 x 20.3 mm.

ARIZONA: Slide on a peak of the rim of the Mogollon Plateau, near Pine, Gila County (J. H. Ferriss), Type 166705 A.N.S.P. Also Pine Creek, near Pine.

The umbilicus is narrower than in any other *Sonorella* except *S. baboquivariensis*, which differs by the forwardly produced margins of its peristome. Except by its smaller umbilicus it resembles *S. binneyi franciscana* and others of that group. *S. fragilis* is thinner, with a larger umbilicus.

Mr. Ferriss kept no alcoholic material of this species, but it is readily recognizable by features of the shell. The locality was rather indefinitely given as the furthest peak of the Mogollon rim visible from Pine; this would probably be about 2 miles eastward, at between 6000 and 7000 feet.

(Μικρός, little, ομφαλός, umbilicus.)

SONORELLA COLORADOENSIS GROUP

Rather small, thin shells, in which short dashes in spiral trends replace the oblique threads of typical forms (or, in *S. rooseveltiana*, some short threads often remain); first post-embryonic whorl with oblique series of papillae. Penis short, the retractor inserted on the epiphallus.

These are the marginal northern and northwestern representatives of the genus, in the Colorado River and about 75 miles south, with one species as far south as the Roosevelt Reservoir. In some of these shells the sculpture of the embryonic whorl does not differ from that of certain *Eremariontae*.

Sonorella* (?) *praesidii (Pilsbry & Ferriss)

Fig. 203.

Micrarionta praesidii Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila. for 1918, p. 312, pl. 6, figs. 8-8b.

The shell is depressed, umbilicate (the width of umbilicus contained about 5.7 times in the diameter), thin. The "dead" shell is grayish white above, pale ecru-drab below, with some radial white streaks, and at the shoulder a narrow, faintly traced gray band which becomes cinnamon



Fig. 203. *Sonorella praesidii*, type.

towards the aperture. Under a lens fine gray spiral lines are seen in places on the base. The initial half whorl is smooth; next whorl has hyphen-like tubercles parallel with the suture, not closely placed; subsequent whorls have faint growth-lines only; there is no trace of spiral striae. The whorls are rather strongly convex, at first slowly increasing, the last very wide, rather deeply descending in front. The aperture is strongly oblique, nearly circular, faintly washed with ochraceous within. The peristome is sharp, very little expanded except at the columellar insertion where it is broadly dilated; terminations connected by a rather long, quite thin parietal callus.

Height 8.7 mm., diameter 16 mm.; umbilicus 2.8 mm.; $4\frac{1}{2}$ whorls.

ARIZONA: Old Fort Grant, at the western foot of the Pinaleno (Graham) Range, Graham County (Dr. Geo. H. Horn about 1864), Type 58121 A.N.S.P.

Micrarionta hutsoni Clapp resembles this shell, but it is smaller, more depressed, with a larger umbilicus. While the pattern of the embryonic whorls is similar, the narrow, hyphen-shaped papillae are longer and much more widely spaced in *praesidii*, somewhat as in some specimens of *S. rooseveltiana*; but the radial wrinkling of the first whorl, conspicuous in *rooseveltiana* is scarcely noticeable in *praesidii*. Some examples of *S. coloradoensis* have similar apical sculpture, when the fine radial wrinkles have been lost by wear. At the time I referred this species to *Micrarionta* I had not noticed that some sonorellas have about the same apical sculpture; still, the generic position of *praesidii* remains a little doubtful.

(*Praesidii*, of a fort.)

Sonorella rooseveltiana Berry

Fig. 204.

Sonorella rooseveltiana S. S. Berry, 1917, Nautilus, 31: 14.—Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. for 1918, p. 314, pl. 6, figs. 9-9b.

“The shell is depressed. In the type the spire is low conoidal, but in some specimens is higher, while in others is raised but little above the level of the principal whorl; umbilicate, the umbilicus contained about eight times in the major diameter; very thin and fragile. Whorls $4\frac{1}{4}$ to $4\frac{1}{2}$. Embryonic whorls a little less than $1\frac{1}{2}$, the initial half-whorl very finely, irregularly, radially, wrinkled-costulate, the wrinkles becoming finer and more wavy in the following whorl, where they are crossed by a series of fine, delicate, raised lines, passing obliquely downward and forward from the summit of the whorl to the suture, the sculpturing sometimes showing with beautiful



Fig. 204. *Sonorella rooseveltiana*, type $\times 1.6$. (After Berry.)

regularity over most of the whorl. Yet when a series of shells is examined the finer sculpturing shows great variation. Frequently the incised lines are more or less interrupted, especially near the summit, into elongate papillae which later coalesce. Sometimes lines or papillae are evident running in a direction counter to those just described and intersecting them. Above the summit, where the wrinkly lines of growth come closer together, the appearance is more granular and less distinct, but occasional traces of similar lines apparently pass obliquely downward (actually upward on account of the depression of the whorl at the suture) and backward from the superior suture to the summit. In most of the specimens the fine wrinkling becomes almost granulose. The next whorl-and-three-quarters show irregular growth-lines crossed obliquely by lines of minute papillae, though I can make out no bristles with the aid of such magnifying power as happens to be by me. The last whorl is apparently smooth except for the lines of growth. This whorl is moderately wide and descends slightly in front. The aperture is subcircular and very oblique. The peristome is thin, its margin only slightly thickened and scarcely at all expanded or reflexed at the base. There is an excessively delicate parietal callus. The type measures, alt. 8, major diameter 16.5, lesser diameter 14 mm.; diameter of umbilicus 2 mm.; aperture 8 x 8 mm.” (Berry.)

Largest specimen, 11 x 19 mm., smallest adult 7 x 15 mm.

ARIZONA: Roosevelt, Gila County, in rock slides on north slopes, 2200 feet elevation (George Willett, 1914), Type 3733 Berry Collection; paratype 117086 A.N.S.P.; highway a couple of miles west of Roosevelt Dam on Mills Creek (J. H. Ferriss).

It is related to *S. coltoniana*, a larger species, and to *S. coloradoensis*, which is less depressed with a smaller umbilicus. Theodore Roosevelt's snail is somewhat less evolved than either by its embryonic sculpture. The embryonic shell may have continuous though irregular forwardly descending threads, with crinkled intervals, or the threads may be entirely broken into short dashes in spiral or somewhat oblique trends. The post-embryonic whorls, to the end of the third, mostly show papillae in oblique series.

Figures of the type, supplied by Dr. Berry, are given. An immature specimen dissected had a very small, slender penis.

Sonorella coltoniana new species

Fig. 205.

The shell is rather strongly depressed, openly umbilicate, the umbilicus contained 6 times in the diameter. Cinnamon-buff, the base paler, with rather indistinct whitish bands on either side of the rather wide (1.4 mm.)

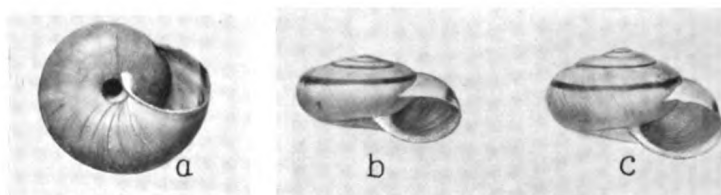


Fig. 205. *Sonorella coltoniana*: a, b, type and paratype; c, Oak Creek.

chestnut-brown shoulder band. After the initial smooth apex the $1\frac{1}{2}$ embryonic whorls have close, fine and very irregular radial wrinkles, becoming weaker on the second whorl; over them, after the first half whorl, are lengthened papillae in somewhat obliquely spiral trends. These continue more weakly on the first post-embryonic whorl or sometimes farther. The last whorl, lightly marked with wrinkles of growth, descends rather deeply in front. The aperture is shortly oval, the margins converging; outer margin very slightly expanding, the basal narrowly expanding, dilated near the columellar insertion.

Height 12 mm., diameter 22.6 mm., aperture 9.8 x 11.7 mm.; $4\frac{1}{2}$ whorls. Type.

Height 11.6 mm., diameter 20.6 mm. Paratype.

Genitalia (Fig. 206), with the penis nearly half the diameter of the shell, the retractor apical. It contains a rather slender, tapering, irregularly and weakly annulate verge. The vagina is about two-thirds as long as the penis. Hermaphrodite duct very large and complexly knotted. Length of penis 9, verge 4.5, epiphallus 6, flagellum 1, vagina 6 mm.

ARIZONA: Cliffs on south side of Walnut Canyon, Coconino County (J. H. Ferriss), Type 166717 A.N.S.P.

This is a rather depressed, widely umbilicated species, with the threads of the embryonic shell wholly broken into spirally lengthened but short

papillae. It is much larger and more openly umbilicate than *S. coloradoensis*. It is most closely related to *S. rooseveltiana*, but with the threads of the embryonic shell more completely short dashes. No thorough comparison of these species can be made until anatomic material of *rooseveltiana* is available.

In Oak Creek Canyon, about 30 miles southwest of Walnut Canyon National Monument, a race occurs in which the shell is usually, but not always, less depressed. It attains greater size, the example figured measuring 14.6 x 23.4 mm., others ranging in diameter from 20 to 25 mm. (Fig. 205 c). The penis is longer, and the tapering verge is convoluted as in *S. compar*, in the subject dissected. Length of penis 14, verge 6, epiphallus 6, penial retractor 9, vagina 10 mm. (Fig. 206 B).

Around Oatman, in western Mojave County, Ferriss took several hundred "bones", a few of them fresh enough to encourage the hope that living snails could be found, although the most laborious search failed to discover them. He did not supply the exact locations of his collecting stations. In one of them the shells are from 15 to 18 mm. diameter; in another the size runs somewhat larger, up to 20.5 mm. The smaller shells resemble *S.*

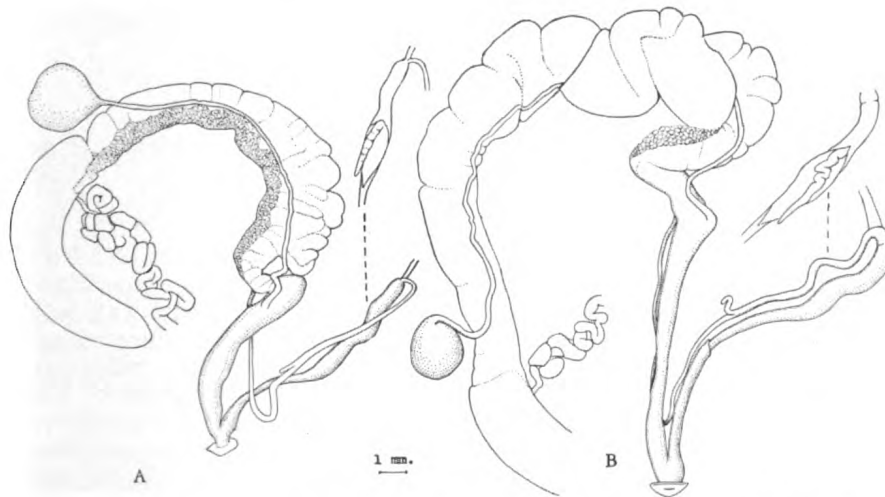


Fig. 206. *Sonorella coltoniana*. A, Cliff ruins, Walnut canyon; B, Oak Creek.

rooseveltiana, but the umbilicus is generally smaller, contained $5\frac{1}{2}$ to $7\frac{2}{3}$ times in the diameter, and the embryonic shell has fine sculpture exactly as in *S. coltoniana*. The exact status of this Oatman race is uncertain pending the discovery of living examples, but it is here considered a form of *coltoniana* on account of the close correspondence of the embryonic sculpture. It is of interest as being the western outpost of the genus, Oatman being

about 14 miles from the western boundary of Arizona, east of the meeting point of the boundaries of Nevada, California and Arizona.

(Named for Harold Sellers Colton, Director of the Museum of Science and Art of Northern Arizona.)

Sonorella coloradoensis (Stearns)

Fig. 207.

Helix (Arionta) coloradoensis Stearns, 1890, Proc. U. S. Nat. Mus., 13: 226, pl. 15, figs. 6, 8, 12.

Epiphragomophora (Arionta) coloradoensis Dall, 1896, Proc. U. S. Nat. Mus., 19: 340.

Sonorella coloradoensis Pilsbry, 1900, Proc. Acad. Nat. Sci. Phila., p. 560.—Bartsch, 1905, Smiths. Misc. Coll., 47: 189, pl. 32, fig. 3.—Pilsbry & Ferriss, 1911, Proc. Acad. Nat. Sci. Phila., p. 178, pl. 12, figs. 26-30, text-fig. 3.

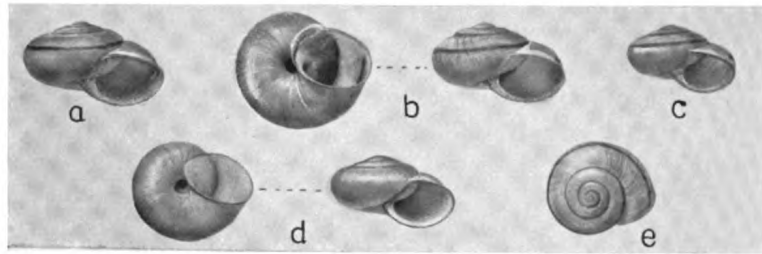


Fig. 207. *Sonorella coloradoensis*: a, Near Chino, Yavapai Co.; b, c, Bright Angel Trail; d, White Creek; e, Bass Trail.

“Shell orbicular, moderately depressed, spire slightly elevated, apex obtuse, number of whorls four to four-and-a-half, rounded. Umbilicus narrow, showing the penultimate whorl, though partially covered by the reflection of the lip at the point of junction with the base of the shell. Aperture obliquely ovate, nearly circular, and almost as broad as high. Lip slightly thickened and reflected, or simple, varying in this respect; more reflected and aperture more effuse at the columella. Parietal wall in the heavier examples calloused, the callus connecting with the inner edges of the outer lip above and below. Shell rather fragile, thin, translucent; surface smooth and shiny, and sculptured with fine incremental lines. Color pale horn to white, and otherwise marked by a single narrow revolving reddish-brown band just above the periphery, which in some specimens is obscure or absent. In some individuals certain faint scars upon the upper whorls imply an occasionally hirsute character.” (Stearns.)

“Alt. 10 mm., maj. lat. 16.4 mm., min. lat. 13.8 mm.; umbilicus about 1.8 mm.; aperture 8.2 x 8.5 mm.” (Bartsch.)

ARIZONA: Grand Canyon of the Colorado opposite the Walhalla Plateau, near the Hance Trail, at 3500 feet (C. Hart Merriam), Type 104100 U.S.N.M. Bright Angel Trail, from 100 feet below the rim down. Bass Trail, from a few hundred feet below the rim down to about 3000 feet. On the north side of the river in Shinumo Creek, from 2500 feet up; White

Creek about a mile above its confluence with Shinumo; Mojave Amphitheatre below the red-wall sandstone; west side of Muav Canyon near Dutton Point; Powell Plateau, 6500 to 7000 feet; third amphitheatre north of Kaibab Saddle, 6700 feet (Ferriss, Pilsbry and Daniels). Cliffs 2 miles northwest of Chino, in northern Yavapai County (Ferriss).

The small size and delicate texture of the very dilute brown, somewhat translucent shell are characteristic. It has a quite narrow band without light borders. It is the farthest north of the genus. Known localities are at intervals for about 40 miles along the river; how much farther up or down it occurs remains to be determined; but it apparently is rather widely distributed south of the Colorado, as it occurs abundantly at Chino, within the northern edge of Yavapai County. While *S. coloradoensis* seems to be generally distributed in the Grand Canyon, the colonies, except near the rim, are isolated and mostly small. Except during wet weather, the snails adhere to igneous or metamorphic rocks, making white circles thereon like other sonorellas. They are found in rocky talus slopes.

Dr. C. Hart Merriam "collected the type of *Helix coloradoensis* Stearns in September, 1889, in the Grand Canyon below the tank then known as Canyon Spring, not far from where John Hance afterward built what is known as the Hance Trail. At that time neither the Bright Angel nor Bass's Trail had been heard of." This locality is, as the river flows, about 13 miles east of the Bright Angel Trail (Grand Canyon), and 30 miles east of Bass Trail. Owing to the sinuosity of the sides of the canyon, the actual distance along any level above the river would be much greater.

In the typical form the umbilicus is contained from $7\frac{2}{3}$ to $8\frac{2}{3}$ times in the diameter. At the Bright Angel Trail (Grand Canyon) near the rim, the shells do not become so large, diameter about 15 mm., as about 2000 feet lower, where the diameter runs from 14 to 18.5 mm.; $4\frac{1}{3}$ to $4\frac{1}{2}$ whorls. In old shells the parietal callus sometimes is thickened at the edge (Fig. 207 b).

Specimens from the Bass Trail, and from the north side, differ from the type by having the umbilicus slightly larger, contained nearly 7 times in the diameter (Fig. 207 d, e).

The embryonic sculpture, after the initial smooth apex, consists of close, fine, radial wrinkles, continuous at first, then becoming interrupted, irregular and weak, with spirally trending series of low and inconspicuous spirally-lengthened papillae. First post-embryonic whorl with similar fine radial wrinkles; subsequently the radial wrinkles weaken and in places these whorls show subregularly arranged scar-like papillae, as far as the third whorl, but not on the last two whorls. The development of papillae is individually variable, from distinct in places to scarcely noticeable; and on some exceptionally well preserved young shells very few short spicule-like

hairs can be seen. All of this sculpture is microscopic and often vague. The peristome is thin and narrowly expanded. In colonies of the south side of the canyon all, or nearly all of the shells have a narrow brown band, but rarely it is wanting. A specimen from Bass Trail measures: height 8.7 mm., diameter 14.6 mm., umbilicus 2.1 mm.

On the north side of the river the band is more frequently absent, an ill-defined white zone taking its place. In White Creek, about 1 mile above its confluence with Shinumo Creek only seven per cent of the shells taken show a chestnut band, the rest being dilute cinnamon-buff with an ill-defined whitish zone at the shoulder (Fig. 207 d). The aperture is more ample in this lot and some others, the lip strongly expanded, somewhat thickened within, and together with the parietal callus, brownish edged. Height 10 mm., diameter 16.7 mm., aperture 8.7 x 9.7 mm.; $4\frac{1}{2}$ whorls.

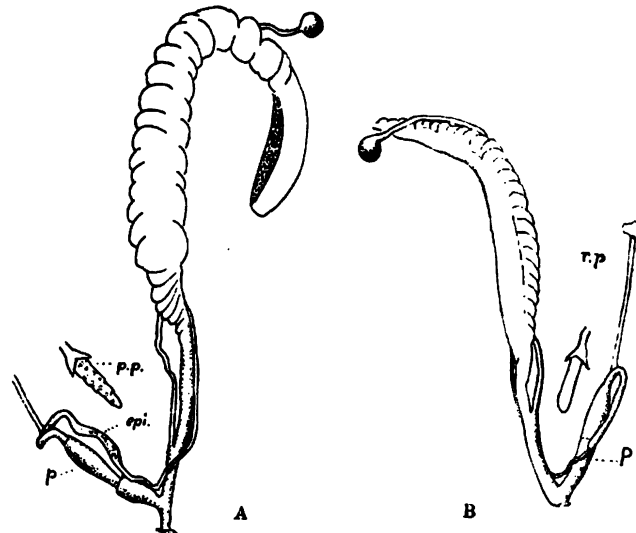


Fig. 208. Genitalia of *Sonorella coloradoensis*. A, Bass Trail. B, bandless form from White Creek.

The soft anatomy of the type was not described, but specimens from both sides of the river at Bass Trail have been dissected. The genitalia of a shell from Bass Trail figured (Fig. 208 A) show the species to be related about as nearly to the forms found in the region immediately south of Tucson, as to any southern species. The penis (p.) is swollen distally, narrow in its basal half, where it is enveloped in a rather long muscular sheath. It contains a tapering verge (p.p), not quite half as long as the penis. The epiphallus (epi.) is about equal to the penis in length, slightly larger than the vas deferens. There is no flagellum. The penial retractor muscle inserts on the epiphallus. The vagina is rather short and slender. Atrium longer than usual in *Sonorella*. Length of the penis 4.5 mm.; verge 2 mm.; vagina 3 mm.; spermatheca and duct 21.5 mm.

A specimen of the bandless form from White Creek, a branch of Shinumo Creek, shows no significant differences in the genitalia from south rim form. The atrium is shorter; verge more cylindrical and blunter, not corrugated. Length of penis 5 mm.; epiphallus 4.7 mm.; verge 2 mm.; vagina 3.8 mm.

In the form from Chino, a railroad station about 70 miles southwest of Grand Canyon, and over 40 miles from the river, the shells average large, from 15.5 to 18.7 mm. in diameter; but they appear typical otherwise (Fig. 207 a). The genitalia show no significant divergence. The verge is cylindrical with deep annular corrugation and a long-conic, smooth end. There is a minute (0.25 mm.) flagellum. Length of penis 6, verge 2.5, epiphallus 6, vagina 4 mm.

SONORELLA TUMAMOCENSIS GROUP

Embryonic whorls with diagonal threads (*hachitana* sculpture). Verge spirally grooved.

Desert snails of hills and low mountains in the Santa Cruz river valley.

Sonorella arida Pilsbry & Ferriss

Fig. 209.

Sonorella sitiens arida Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 409, pl. 8, fig. 6-6b.

Sonorella hinkleyi Pilsbry & Ferriss, 1919, Nautilus, 33: 19; 1923, Proc. Acad. Nat. Sci. Phila., 75: 87, pl. 3, figs. 1, 4; pl. 8, fig. 7.

Sonorella tumacacori Pilsbry & Ferriss, 1919, Nautilus, 33: 19.

Sonorella hinkleyi tumacacori Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 89, pl. 3, fig. 2; pl. 8, fig. 4.

Sonorella hinkleyi fraterna Ferriss, 1919, Nautilus, 33: 38, nude name.

Sonorella cayetanensis Pilsbry & Ferriss, 1919, Nautilus, 33: 19.

Sonorella hinkleyi cayetanensis Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 88, pl. 3, fig. 5; text-fig. 9.

The shell resembles *S. sitiens*, but differs in these features: the umbilicus is decidedly wider, its diameter contained about $6\frac{1}{2}$ times in that of the shell; the color is paler; the aperture is noticeably smaller. The embryonic $1\frac{1}{2}$ whorls have radial ripples after the usual smooth apex; rather widely spaced and irregular spiral and forwardly descending threads then appear, partly netted together, the intervals closely and finely radially wrinkled.



Fig. 209. *Sonorella arida*, type.

This sculpture is more or less completely lost in many adult shells. The last whorl descends a little and slowly in front. The peristome expands a little and is dilated at the columellar insertion.

Height 10.8 mm., diameter 19.1 mm., aperture 9 x 9.6 mm.; $4\frac{1}{2}$ whorls.

ARIZONA: Cerro Colorado, around the base of a conspicuous crag at the southeastern end of the range (Ferriss and Pilsbry), Type 112160 A.N.S.P. San Cayetano Mountains, from the southern foothills about two miles from Calabasas up to about 7500 feet (Ferriss; for *S. hinkleyi* and *S. cayetanensis*). Tumacácori Mountains, on Tumacácori Peak and the next mountain southward (Ferriss; for *S. tumacacori*).

This species differs from *S. sitiens* by the irregular threads of the embryonic shell, wanting in that species. They are sometimes interrupted into stippling, or meshed into an irregular network. If I am right in merging the sonorellas of the Cayetanos and Tumacácoris into *arida*, the verge is quite unlike that of *sitiens*. The vagina is longer than the penis, with a node at about the posterior third, thus differing from *S. tumamocensis*, which is closely allied. *S. tryoniana*, from the foothills of the Patagonia range, eastward, is less depressed, with the margins of the lip running further forward. It also has a shorter vagina.

The forms called *hinkleyi*, *cayetanensis* and *tumacacori* were described from only a few specimens. Large numbers subsequently sent by Mr. Ferriss show that they intergrade so fully that the separation into races seems impracticable. The anatomy of the typical *arida* is unknown, but the apical sculpture and other characters seem so completely identical with Cayetano and Tumacácori snails that we can hardly doubt that the genitalia will conform also.

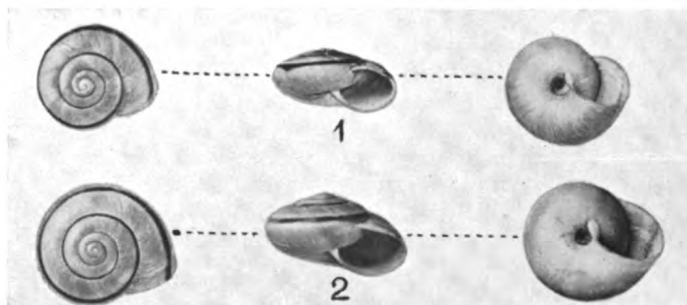


Fig. 210. *Sonorella arida*. 1. type of *S. hinkleyi*, Cayetano Range; 2. type of *S. tumacacori*, Tumacácori Range.

The type of *hinkleyi* (Fig. 210: 1) measures 8.5 x 16 mm.; umbilicus 6 times in diameter. The penis is rather long with a basal sheath nearly a third of its length; the verge cylindrical with conic end and weak spiral plication. Epiphallus about as long as penis, the long penial retractor inserted upon it. No flagellum. The vagina is longer than the penis, and at the posterior third there is an annular swelling, the wall there being thickened and muscular, with an internal annular ridge. Above this the internal wall has fine, irregular, longitudinal threads. Length of penis 10.5, verge

4, epiphallus 10, vagina 13 mm. Another measures: penis 10, verge 3.3, epiphallus 9.5, vagina 11 mm. (Fig. 211 A, F.)

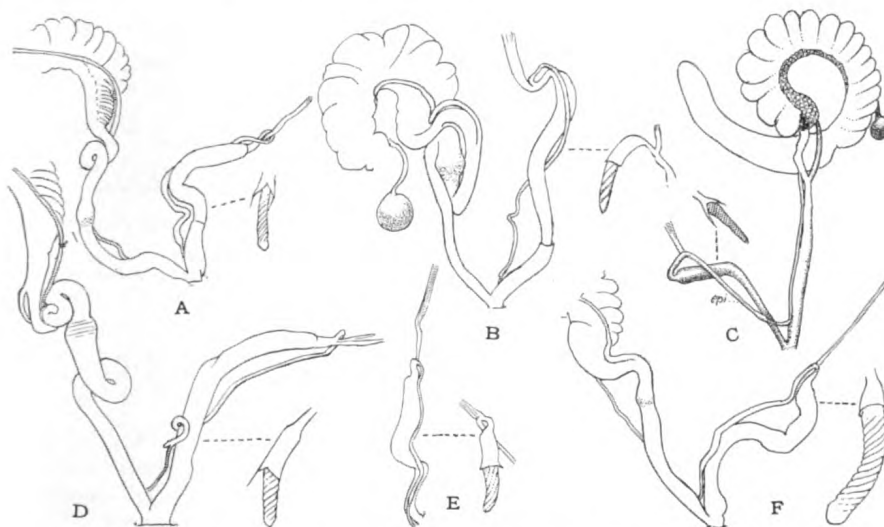


Fig. 211. Genitalia of: A, F, *Sonorella arida* (*hinkleyi*); B, *S. arida* (*tumacacori*). C, E, *S. tumamocensis*, type and topotype. D, *S. arida* (*cayetanensis*).

In a porphyry slide on a small knob, southern side of the southern peak of the Cayetanos, most of the specimens taken are albinos, the shell white throughout (Fig. 212). Ferriss reports 452 albinos to 24 banded specimens.

The Tumacácori Mountain form (Fig. 210: 2) is rather solid and opaque, the type of *tumacacori*, 43738 A.N.S.P., measuring 10 x 17.8 mm., umbilicus $6\frac{1}{2}$ times in diameter, or smaller, diameter 15.8 mm. In one lot, containing also shells of typical size, there are some as large as "*cayetanensis*"; 10.9 x 20 mm., aperture 10.2 x 11.3 mm., umbilicus $6\frac{2}{3}$ times in diameter. Genitalia about as described for San Cayetano snails; flagellum minute; other organs somewhat longer (Fig. 211 B). Four measure as follows:

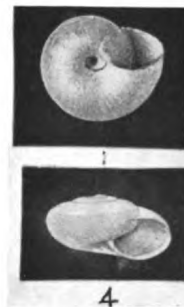


Fig. 212. *Sonorella arida*, albino, Cayetano Range.

Penis	14 mm.	13.0 mm.	13 mm.	11.8 mm.
Verge	5 "	4.2 "	5 "	4.2 "
Epiphallus	15 "	11.5 "	..	11.5 "
Vagina	16 "	17.0 "	..	14.0 "

On the highest peak of the San Cayetano Range, from near the top to rather low, many specimens were taken by Ferriss, which differ from the

"*hinkleyi*" form by their much larger size and less depressed shape. The shell is rather thin and somewhat translucent when alive. Sculpture as in *arida*. This is what was named *cayetanensis* (Fig. 213). The type, 43737 A.N.S.P., measures: height 11.3 mm., diameter 21.2 mm., aperture 10.6 x 12 mm.; umbilicus nearly 8 times in diameter; $4\frac{1}{2}$ whorls. Others are smaller, down to 19.5 mm. in diameter; and the umbilicus may be larger, $7\frac{1}{3}$ times in diameter. Genitalia (Fig. 211 D), with penis 13.5 mm. long, verge 5, epiphallus 13.5, vagina 20 mm.

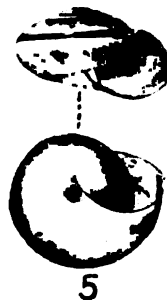


Fig. 213. *S. arida* (*cayetanensis*).

***Sonorella tumamocensis* Pilsbry & Ferriss**

Fig. 214.

Sonorella tumamocensis Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 401, pl. 10, figs. 4-4b, pl. 13, figs. 5, 8; 1923, Proc. Acad. Nat. Sci. Phila., 75: 90, pl. 7, figs. 14, 15.

The shell is depressed, umbilicate (umbilicus contained about 6 times in the diameter of the shell), thin, light pinkish cinnamon, fading to whitish on the base, and having indistinct whitish borders above and below the rather narrow chestnut-brown shoulder band. Apical sculpture is usually very weak, the initial half-whorl smooth, or with faint radial ripples; the rest of the embryonic shell is marked with widely spaced delicate, interrupted tangential (protractive) threads, on a nearly smooth or radially rippled ground. The subsequent neanic and last whorls have weak growth lines. Whorls $4\frac{1}{2}$, convex, the last slowly descending in front. Aperture rounded, nearly as high as wide. Peristome thin, the outer and basal margins very narrowly expanded. The columellar lip, in basal view, shows very little dilation.

Height 10.5 mm., diameter 17.5 mm.; aperture 8.7 x 9.5 mm.; umbilicus 2.8 mm. wide.

Genitalia (Fig. 211 c, e, type and topotype). The penis is about as long as the vagina, slender in its lower part, somewhat swollen above. Around the base there is a very short sheath of very loose open texture. It contains a slender, slowly tapering verge about one-third as long as the penis, its surface closely grooved spirally, the apex obtuse but small. The epiphallus is slender, terminating in a vestigial, bud-like flagellum. The retractor muscle is inserted on the epiphallus. Length of penis 10, verge 3.5, epiphallus 10, vagina 10.7, spermatheca 23.5 mm., type. Penis 9, verge 4, epiphallus 9 mm., no flagellum; shell 8.5 x 15.7 mm., topotype.

Top of the head and back are slate-colored, shading into gray on the sides, whitish towards the edges of the foot. Tail and sole white. Faint lines define the three areas of the sole. Jaw has 3 or 4 very weak ribs.



Fig. 214. *Sonorella tumamocensis*, type.

ARIZONA: Tumamoc Hill, near Tucson (Pilsbry, Ferriss and Daniels, 1910), Type 112245 A.N.S.P. Tucson Range at Cat Mountain, etc.; southern and northern foothills of the Roskrige Range, Silver Bell mining camp and other places (Ferriss).

The shell closely resembles *S. eremita* of the Mineral Hill group, but it is much thinner with the peristome decidedly less expanded and the embryonic whorls less sculptured. The penis is much longer than in *eremita*. In individuals having the shell about the same size as *S. tryoniana* the penis, verge, epiphallus and vagina are about twice as long; the spermathecal duct remaining about equal in the two species.

At some stations in the Tucson Range the specimens vary from 18 to 20.5 mm. in diameter, becoming larger than any from the type locality.

In rock slides of a small, black hill in the southern foothills of the Roskrige Range, the numerous specimens are much like the smallest examples of typical *S. tumamocensis*, diameter 14 to 16.2 mm. They are more depressed than the larger Tucson Range shells, somewhat translucent. There is considerable variation in the size of the umbilicus, which is contained $5\frac{3}{4}$ to 7 times in the diameter. These shells are much like *S. ferrissi*, but the last whorl is more depressed in the latter. The animals had been dried, but by the use of potash one was soaked up. The genitalia (figured in my paper of 1923, pl. 7, fig. 15) do not differ materially from *tumamocensis*, except that the verge appears to be smooth and shaped as in *S. binneyi*, not tapering and spirally grooved as in *tumamocensis*. There is a very small flagellum. Length of penis 12, verge 3.5, epiphallus 7.5, vagina 8 mm.

The Tumamoc Hills are an outlying spur of the Tucson Range, about a mile from Tucson west of the Santa Cruz River. *Sonorella* occurred in great piles of black basalt, on the north slope of the hill, from just below the flat summit down half way to the Desert Laboratory. Most of them were taken not far from the 2750-foot contour. Living snails are scarce and hard to get. None were found on the slopes of Tumamoc Hill, nor could we find them on the other two hills of the group.

Sonorella tumamocensis linearis Pilsbry & Ferriss

Fig. 215.

Sonorella linearis Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 68, pl. 1, fig. 12.

The shell is umbilicate (the umbilicus contained about $7\frac{1}{4}$ times in the diameter), dilute cinnamon with a chestnut-brown band with very indistinct pale borders, somewhat glossy, the base whitish. Embryonic shell radially rugose or weakly so, with a few irregular, straggling spiral threads near the outer suture in some specimens. Last whorl with fine, weak growth lines, and below the suture on the last whorl a group of incised spiral lines (weak on some specimens, absent in others). Whorls increase rather slowly, the last slowly descending in front. The peristome is very slightly expanded.

Height 10.7 mm., diameter 17.6 mm., umbilicus 2.4 mm.; $4\frac{1}{2}$ whorls. Type.

ARIZONA: Northern end of the Santa Rita Range (Ferriss), Type 130996 A.N.S.P., on the western side of the saddle, overlooking Helvetia. Also Rosemont, abundant.

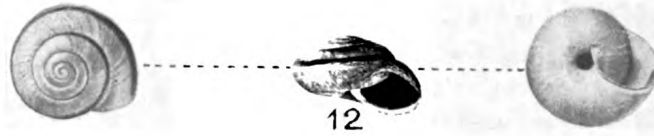


Fig. 215. *Sonorella tumamocensis linearis*, type and paratypes.

Additional material sent in by Ferriss shows that the spiral lines which served to distinguish this form are quite variable and often wholly wanting. The soft anatomy is unknown. Until living specimens make a definite appraisal of its affinities possible, it is associated with the similar species *tumamocensis* as a variety. It occurred with *S. rosemontensis*.

Sonorella eremita Pilsbry & Ferriss

Fig. 216.

Sonorella eremita Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 404, pl. 8, figs. 7-7c; pl. 13, figs. 2, 6, 6a, 10.

The shell is globose-depressed, umbilicate, the width of umbilicus contained $5\frac{1}{2}$ to $6\frac{1}{2}$ times in the diameter; more solid than other species of the same region, glossy, opaque pinkish buff, fading to nearly white around the umbilicus, and having a chestnut-brown shoulder band without noticeable

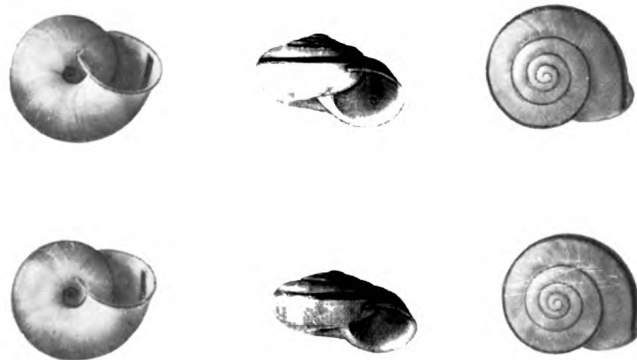


Fig. 216. *Sonorella eremita*, type and paratype.

light borders. The embryonic shell, of about $1\frac{1}{2}$ whorls, has strongly developed sculpture of the *hachitana* type. The initial half-whorl has some radial ripples or wrinkles, followed by an irregular network; then a series of long, protractive threads on the outer two-thirds, meeting shorter forwardly ascending threads, more or less interrupted, on the inner third; the

intervals occupied by short radial impressions. The later whorls are marked with very fine, unequal growth-lines. The spire is very low, conoidal. Whorls $4\frac{1}{2}$, moderately convex, the last slowly descending in front. The oblique aperture is rounded, but slightly wider than high. Peristome slightly expanded above, the outer and basal margins expanding more, slightly thickened, the margins converging, connected by a very thin parietal film.

Height 11.4 mm., diameter 19.5 mm.; umbilicus 3 mm. Type.

Height 10.5 mm., diameter 18.6 mm. Paratype.

The top of the head is gray, integument elsewhere cream-tinted. The median area of the sole is whitish, twice as wide as either side area, the latter flesh-tinted.

The genitalia (Fig. 217). Penis very small and slender, having a very short, weak basal sheath of a few loose fibres. The verge is coarsely annulated, very slender and long. The penial retractor muscle is inserted on the epiphallus, which is about as long as the penis, extremely slender, not so wide as the vas deferens, but enlarged a trifle where it joins the latter. There is no flagellum. Length of penis 4.2, verge 3, vagina 5.5, spermatheca 25, diameter shell 19 mm. In other examples the penis measures from 3.5 to 4.4 mm.

The jaw has four or five unequal ribs, sometimes rather weak.

ARIZONA: West end of "San Xavier Hill", the southwestern hill of the Mineral Hills, Pima County (Pilsbry and Daniels, 1910), Type 112161 A.N.S.P.

"In the genitalia, as well as the shell, this species resembles *S. papagorum*, but it differs by having a smaller penis and by the very slender epiphallus, which is actually smaller than the vas deferens in several specimens dissected. In *S. tumamocensis* the penis is very much longer. The shell is smaller than *S. papagorum*, with far more strongly developed apical sculpture than in any other species of this district. It is also more solid, and, having an aspect of its own, is not likely to be confused with any other *Sonorella* known to us." The size is quite variable, from 9 x 16 mm., $4\frac{1}{2}$ whorls, to 12.7 x 21.3 mm., $4\frac{1}{2}$ whorls.

The Mineral Hill group, Twin Buttes and Tinaja Hills are much degraded outliers of the Sierrita Mountains. Only the Mineral Hills have been worked for land snails, though all doubtless have *sonorellas*—and very little else. These hills lie about 20 miles west of south from Tucson and about 7 miles north of the Sierritas. Xerophytic vegetation extends over them, mesquite, cat-claw, palo verde, ocotillo and sotol being the more conspicuous plants, to which may be added tree cacti on southern slopes, and on the mesa, many opuntias, a few barrel cacti and yuccas. The absence

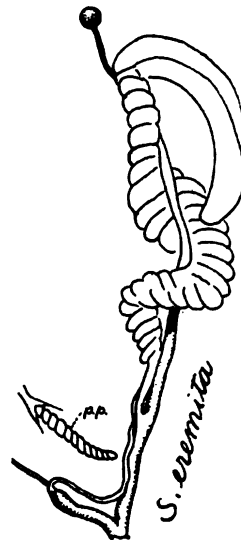


Fig. 217.

of *Agave* is peculiar. These hills are a favorite resort of rattlesnakes. I got also a coral snake. Mollusks were found on San Xavier Hill only. There is a depression in the western end of the hill, between short, low cliffs of white quartz. The cliff towards the south has partly fallen in a tumble of huge blocks with some smaller stone between them. This talus is perhaps 200 feet long to the last scattered blocks, and at the widest 40 feet wide; its lower end about 200 feet above the mesa. In it *Sonorella* "bones" were abundant, but living snails extremely scarce, and confined to the deeper portions of the talus, between the piled-up quartz blocks. The entire known range of this species is not much greater than the area occupied by a house of moderate size.

Sonorella rosemontensis new species

Fig. 218.

Sonorella hesterna Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 90, pl. 8, figs. 8, 9. Not *S. hesterna* P. & F., 1919.



Fig. 218. *Sonorella rosemontensis*, type.

The shell is similar to *S. walkeri aguacalientensis*; umbilicus contained nearly $6\frac{1}{2}$ times in the diameter; polished, moderately solid, pale brown, fading around the umbilicus, and with the usual light-bordered chestnut-brown band; last half whorl or more of the embryonic shell with forwardly descending threads, usually distinct in adult shells.

Height 12.7 mm., diameter 21.7 mm., aperture 10.8 x 11.7 mm.; $4\frac{1}{2}$ whorls.

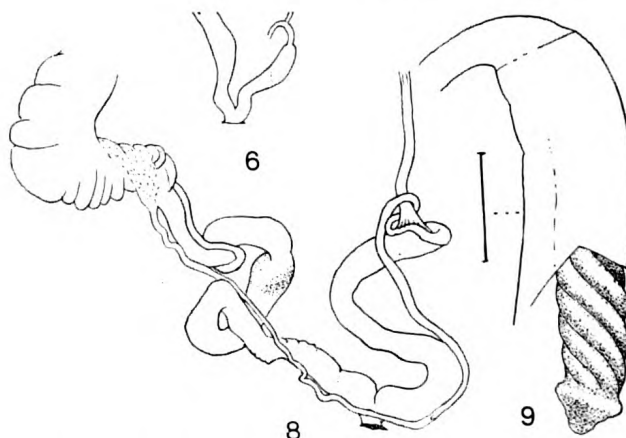


Fig. 219. *Sonorella rosemontensis*. Genitalia; verge $\times 14$.

It is very closely related to *S. arida*, the genitalia being of the same general character, but the shell is larger and more solid. The verge is strongly plicate spirally, with a conic end. There is a muscular swelling or node on the vagina. Flagellum minute, vestigial. Length of penis 13, verge 3.7, epiphallus 15, vagina 17 mm. (Fig. 219).

ARIZONA: Northern end of the Santa Rita Mountains near Rosemont (J. H. Ferriss), Type 166642 A.N.S.P.; Helvetia; Greaterville.

Topotypes measure from 19 to 24 mm. in diameter. It was formerly considered to be identical with *S. hesterna*, but the well developed threads of the embryonic shell apparently indicate a different species. Were it not for the very different verge, this form would hardly be separated from *S. walkeri*.

SONORELLA AMBIGUA GROUP

Embryonic whorls with close radial wrinkles but no spirally diagonal threads; later whorls smoothish. Verge rather stout, long or short, with obtuse end.

Snails of desert hills and low mountains, mainly south and west of Tucson.

Sonorella sitiens Pilsbry & Ferriss

Fig. 220.

Sonorella sitiens Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 407, pl. 8, figs. 5-5c, pl. 13, figs. 3, 7; 1923, Proc. Acad. Nat. Sci. Phila., 75: 79, pl. 6, figs. 7, 9.

Sonorella sitiens comobabiensis Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 409; 1923, Proc. Acad. Nat. Sci. Phila., 75: 80, pl. 6, fig. 11.

The shell is depressed, umbilicate (the width of umbilicus contained about ten times in the diameter of the shell), rather thin, cinnamon colored (varying in tone), paler around the umbilicus, encircled by a chestnut-brown band at the shoulder, bordered with a white band above and below. Surface somewhat glossy. The initial fourth of a whorl is smooth; the rest of the embryonic shell has very fine, irregular and sometimes interrupted



Fig. 220. *Sonorella sitiens*, type and paratype.

radial wrinkles, without ascending or descending spiral threads. The neanic and last whorls are marked with delicate growth lines. Spire low; whorls $4\frac{1}{2}$, convex, the last slowly descending in front. Aperture oblique, rounded oval. Peristome thin but more or less thickened within, the upper margin hardly expanded, outer and basal margins a little expanding.

Height 11.4 mm., diameter 20.2 mm.; aperture, alt. 10.2 x 12.2 mm.
Type.

Height 12.2 mm., diameter 18.7 mm. Figured paratype.

The back, top and sides of head are slate colored, the tail and a wide band above the foot edges whitish.

Genitalia (Fig. 221 a). The penis is swollen distally, becoming narrow in its basal half, which is enveloped in a muscular sheath, the outer edge of which is attached to the end of the epiphallus. The verge is extremely short and wide, cylindric, with a few annular corrugations and a shortly conic end. The epiphallus is slender, swollen at its distal end, without trace of a flagellum. The lower part of the vagina is very stout. Length of penis 6, verge 1, epiphallus 5, vagina 5 mm., diameter shell 20.2 mm. Another, penis 7, verge 1, vagina 5, spermatheca 25 mm.

Jaw (Fig. 221 b) has 8 strong, narrow ribs.

ARIZONA: Las Gijas Mountains (Pilsbry & Ferriss), Type 112158 A.N.S.P., from above Las Gijas mine, at the northwest end. Pajarito Mountains in Pina Blanca Canyon south of Oro Blanco, and in Clark's Mine Canyon (J. H. Ferriss).

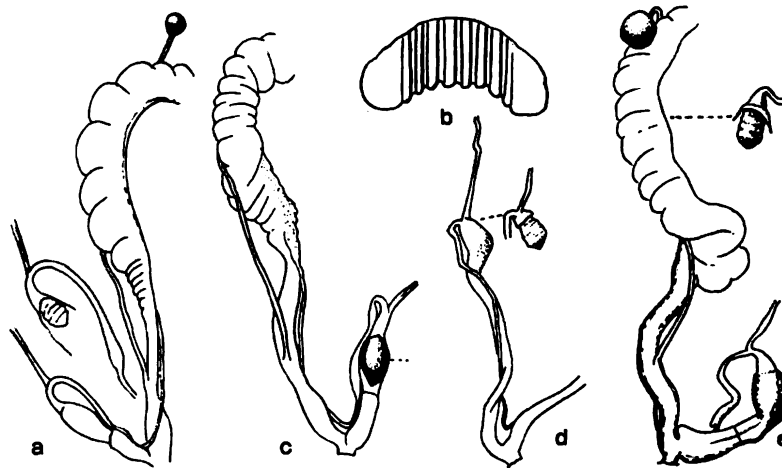


Fig. 221. a, b, *Sonorella sitiens*, genitalia and jaw of type; c, Pajarito Mts.; d, Quijotoa Mts. e, *S. sitiens montezuma*.

The shell is less solid than *S. eremita*, the aperture decidedly larger, the umbilicus smaller. The color also is darker. The absence of oblique threads on the embryonic shell is a feature unlike *arida* or *tryoniana*. It differs from *eremita* conspicuously in the genitalia, the penis of *S. sitiens* being provided with a sheath of half its length, and the verge being extremely short and stout, while in *S. eremita* the sheath is represented only by a few loose muscular fibres at the base, and the verge is slender and relatively long. No other *Sonorella* known has a verge like that of *S. sitiens*.

In the Pajarito Mountains the size runs from 17 to 21 mm. in diameter, and the umbilicus is wider than in the Gijas, contained 6½ to 7 times in the diameter; but the genitalia have the essential features of the Gija Hills type,—a very short, thick cylindric verge and no flagellum; but in these examples the verge is not corrugated, evidently a condition of preservation; it is apparently less contracted, being the fraction of a millimeter longer. In a specimen from Clark's Mine Canyon it is 2 mm. long. The organs of 3 specimens measure in length as follows:

Museum No.	43740	43734	43723
Length of penis	4.5	6	5 mm.
Length of verge	1.3	1.4	2 "
Length of epiphallus	7	5	7 "
Length of vagina	4	5	6 "
Figure	221c	—	—

Las Gijas are a low northern outlier of the Pajarito Mountains, the latter extending over the boundary into Mexico, west of Nogales. In Las Gijas snails were rare, found among bowlders above the mine and in a dyke half a mile south on the ridge. In the Pajaritos, *S. sitiens* is common and doubtless extends into Sonora. The presence of races in the Huachucas and the Comobabis—places about 100 miles apart—testifies to a wide distribution, now or formerly, along the international boundary or below it.

Mountains near the 112th meridian.—In a long series from the Comobabi, Cababi and Quijotoa ranges, from about 2500 to 4000 elevation, the shell is decidedly paler colored; diameter 17 to 20.5 mm.; umbilicus about 8 (7½ to 9) times in the diameter. Specimens dissected show the peculiarly short, thick verge characteristic of *S. sitiens* alone; but both penis and verge are slightly longer than in typical *sitiens*, and the penial retractor muscle is inserted on or close to the summit of the penis, not as in typical *sitiens* and *S. s. montezuma*, distinctly on the epiphallus. Length of penis 10, of verge 2 mm. (Fig. 221 d).

With large series of *sitiens* from the Pajaritos now available for comparison, this western form does not seem to merit subspecific distinction, and the term *comobabiensis* is now discarded. Probably intervening colonies will be found in the southern Baboquivaris and elsewhere. Some of the shells from these western ranges seem indistinguishable from *S. vespertina*, but in many specimens I have opened the verges are conspicuously different.

Sonorella sitiens montezuma Pilsbry & Ferriss Fig. 222.

Sonorella montezuma Pilsbry & Ferriss, 1919, Nautilus, 33: 20.
Sonorella sitiens montezuma Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 79, pl. 2, fig. 8; pl. 6, fig. 10.

Shell smaller than *sitiens*, with similar sculpture, the brown tint fainter. Height 9.2 mm., diameter 15.3 mm.; scarcely 4½ whorls. Type. Other specimens from 13.7 to 17.2 mm. in diameter.

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The penis is longer than the vagina, has a sheath nearly half its length, and contains a very short, thick, cylindric verge with shortly conic end. The epiphallus is enlarged where it enters penis. A very short flagellum is present. Length of penis 6, verge 2.5, epiphallus 6, vagina 6, spermatheca 16 mm. (Fig. 221 e).

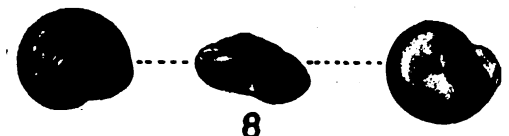


Fig. 222. *Sonorella sitiens montezuma*, type.

ARIZONA: South end of the Huachuca Mountains in Montezuma Canyon and the pass into Copper Canyon, often abundant (J. H. Ferriss), Type 130583 A.N.S.P.

This race differs very little from *S. sitiens* except by its diminutive size in large series collected. Its area lies about 50 miles east of known localities of *sitiens*.

***Sonorella papagorum* Pilsbry & Ferriss**

Fig. 223.

Sonorella papagorum Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 403, pl. 8, figs. 8-8 b; pl. 13, fig. 4.

The shell is depressed, umbilicate, the umbilicus contained nearly 8 times in the diameter of the shell, rather thin, glossy, light pinkish cinnamon, fading to whitish around the umbilicus, and pale at the edges of a dark chestnut-brown band at the shoulder. Embryonic shell of about $1\frac{3}{4}$ whorls, the apical sculpture very weakly developed, the initial half-whorl smooth, the rest of the embryonic shell with weak, irregular radial wrinkles and some fine spiral scratches. Subsequent whorls are lightly marked with growth lines. Whorls $4\frac{1}{2}$, convex, the last descending slowly in front. Aperture oblique, rotund-oval. Peristome slightly expanded above, the outer and basal margins well expanded, thin; columellar margin broadly dilated, partly covering the umbilicus.

Height 13.8 mm., diameter 23.2 mm.; aperture, alt. 11.8, diameter 13.7 mm.; width of umbilicus 2.8 mm.

Genitalia (Fig. 224). Penis small and slender, but equal in length to the vagina and of equal calibre throughout. A short, loose sheath envelops its base. The verge is nearly as long as the penis, very slender, slowly tapering, indistinctly annulate. The slender epiphallus bears the retractor muscle and terminates in a very minute flagellum. Length of penis 6, verge 5, epiphallus 7, flagellum 0.5, vagina 7 mm.

Jaw (Fig. 225) has five or six strong, unequal ribs, or in one specimen four unequal weaker ribs (Fig. 224: 6). It is quite variable.

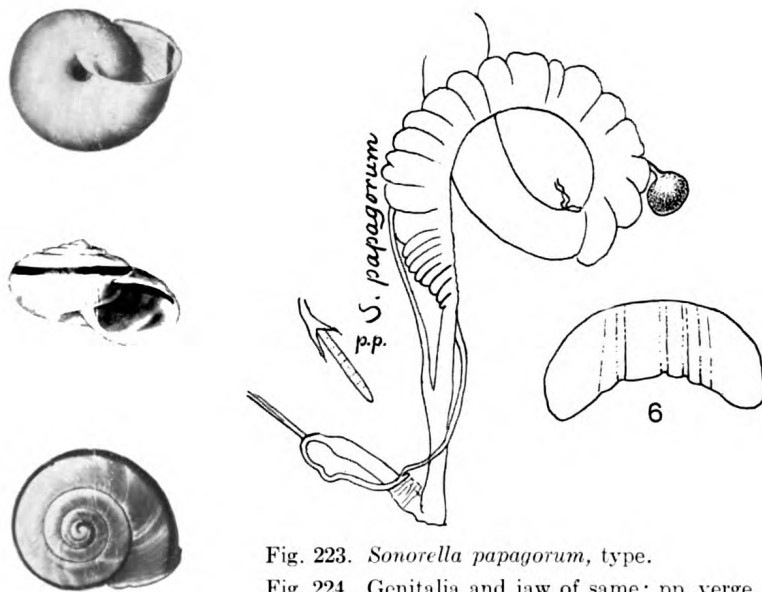


Fig. 223. *Sonorella papagorum*, type.
 Fig. 224. Genitalia and jaw of same; pp, verge.

ARIZONA: Black Mountain, near the mission of San Xavier del Bac, in the Papago Indian Reservation, Pima County, about 9 miles south of Tucson, elevation about 3200 feet (Pilsbry and Daniels, 5-10-1910), Type 112161 A.N.S.P.

The only variation noted in a considerable series is in size, from 20.5 to 24.3 mm.

This shell is less solid than *S. eremita*, with a narrower umbilicus and far weaker apical sculpture. It differs from *S. walkeri* and *S. huachucana* by the slender vas deferens and by the subobsolete sculpture of the embryonic whorls, the last without the diagonal threads of those species and of *S. eremita*.

Black Mountain is a rather remote and isolated outlier of the Tucson Range, which has here its southeastern terminus. It is a level-topped ridge, divided by a deep gap into a longer and a shorter mountain. The slopes are everywhere very steep, largely covered with slides of black basalt. Between the slides, which are, of course, barren of vegetation, there is some desert verdure: ocotillo, mesquite, cat-claw, palo verde, etc., are typical plants, and giant cacti grow on the south side. No agave or sotol were seen. The *Sonorellas* are found rather deep in the slides. We worked on the north side of the east end, close under the summit. Some hazard attends the hunt

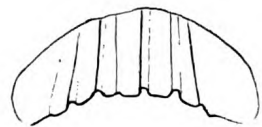


Fig. 225. Jaw of *Sonorella papagorum*.

in these slides, which are so steep that the heavy rock starts to move on small provocation.

(The name signifies "of the Papagos," an Indian tribe still inhabiting this district.)

Sonorella ambigua Pilsbry & Ferriss

Figs. 226, 228: 1-4.

Sonorella ashmuni ambigua Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 441, pl. 10, figs. 6-6 b.

Sonorella ambigua Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 72, pl. 2, figs. 1-4; pl. 5, figs. 1-10, 12; pl. 6, figs. 1-5.

Sonorella ambigua cyclostoma Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 78, pl. 2, figs. 5-7; pl. 6, fig. 6.

The shell is rather solid, moderately depressed; umbilicus contained $7\frac{3}{4}$ (type) to 8 times in the diameter; glossy, ochraceous buff with a slight cinnamon cast, whitish on the base, very little or not whitish alongside of the chestnut-brown band. The tip of the apex is smooth, followed by a few radial wrinkles, then some small papillae near the suture. The rest of the embryonic shell is weakly rugose radially, sometimes showing traces of sparsely strewn papillae, more papillose near the upper suture; without



Fig. 226. *Sonorella ambigua*, three views of the type.

spirally retractive or protractive threads. Later whorls have light growth lines, and traces of spiral striae may be seen below the last suture (but they are more frequently wanting). The last whorl is wide and descends rather rapidly in front. Aperture very shortly oval; peristome expanded, slightly thickened within. Parietal callus thin.

Height 13 mm., diameter 22.7 mm., aperture 11.1 x 12.5 mm.; $4\frac{1}{2}$ whorls. Type.

The genitalia were examined in specimens from three stations in the Cababi Hills and several in the Coyote and Roskruge ranges (Figs. 227 a-c, e, f). The large penis is long, half the diameter of the shell or slightly more, sheathed at the base, and contains a large verge which is between half and two-thirds as long as penis, truncate or rounded at the end, where it is generally a little enlarged, and more or less wrinkled and dented in alcoholic preparations. The penial retractor is less than half as long as penis, inserted on the epiphallus where the latter enlarges basally. There is a very small flagellum. Measurements of length follow:

Penis	12.5	12	18	14.5	11 mm.
Verge	8	8.5	14	10	5 mm.
Epiphallus	9	9	14	12	10 mm.
Retractor	5	5	10	...	.. mm.
Vagina	12	...	14	10.5	9 mm.
Figure 227	a	...	b, c	e	f

ARIZONA: Robles Hills and Roskruge Mountains. Coyote Range and Kitt's Peak. Santa Rosa Ranch, east of the Comobabi Range (Ferriss). Cababi Hills (Frank Cole), Type 112254 A.N.S.P. Along the Comovo road to Ajo, but not nearly reaching that place (Ferriss). Santa Rosa spur of the Nariz Mountains at summit, 760 meters, on the international boundary near Monument 163, W. $112^{\circ} 38'$ (Dr. E. A. Mearns, 187479 U.S.N.M.).

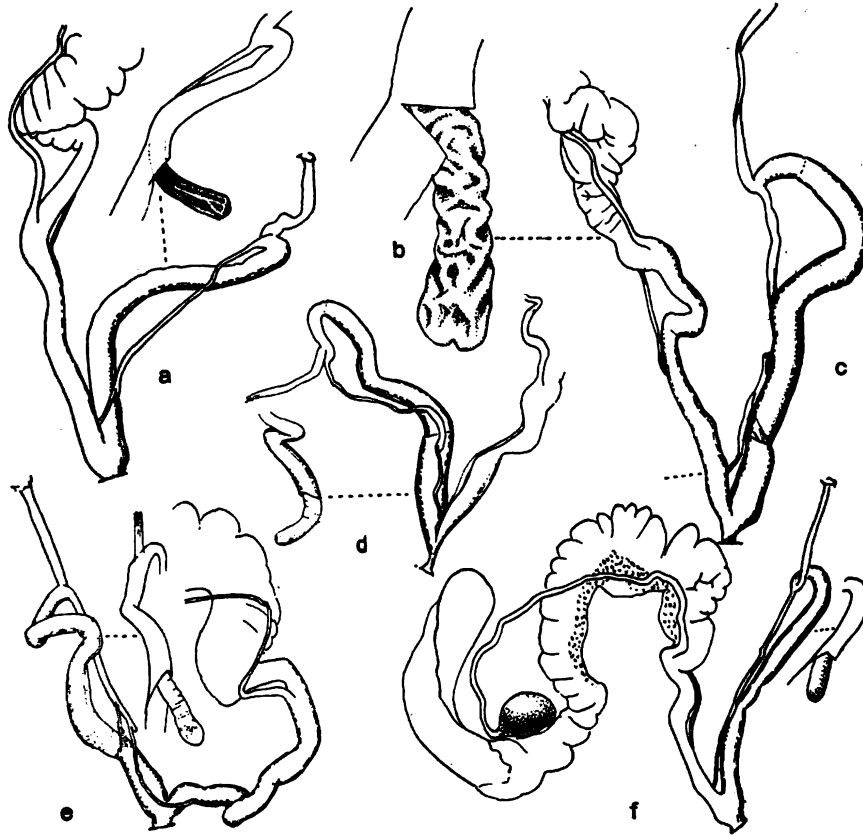


Fig. 227. Genitalia of *Sonorella ambigua*. a, Bobb's Butte, Roskruge Mts., 118078; b, c, west of Coyote Mts., 118093; d, west of Comovo Church, 118096 (form *cyclostoma*); e, Cababi Mts., 118018; f, Roskruge Mts., 118081.

S. sabinoensis tucsonica, which replaces *S. ambigua* in the next mountains eastward, the Tucson range, lives in similarly arid places and has a very similar shell, but it differs by possessing diagonal threads on the embryonic shell, and a slender, tapering verge. *S. ashmuni capax* also has obliquely spiral threads on the embryonic whorl. The absence of such threads on the embryo shell, the rather large caliber of the long penis and of the blunt verge, generally larger at the end than further up, the penis longer than the epiphallus, are diagnostic of *S. ambigua*. The wrinkling of the verge,

doubtless due to contraction in alcohol, still ultimately depends upon its structure, and it varies in specimens from different mountain ranges. No fresh specimens have been dissected; the figures and descriptions are from alcoholic preparations.

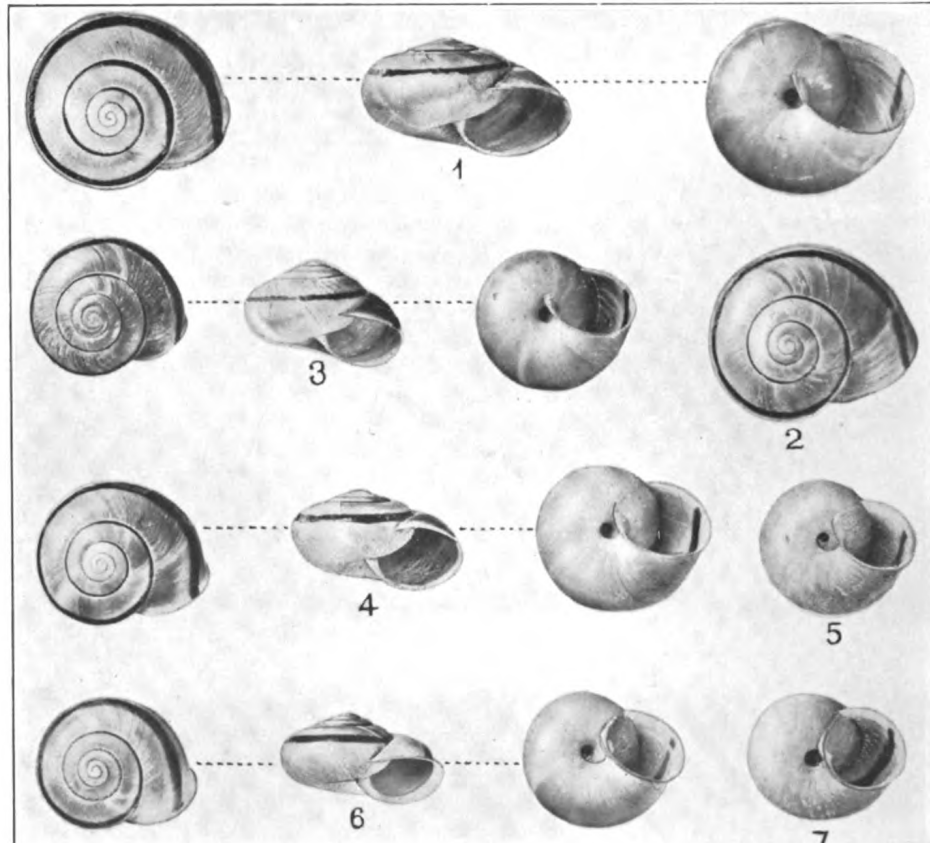


Fig. 228. *Sonorella ambigua*. 1, 2, Coyote Mts.; 3, 4, outlier of Kitt's Peak. 5-7, form *cyclostoma*, hills south of Comovo road.

The shell varies considerably in size. In the Robles Hills it is usually small, 18.5 to 21.5 mm. in diameter. In the Roskruges the lots run 19 to 24 mm. The largest are from the Coyote Range, up to 28.3 mm., the last whorl very wide, as in Figure 228: 1, 2; but in other lots about 23 mm. On and around Kitt's Peak at the north end of the Baboquivari Range both large and small shells are found, the smallest, 18.5 to 22 mm., in the humid place where *S. xanthenes* occurs. In the Cababi Mountains, topotypes run from 21 to 23.5 mm., the largest from this range having a diameter of 24.6 mm. The penis and other organs of course vary in length as well as the shells; many measurements were given in our paper of 1923.

This is a true desert snail, found in stone piles and slides in arid ranges; exceptionally, as on Kitt's Peak, in a somewhat humid place. It spreads over a wide area for a *Sonorella*, from about 25 miles west of Tucson at Robles ranch and the Roskrige Mountains to the Nariz Mountains on the Mexican boundary, some 80 miles southwest, and west of any other south Arizona species of the genus. It appears to have been first taken by Dr. Mearns during the International Boundary Survey; then in the Coyotes by E. A. Goldman of the Biological Survey, whose specimens are 215129 U.S.N.M., 4 dead shells, one in good condition. In 1915 Frank Cole found the type lot in the Cababi range. The species was next found by J. A. G. Rehn, who took numerous examples in the main canyon of the Coyotes at between 3600 and 3750 feet, in August, 1916. Finally, in 1918 Mr. Ferriss worked over the whole area as now known, except the Nariz Mountains, collecting large series, of which some 850 specimens are in the Academy's collection.

A form of this species from small hills south of Comovo road to Ajo, about 3 miles west of Comovo Church, was described as *S. ambigua cyclostoma* (Fig. 228: 5-7). It is a peculiar local form, but probably not distinct enough for subspecific rank. The caliber of the whorls is somewhat reduced and the aperture is less oval, nearly round. The lip margins converge more than in *ambigua*, and are united by a callus in old individuals. Umbilicus rather large, contained 6 times in the diameter. Embryonic shell as in *S. ambigua*. The peristome is well expanded and somewhat thickened within. Height 11 mm., diameter 21.6 mm., aperture 10.6 x 11.6 mm.; $4\frac{1}{2}$ whorls.

Genitalia as in some specimens of *S. ambigua*, the verge smooth. Length of penis 12.5, verge 9, epiphallus 10.5, vagina 9.5 mm. (Fig. 227 d). The animal, in alcohol, is light brownish vinaceous, duskier on the back, as in *S. ambigua*.

(*Ambiguus*, doubtful.)

SONORELLA DRAGOONENSIS GROUP

Embryonic shell without diagonal threads; the first or all later whorls with epidermal hairs or papillae. Verge thick, cylindrical, blunt at the end. The hairs mentioned are sometimes present only in quite perfect shells.

The Dragoon and Mule Mountains, where these snails live, have some brush but no forest at the present time.

Sonorella dragoonensis Pilsbry & Ferriss

Fig. 229.

Sonorella dragoonensis Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 369, pl. 8, figs. 1-1 b; pl. 11, figs. 4, 4 a.

The shell is rather depressed, umbilicate (the umbilicus contained nearly 6 times in diameter of the shell), thin, somewhat translucent, pale buffy brown, with whitish bands on both sides of a chestnut-brown band at the

shoulder. The spire is low conic, whorls $4\frac{2}{3}$, moderately convex. First whorl beginning smooth, followed by a brief stage of coarse radial wrinkles, and succeeded by papillae and short, irregular radial wrinkles in groups, or irregular rugosity, interrupted by short wrinkles in a spiral direction, but often indistinct, which on the lower part of the whorl bear epidermal bristles, beginning on the latter half of the first whorl, and continuing throughout



Fig. 229. *Sonorella dragoonensis*.

the embryonic and neanic stages as far as the end of the third whorl. It is succeeded by an excessively minute vermiculate sculpture, which rapidly becomes fainter and disappears on the last two whorls, which are glossy and nearly smooth except for faint growth lines. Last whorl wide, descending in front. Aperture very oblique, round-oval. Peristome thin, very narrowly expanded throughout, a little recurved below; the margins approaching, parietal callus short, thin except in old shells.

Height 11.2 mm., diameter 19.7 mm.; aperture 9.7 x 10.7 mm.

Back dusky, tentacles dark, sole pale yellowish, with faint longitudinal lines, demarking the areas, near the tail.

Genitalia (Fig. 230: 4, 4a, no. 103093). The penis is large, cylindric, encircled by a small muscular sheath at the contracted base, its retractor muscle inserted upon the apex of the penis and the base of the epiphallus. The walls of the penis are thin. Verge (Fig. 230: 4a) nearly as long as the penis, stout, cylindric, having obliquely longitudinal corrugation near the end, the apex being obtusely conic with terminal pore. The flagellum is longer than usual. Epiphallus is about equal to the penis in length. The vagina is decidedly shorter than the penis. The duct of the spermatheca is very long. Length of penis 10; epiphallus 10; flagellum 1.3; verge 8; vagina 6; spermatheca and duct 39 mm.

No. 103094: Penis, 11; epiphallus, 9; flagellum, 1.3; verge 7.5; vagina 7 mm.

The jaw is highly arched, with five broad, unequal ribs.

ARIZONA: Dragoon Mountains (Ferriss & Daniels), Types from Bear Canyon, 103094, A.N.S.P. Also south of the Huzzar Mine, in the same vicinity.

This snail resembles *Dos Cabezas* species by the position of the insertion of the penis-retractor, the cylindric verge and the short vagina. It differs from all of these in its very large and differently sculptured verge, and the thin shell, with rounded aperture, and minute granulation and hairs on the neanic whorls, and a different pattern on the embryonic whorls, like the following species. It is not closely related to any species of the ranges farther west. The diameter varies from 18.5 to 21 mm.

Fig. 230. 1-1c, 2-2b, *Sonorella bartschi*. 3, 3a, *S. ferrissi*. 4, 4a, *S. dragoonensis*. 5-5c, *S. apache*.

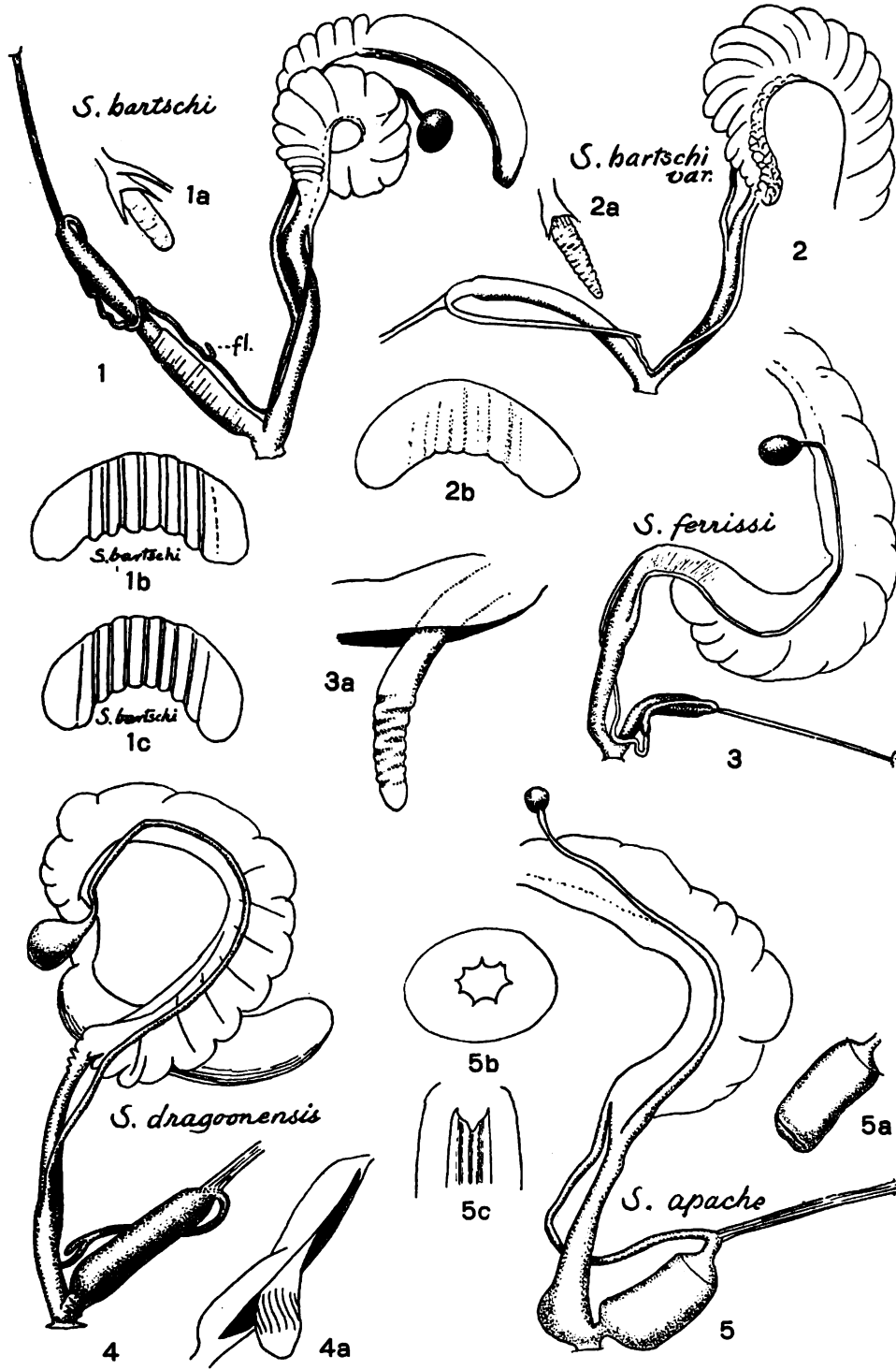


Fig. 230 (explanation on page 358).

Sonorella apache Pilsbry & Ferriss

Fig. 231.

Sonorella apache Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 371, pl. 8, figs. 2-2b; pl. 11, figs. 5-5c.

The shell is depressed, with low, conoidal spire, umbilicate, the width of umbilicus contained 8 times in the diameter; extremely thin; matt isabella color above, paler below, glossy and diaphanous in the central half of the base, encircled by a narrow chestnut-brown band above the periphery. Whorls $4\frac{1}{2}$, the embryonic shell comprising $1\frac{1}{2}$, sculptured like that of *S.*



Fig. 231. *Sonorella apache*, type.

dragoonensis. The neanic whorls are very minutely crinkled and closely set with short, delicate bristles in irregular oblique lines. About 110 of these bristles stand on one square millimeter, on the upper surface of the last whorl in front of the aperture. The bristles are delicate, and in cleaning the shell they are likely to be removed in large part. The last whorl is wide and descends rather deeply in front. The aperture is very oblique, subcircular. Peristome thin, the upper and outer margins very narrowly expanding, basal margin slightly recurved, columellar margin dilated, running forward. The ends of the peristome converge strongly, and are connected by a very thin, short, parietal film.

Height 10.5 mm., diameter 17 mm.; width of umbilicus 1.9 mm., aperture 8.7 x 9.8 mm.

Genitalia (Fig. 230: 5-5c). The penis is short and very thick, cylindric, obtuse at the ends, much shorter than the vagina. It has very thin walls, and is filled by a thick, fleshy verge (Fig. 230: 5a). This is thick-walled with a rather large cavity having plicate walls so that it is star-shaped in section (Fig. 230: 5b). At the upper end of its cavity there is a short, conic nipple (Fig. 230: 5c); at the distal end of the verge the cavity opens by a transverse slit. The retractor muscle of the penis is inserted on the epiphallus near the penis. The epiphallus passes imperceptibly into the vas deferens. There is no flagellum. The lower end of the vagina is swollen, having thick, fleshy walls. The organs measure as follows: Penis 7, verge 5, retractor muscle 8, vagina 11 mm.

ARIZONA: Dragoon Mountains (Pilsbry & Ferriss), the Type from the southern (or cataract) branch of Tweed Canyon, on the east side of the rocky bed near the foot of the "falls," 111529 A.N.S.P. Also found in a large slide of heavy, angular stone farther north on the same branch, rather high on the west side of the ravine, under the great crag. A few dead shells were found in a gulch of the rugged south wall of Tweed Canyon, and on the eastern ridge of the amphitheatre of upper Tweed Canyon.

This species is somewhat related to *S. dragoonensis*, but differs by its smaller size, thinner shell, decidedly smaller umbilicus, and by having the last whorl densely hairy, the hairs extremely short and close. *S. apache* differs from *S. dragoonensis* rather conspicuously in soft anatomy. The penis is shorter with a differently constructed verge; there is no flagellum; the vagina is much longer and is strongly swollen at the base. The anatomical characters of both have been examined in several specimens from different stations.

The delicately hairy periostracum will serve to separate *S. apache* from other species of the genus. It is an extremely distinct species.

S. apache was found only in igneous or metamorphic rock, never in the limestone. It was not found sealed to the rock, nor were any white circles seen on the rocks it inhabits, thus differing from nearly all other *Sonorellas* collected by the author.

The largest shell seen measures 18.5 mm. in diameter.

(This snail lives among the great crags around Cochise Stronghold, a favorite resort of the Apaches, for whom the species was named.)

***Sonorella ferrissi* Pilsbry**

Fig. 232.

Sonorella ferrissi Pilsbry, in Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 368, pl. 8, figs. 3-3b; pl. 11, figs. 3, 3a.

The shell is strongly depressed, umbilicate, the width of umbilicus contained five to six times in the diameter; rather solid; of a pale brown tint, between cinnamon and wood-brown, fading around the umbilicus, having broad white bands above and below the narrow chestnut-brown shoulder band and crossed by one or several whitish streaks, reminiscent of former



Fig. 232. *Sonorella ferrissi*, type and paratypes.

peristomes. The surface is semimatt. The initial one-fourth whorl is smooth; a brief stage of coarse radial wrinkles ensues, followed by fine, short, interrupted radial wrinkles, so short as to be papillae near the upper suture, and sparse, short elevations, arranged in spiral, forwardly descending series. On the second whorl these elevations become distinct, rather regular papillae, which persist, in some examples, upon the third whorl; in young shells these papillae bear short hairs, which are usually lost in adult shells. The last whorl has fine striae and microscopic wrinkling. The spire is but slightly convex. The whorls increase slowly, the last descends a little in front and is rounded at the periphery and base. The peristome expands very slightly in its lower half, and its edge has a rusty tint. It is thickened within by a rather wide but thin white callus, which shows as an opaque buff border behind the lip. The columellar termination is slightly dilated, and the parietal callus moderately thick in fully mature or old individuals.

Height 7 mm., diameter 14.5 mm.; $4\frac{1}{2}$ whorls.

Genitalia (Fig. 230: 3, 3a). The penis is somewhat slender, slightly shorter than the vagina, and a trifle longer than the epiphallus. It contains a cylindrical verge nearly as long as itself, transversely wrinkled in the distal third and rounded at the end (Fig. 3a). The retractor muscle is inserted on the epiphallus near its base. There is no flagellum. Length of penis 4 mm.; verge 3+ mm.; penial retractor 6 mm.; epiphallus 3+ mm.; vagina $5\frac{1}{2}$ mm.

ARIZONA: Dragoon Mountains, from the northern ridge of Tweed Canyon to the ridges facing the northern slope of the mountains (Ferriss, Pilsbry and Daniels), Type 103097 A.N.S.P.

The shell in this extremely distinct species reminds one a little of *Trichodiscina*. There is no other *Sonorella* like it. The embryonic sculpture is alike in this snail and the two preceding, particularly in the development of hairs on the last embryonic and first neanic whorls. By the form of the verge it resembles *S. bicipitis* of the Dos Cabezas Range as much as anything. It is abundant in the northern part of the Dragoon Range, but Tweed Canyon apparently forms an impassable barrier to its spread southward.

We rarely found *Sonorella ferrissi* sealed to stones, forming small rings. Most living ones were found activating loose under stones or in the earth, lying with the aperture up, like eastern helices, and sealed with a somewhat convex white epiphragm. It belongs exclusively to the limestone terrain.

(Named for my friend and frequent companion in the field for half a lifetime. Nautilus 40: 1.)

***Sonorella bartschi* Pilsbry & Ferriss**

Fig. 233.

Sonorella bartschi Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 384, pl. 8, figs. 4-4b; pl. 11, figs. 1-2b.

The shell is strongly depressed, rather openly umbilicate, width of umbilicus contained nearly six times in the diameter; moderately strong, though thin; color between cinnamon and wood brown, fading to white around the umbilicus, and encircled above the periphery with a dark chestnut band, bordered above and below with white bands, as wide as the dark band or wider. Surface glossy; initial $\frac{1}{3}$ whorl of the embryonic shell smooth; a few radial wrinkles follow, after which it has radial striae which become more or less interrupted, forming irregular, long granules; beginning with the second whorl, there are short hairs, subregularly placed in forwardly descending rows; these, or their scars, continue to the penultimate whorl, where they weaken and disappear. The last whorl has a weak sculpture of growth wrinkles only. Whorls rather slowly increasing, convex, the last descending well below the periphery in front. Aperture strongly oblique, subcircular. Peristome thin, expanded rather slightly above, strongly below, the ends approaching and joined by a very short but distinct parietal callus.

Height 11.4 mm., diameter 20 mm.; aperture 9.7 x 10.8 mm.; umbilicus 3.5 mm. wide; whorls $4\frac{2}{3}$. Type.

Height 10.2 mm., diameter 18 mm.; whorls $4\frac{1}{2}$.

The back and tentacles are slate colored, sides gray. The sole shows no longitudinal divisions or areas.

Genitalia (Fig. 230: 1, 1a, 2, 2a). The penis is long, its lower half very slender, enveloped in a long sheath composed of glossy circular muscular tissue. The upper half is somewhat swollen. The verge (Fig. 1a) is rather short, cylindrical, very faintly wrinkled transversely, the distal end obtuse, rounded. The flagellum is about 0.8 mm. long. The vagina is about half as long as the penis. Length of penis 14 mm.; epiphallus 11 mm.; verge about 5 mm.; vagina 7 mm.; spermatheca and duct 22 mm.

The jaw (Fig. 230: 1b, 1c) has six to eight rather strong ribs.

ARIZONA: Mule Mountains on Mt. Ballard, in the Escabrosa Ridge, about 2 miles west of Bisbee, on a ledge of the north side near the summit, elevation about 7000 feet (Pilsbry), Type 103095 A.N.S.P. It was also taken on the northern slope of a limestone hill about two miles east of Warren.

The shell is quite characteristic by its conspicuous white bands bordering the dark band at the shoulder, the rather open umbilicus, and the nearly circular, strongly oblique aperture. It is a handsome snail when fresh, not closely resembling any other species we have seen.

The hairs of the neanic whorls are very delicate and fugacious; but when they are gone the spire still remains rougher than the last whorl, having an indistinct pattern of radial wrinkles or irregular, long granules. This disappears entirely on the last whorl. The embryonic whorls are essentially similar to those of the Dragoon mountain group, and these appear to be its nearest relatives. The diameter varies from 14 to 20 mm.

We do not find in the shells of the Warren form any constant difference from those of the type locality; but the genitalia (Fig. 230: 2, 2a) and jaw differ somewhat in the only living adult taken. The penis has scarcely any sheath; only a few fibres bind the epiphallus. Flagellum more minute. Verge (Fig. 2a) nearly half the length of the penis, tapering and wrinkled. The penial retractor is inserted on the epiphallus near its base. The vagina is nearly as long as the penis. Length of penis 10.5 mm.; epiphallus 10 mm.; verge 5 mm.; vagina 9 mm.

The jaw (Fig. 230: 2b) has about 5 weakly developed ribs.

(Named for Dr. Paul Bartsch of the National Museum, author of an early monographic paper on *Sonorella*.)



Fig. 233. *S. bartschi*. Type.

SONORELLA CLAPPI GROUP

Embryonic whorls without diagonal threads, the rest of the shell minutely granulose or with impressed spirals on upper surface of last whorl; young shells usually minutely hairy. Vagina not longer than the penis.

Sonorella clappi Pilsbry & Ferriss

Fig. 234.

Sonorella clappi Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 397, pl. 9, figs. 8-8b; pl. 12, figs. 6, 7.

The shell is umbilicate (umbilicus contained about 7.3 times in the diameter), thin, depressed, semimatt, cinnamon-buff the base paler, fading to olive-buff in the middle, and with a chestnut-brown shoulder band having paler borders. Embryonic shell of $1\frac{2}{3}$ whorls, the initial $\frac{1}{4}$ whorl smooth,



Fig. 234. *Sonorella clappi*, type and paratype.

the rest densely and evenly reticulate-granulous, having an indistinct zig-zag pattern in some places, but without the spirally descending threads of the *hachitana* type. Subsequent whorls are lightly striate and microscopically wrinkle-granose, this sculpture becoming weaker on the base. Whorls $4\frac{1}{3}$, the last descending in front, rounded peripherally. Aperture rounded-oval, the peristome thin, narrowly expanded.

Height 10.3 mm., diameter 19 mm.; umbilicus 2.5 mm. Type.

Height 10.3 mm., diameter 18 mm. Globose topotype.

Height 9 mm., diameter 17.7 mm. Depressed topotype.

Genitalia (Fig. 157: 6, 7). Penis slender throughout, with a thick, short basal sheath and a long verge. Epiphallus and vas deferens slender, the former terminating in a minute flagellum, the retractor muscle inserted close to its base. Vagina shorter than the penis. Length of penis 8.5, epiphallus 8.5, verge 6, vagina 5 mm. (type). In another specimen, penis 6.5, epiphallus 8, vagina 3, spermatheca 25 mm.

ARIZONA: Santa Rita Mountains in the Walnut Canyon branch, 5000 feet, and in several places around the heads of Agua Caliente Canyon at 6500-7000 feet; across the ridge eastward in Madera Canyon, 6000-7000 feet; Camperel Canyon on the eastern slope of the mountains, northeastern flank of Old Baldy, down to about 6500 feet (Ferriss, Daniels and Pilsbry), Type 112163 A.N.S.P., from Madera Canyon.

This is a smaller, thinner shell than other Santa Rita *Sonorellas*, and readily distinguished by its microscopic granulation and the beautiful sculpture of the embryo. The size runs from 16.7 to 19.8 mm. diameter. It is variable in degree of elevation of the spire, size of umbilicus and color.

In Madera Canyon the shell has a russet hue. In Walnut branch of Agua Caliente Canyon the color ranges from almost chamois in the thicker old individuals to nearly water green in those barely grown to full size. Around the head of Agua Caliente Canyon the color is similar. The microscopic granulation is sometimes typically developed on the last whorl, but is often more or less obsolete, sometimes only visible in a few places; and most specimens show incised spiral lines on the last whorl. The colorless mucus is very tenacious.

In the lower stations it lives in canyons well shaded with deciduous trees, but the higher stations and those on the east slope of the range are in the pine zone.

S. clappi resembles the Huachuacan *S. granulatissima* and *S. danielsi* in the embryonic sculpture and the general appearance, but in those species the aperture is more oblique than usual in *S. clappi* and the genitalia are conspicuously different.

A couple of shells from Station 17½, Camperel Canyon, on the eastern slope of the range, resemble the Agua Caliente form in being light colored. One from Station 17, in the same canyon, is the darkest of all, being nearly a sorghum-brown color, more vinaceous where the cuticle is worn off. The genitalia (Fig. 157: 4, 4a) differ from typical *S. clappi* by the longer penis and penis sheath, and the shorter vagina. Length of penis 13, verge 10, epiphallus 10, flagellum 1, vagina 4.5 mm.

(Named for Dr. George H. Clapp, long-time friend of both authors.)

Sonorella clappi occidentalis Pilsbry & Ferriss

Fig. 235.

Sonorella granulatissima occidentalis Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 398, pl. 9, figs. 7-7b.

The shell is similar to *S. granulatissima* and *S. clappi* in sculpture; light brownish cinnamon colored, fading on the base, and with distinct whitish bands above and below the chestnut-brown suprapерipheral band. The



Fig. 235. *Sonorella clappi occidentalis*, type.

surface is microscopically densely granulose, with numerous well impressed spiral lines (as figured for *S. danielsi*), becoming weaker below periphery. Last whorl narrower than in *clappi* (in apical view), and there is about a half whorl more than in *clappi* of equal size; it is less depressed than *S. clappi*; umbilicus contained $6\frac{2}{3}$ times in the diameter.

Height 12.2 mm., diameter 19.8 mm.; $4\frac{2}{3}$ whorls.

ARIZONA: Santa Rita Mountains, on the northeastern flank of Old Baldy (Camperel Canyon), (Pilsbry), Type 112165 A.N.S.P.

First described as a subspecies of *S. granulatissima*, but I think it more likely to belong near *S. clappi*, of the same mountains. The soft parts, which were lost, will decide its affinities.

(*Occidentalis*, western.)

Sonorella vespertina Pilsbry & Ferriss

Fig. 236.

Sonorella vespertina Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 414, pl. 10, figs. 5-5b; pl. 13, fig. 9.

The shell is umbilicate (width of umbilicus contained about 8 times in diameter of the shell); cinnamon buff, fading to whitish around the umbilicus, and with white bands above and below the chestnut-brown shoulder band. Surface glossy, the initial half-whorl having some radial wrinkles,



Fig. 236. *Sonorella vespertina*, type and paratypes.

the rest of the embryonic shell without any distinct sculpture, though there is some extremely indistinct radial roughness, stronger near the suture. In fresh young shells of $2\frac{1}{2}$ whorls the surface of the last embryonic and first neanic whorls is densely set with very short hairs, extending also over the base. These are fugacious, lost with further growth. The later whorls are marked with the usual growth lines. Whorls $4\frac{1}{2}$, the last rapidly widening, rather steeply descending close to the aperture. Peristome narrowly expanded on the outer and basal margins, dilated and reflexed at the columellar insertion.

Height 11 mm., diameter 19.8 mm.; aperture 9.2 x 11.5 mm.

Genitalia (Fig. 237: 9). The penis is very small and tapers distally to the epiphallus, the long penial retractor being inserted in the latter. The flagellum (fl.) is represented by a minute bud or a slight swelling. The verge (pp.) is slender, tapering, and weakly annular. The vagina is slender. Free vas deferens very long. Length of penis 4.3, verge 2.5, epiphallus 5.5, vagina 5.5 mm.

ARIZONA: Baboquivari Mountains, on the west side of the ridge, close to the summit, a half-mile south of Baboquivari Peak, abundant (Pilsbry and Daniels), Type 111554 A.N.S.P.

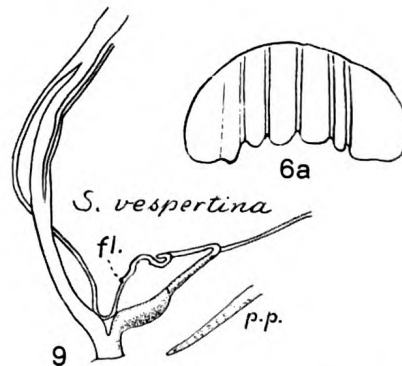


Fig. 237: 6a, *Sonorella eremita*, jaw; 9, *S. vespertina*, genitalia.

This species is readily distinguished from *S. baboquivariensis*, the only other *Sonorella* found in that vicinity, by the wider umbilicus, smaller aperture, the shorter, steeper descent of the last whorl to the aperture, and the absence of distinct sculpture on the embryonic whorl; also by the very different genitalia. The lip is less expanded and the shell is constantly smaller and more depressed than *S. papagorum*, with which it agrees in the obsolescence of the apical sculpture. In shell characters it comes very close to *S. sitiens*, which differs by the form of its verge. The size varies from diameter 17.8 mm. with $4\frac{1}{3}$ whorls to 20.4 mm. Specimens reported from the Qui-i-tomoc Hills prove to be *S. sitiens*.

(*Vespertinus*, of the evening, hence western.)

Sonorella odorata Pilsbry & Ferriss

Fig. 238.

Sonorella odorata Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 285, pl. 3, figs. 1-4, text-fig. 1 a-d; 1923, Proc. Acad. Nat. Sci. Phila., 75: 87, pl. 6, fig. 8.

The shell is thin, depressed, umbilicate, the umbilicus contained about 7 times in the diameter of shell; buffy-citrine below, somewhat lighter than isabella color above, with a chestnut brown band at the shoulder. The first half whorl has irregular radial wrinkles soon passing into a low granulation,

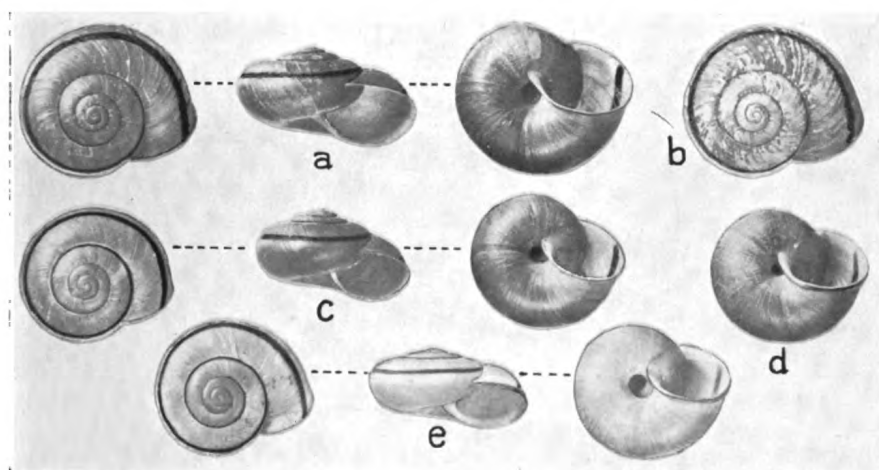


Fig. 238. *Sonorella odorata*: a, b, near Alder Spring; c, head of Alder Canyon; d, Soldier Camp. e, *S. odorata marmoris*.

the last embryonic whorl granular, over which there are close decurrent threads, interrupted into short dashes on the upper part of the whorl. Subsequent whorls are very minutely granular, somewhat dull; the last whorl has a very minute spiral, wavy corrugation in the most fully sculptured shells; but often it is interrupted or nearly effaced. It is wanting at the base, which is more glossy. The whorls are quite convex, the early ones

increasing slowly, the last widening rapidly, rather abruptly descending close to the aperture. The aperture is elliptical-lunate; peristome is narrowly expanded throughout, dilated at the columellar insertion.

Height 11.4 mm., diameter 19.8 mm.; $4\frac{1}{2}$ whorls. Type.

Height 13.4 mm., diameter 23.3 mm.; $4\frac{3}{8}$ whorls. Near Alder Spring.

Height 13.2 mm., diameter 22 mm. Near Alder Spring.

The sole is tripartite in color, the side areas being somewhat darker. The back and head are quite dark in most alcoholic specimens, black in life, the tips of the tubercles lighter.

The penis is small, containing a cylindric verge with rounded end, about two-thirds as long as the penis. The penial retractor is inserted upon the epiphallus not far from its base. The flagellum is present as a very minute but distinct bud in most of the specimens opened, but in two it was not seen though looked for (Fig. 239). Measurements in mm. follow:

Locality	Penis	Verge	Epiphallus	Flagellum	Penial retractor.	Vagina	Diameter of shell	Number
Head of Alder Canyon	6.6	..	7.5	trace	7	6	20	119,033
" " " "	6.5	4	7.2	0	8.5	7	20	119,033
N.-E. side Mt. Lemon	6	3.3	8	trace	5	4.5	19	119,034
" " " "	6	4	5	trace	7	4	24	119,035
" " " "	7	5	8	trace	6	5	..	119,035
Spud Rock	6	3	10	trace	..	7	22	
<i>S. o. marmoris</i> , Station 36 ..	10.7	6.5	8	1	..	8	20	109,075 a

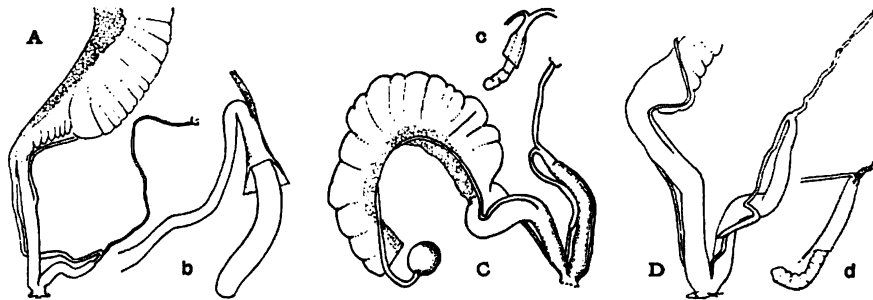


Fig. 239. A, b, c, c, *Sonorella odorata*. D, d, *S. odorata marmoris*.

ARIZONA: Santa Catalinas above 7500 feet: Mt. Lemon in several places; Soldier Camp; Bear Wallow; Head of Alder Canyon, type locality, 119033 A.N.S.P. Kellogg Peak, southeastern side. Rincon Mountains at Spud Rock Ranger Station, and on the north slope (J. H. Ferriss).

By the genitalia this species is related to *S. clappi* of the Santa Rita Range, and *S. ferrissi* of the Dragoons, though differing from both in several details. The shell is most like *S. clappi*. It differs from other Santa Catalina species by the minute granulation of the surface, which gives it a dull, silky luster.

The sculpture is variable. In shells from Mt. Lemon and Soldier Camp the pattern is less strongly developed than is usual in Alder Canyon, or sometimes it is partly effaced. Some very faintly impressed spiral lines are often visible on the last whorl. But little of the sculpture can be seen with a hand-lens. The color also varies. At Soldier Camp (Fig. 238 d), Cañada del Oro and some other places the general hue is cinnamon or cinnamon-buff, opaque, and the size small, diameter 18 to 20 mm. The smallest adult seen measures 17 mm. in diameter.

It lives in deep, humid forest in colonies, as our eastern helices do, under logs and bark of quaking asp and Arizona fir, sometimes by dozens. It is a timber snail of the Canadian zone forest. In general aspect the shell reminds one of the Californian helices.

"This is a common snail in the heavily wooded upper levels of the Santa Catalinas, taken at many stations. When picked up it emits a strong unpleasant odor recalling that of the goldenrod of Thunderhead Mountain in East Tennessee (probably *Solidago odora*). This was first noticed at Kellogg Peak. When picked up the snail shot out two or three drops of liquid six inches or more (evidently expelled from the lung as the foot is retracted). One often smelled them before finding any. Only three or four shells broken by mice or squirrels were noticed in the course of collecting, and it may be that the snail-eaters object to the smell." (J. H. Ferriss.)

Form *populna* new form.—In the Rincon Mountains, Mr. Ferriss found a form in which the shell is thinner, dilute chamois to olive-buff, the band with only indistinct light borders or none; umbilicus contained 7 times in diameter; last whorl wider than in *odorata*; the upper and columellar margins of peristome brought further forward and more approaching; granulation very weak and minute. This form may be called form *populna*, the type being 166375 A.N.S.P., from Spud Rock Range Station, deep in rock slides in an aspen grove. Two specimens found in a day's search "on the northern slope of the Rincons" have irregularly spaced impressed and wavy spiral lines on the last whorl. Such lines are rarely seen in the Spud Rock series, and when present are less developed.

Sonorella odorata marmoris Pilsbry & Ferriss

Fig. 238 e.

Sonorella odorata marmoris Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 288, pl. 3, figs. 6-6 b; text-fig. 2.

The shell is more solid and cretaceous than *S. odorata*, opaque; dilute cinnamon-buff, paler around the umbilicus and on both sides of the chestnut-brown band. Last whorl is decidedly more depressed than in *S. odorata*, and is narrower as viewed from above. The umbilicus is wider, contained not quite 6 times in diameter. The aperture is much smaller.

Height 10 mm., diameter 20.3 mm.; 4 $\frac{3}{4}$ whorls. Type.

Height 9 mm., diameter 18 mm.; 4 $\frac{1}{2}$ whorls.

Genitalia (Fig. 239 d, d) in general similar to *S. odorata* but the penis and verge are decidedly longer, and there is a flagellum, well developed for a *Sonorella*. Measurements of the organs are given in the table on page 368.

ARIZONA: Santa Catalina Mountains: Marble Peak, on the east side above the rock slide; Old Dan's Gulch on the northwest side, type locality; ridge running toward Mt. Lemon (J. H. Ferriss), Type 109075 A.N.S.P.

It lives in relatively dry rock slides, with the smooth *Sonorella marmorarius*, high on Marble Peak and its flanks, thus differing in habits from *S. odorata*. The last whorl shows an irregular, microscopic granulation on the upper surface. The shell is readily separable from *odorata*. It has the same peculiar odor.

(*Marmoris*, of marble.)

Sonorella grahamensis Pilsbry & Ferriss

Fig. 240.

Sonorella grahamensis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 311, pl. 6, figs. 7-7 b; text-fig. 9.



Fig. 240. *Sonorella grahamensis*, type.

The shell is umbilicate, width of umbilicus contained about 8 times in the diameter of shell, very thin, tawny-olive, paler at the base, with the usual band which has indistinct pallid borders; not very glossy. Embryonic $1\frac{1}{2}$ whorls with radial rugosity and granulation after the initial smooth tip, then fine, irregular and indistinct wrinkle network; no oblique threads. Last whorl under the lens showing the usual weak growth-lines, and both above and below there are numerous impressed spiral lines. Whorls slowly increasing at first, the last rapidly widening, descending in front. Aperture rounded-oval, quite oblique. Peristome is thin, very little expanded.

Height 10.3 mm., diameter 19 mm.; umbilicus 2.2 mm.; $4\frac{1}{2}$ whorls.

Genitalia (Fig. 241). The penis has a well developed sheath at the base, and contains a long, tapering verge. The penial retractor is inserted at the base of epiphallus and apex of penis as in the *hachitana* group.

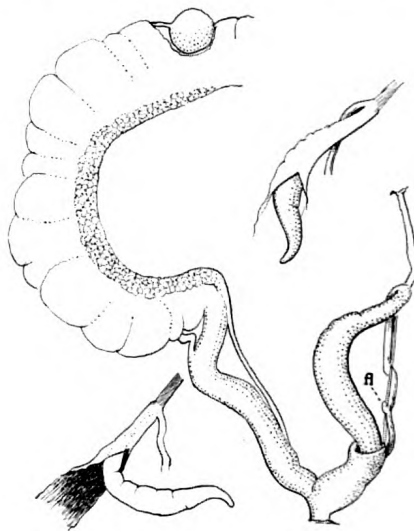


Fig. 241. Genitalia of *S. grahamensis*, with two details of the verge. Type specimen. fl., flagellum.

There is a short flagellum. Length of penis 9 mm.; verge 7; epiphallus 6; flagellum 0.5; penial retractor 4.7; vagina 7; spermatheca and duct 19 mm.

ARIZONA: Mt. Graham, in the Pinaleno Range, Graham County (J. H. Ferriss), Type 109101 A.N.S.P.

Graham Mountain, 10516 feet, is composed of crumbling granite and is very dry on both north and south sides. On top there is yellow pine and quaking asp forest. Camp was made in Stockton Pass, and a couple of hour's collecting done at Mud Spring, on the summit. Besides *Sonorella* and *Oreohelix*, *Vitrina alaskana* was abundant, and young Vallonias were found. The Pinaleno Range lies in line with the Chiricahua system, though separated from the northern end of the Dos Cabezas Mountains by a wide mesa in which the Southern Pacific Railroad runs.

S. grahamensis is not closely related to any other species known. The delicate, spirally striate shell and absence of oblique threads on the second whorl are characteristic.

SONORELLA GRANULATISSIMA GROUP

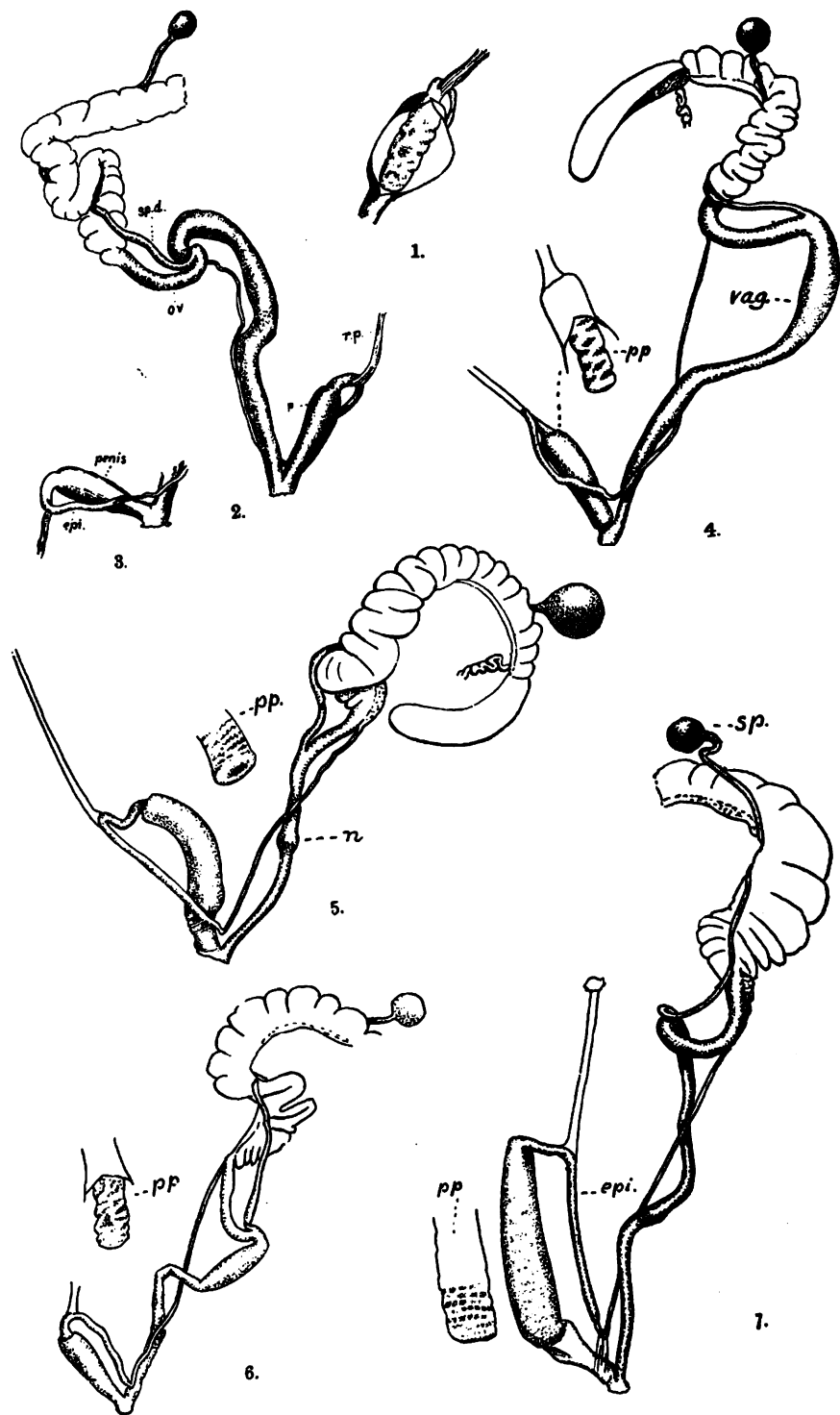
Shells densely granulose; without decurrent threads on the embryonic shell such as are present in the *hachitana* group. Length of penis usually less than diameter of the shell; vagina long, equalling or exceeding the shell diameter.

The three closely related forms composing this quite distinct group occupy the whole wooded part of the Huachuca Range. They differ from *S. clappi* and other granulose species by the very long vagina.

Measurements of the genitalia in mm. follow:

Species, Locality and Museum No.	Penis	Verge	Epiphallus	Flagellum	Vagina	Spermatheca	Diam. shell
<i>S. granulatissima.</i>							
Ramsey, 83,257	7.3	4.8	6	0.7	21	24-25	19
Miller Cn., 94,336	6	4	..	0	28	22	21
Carr Cn., 90,404	5.5	4	..	0	16	.....	18
<i>S. g. latior.</i>							
Tanner Cn., 94,387	6	3.5	5	0	17	16	21-22
Brown Cn., 94,356	6	4.5	6	0	21	.....	18.5
Brown, w. fork, 94,359	5	3.3	4	0	14	.....	18
Salvation, 94,395	7	5	..	0	27	.....	20
Limestone Mt., 94,393	7.5	...	..	0	21	.....	23
<i>S. danielsi.</i>							
Head of Bear, 94,318 ¹	18.5	13	10	0	27.5	22	19
Ditto, 94,317	15	10	..	0	...	.....	18.5
E. fork Cave, 94,352	12	8.5	..	0	17.5	.....	19
Miller Pk., 94,337	13.5	9	10	0	19	25	18-19
Ash Mt. 44,041	10	...	10	0	16	.....	21.4
Copper Cn., 44,035	11.5	8.5	..	0	18	.....	20

¹ Measured from a drowned animal dissected fresh. The other measurements were from alcoholic preparations, some of them considerably contracted.



Sonorella granulatissima Pilsbry

Fig. 243 a.

Sonorella granulatissima Pilsbry, 1902, Nautilus, 16: 32.—Bartsch, 1904, Smiths. Misc. Coll., 47: 193, pl. 32, fig. 4.—Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 262, pl. 17, figs. 21-23; pl. 18, figs. 41-43, 51-54 (shell); pl. 20, figs. 16-18 (genitalia); pl. 23, fig. 23 (jaw).—Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila. for 1909, p. 500, pl. 19, figs. 7-9; pl. 21, figs. 1-4.

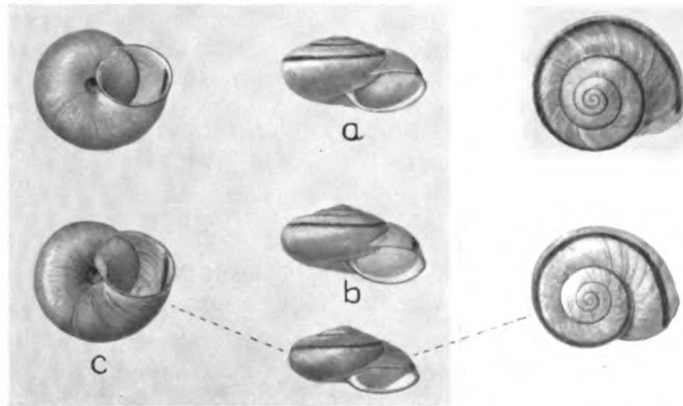


Fig. 243. a, *Sonorella granulatissima*. b, c, *Sonorella danielsi*.

The shell is thin, moderately depressed, with the umbilicus small, contained 8 times in the diameter; translucent, very dilute brownish, usually paler at base, with a cinnamon-brown band without noticeable light bordering bands. Surface with a somewhat silky sheen, more glossy at base. Embryonic shell with radial ripples after the small smooth tip, followed by granulation, the granules somewhat netted together, and after the first half turn they are gradually transformed into obliquely ascending and descending little ridges, but without any of the threads of the *hachitana* group. Post-embryonic whorls are densely and finely granular over the usual light wrinkles of growth. A few weak spiral impressed lines may usually be traced in some places on the last whorl (Fig. 243 a), which descends rather deeply to the aperture. The large aperture is shortly oval, the peristome thin, a little expanded, its margins converging. Type and paratype measure:

Height 10.4 mm., diameter 19.3 mm., aperture 9.7 x 11 mm.; $4\frac{1}{2}$ whorls.

Height 10 mm., diameter 18.5 mm., aperture 8.9 x 9.8 mm.; $4\frac{1}{2}$ whorls.

Diameter 18 to 20 mm. Topotypes.

Diameter 17.8 to 21.4 mm. Carr Canyon.

The sole is indistinctly tripartite, the middle field ochraceous, the sides dusky; the colors separated by very faint lines. The upper surface is blackish-gray, evenly pebble-granose. A subobsolete dorsal line is discernible, and a very weak line on the tail, not quite median.

Fig. 242. 1, 2, 3, *Sonorella granulatissima*, type, Ramsey Canyon; 4, Miller Canyon. 5, 7, *S. danielsi*, paratype and type. 6, *S. granulatissima latior*, Tanner Canyon.

The jaw (Fig. 140) has four very wide, low, flat ribs.

The radula has 36.136 teeth, the central and inner laterals unicuspid, the eleventh showing a minute ectocone. Most of the marginal teeth have both cusps bifid.

Genitalia (Figs. 242: 1-3). The penis is short, its length contained 3 or 4 times in that of the vagina. It is abruptly truncate distally. The verge is quite short, 3.3 to 5 mm. long, cylindric, truncate at the end, and coarsely wrinkled. It is fleshy, perforated by a minute pore, which opens at the end. The rather short epiphallus has no flagellum in any example opened with the exception of one of the topotypes, in which there is a minute, vestigial flagellum about 0.7 mm. long, and bound to the vas deferens by the outer muscular fascia. As a rule, with rare exceptions, therefore, the flagellum is absent. The vagina is large, very long, about three times the length of the penis. Its upper part has thick muscular walls, the outer layer consisting of glossy circular muscular fibers. Usually this part is more or less swollen and fusiform. The lower part of the vagina is thin-walled. This feature was conspicuous in every one of about 20 individuals of 12 lots of *S. granulatissima* and *S. g. latior* which were examined. Measurements on page 371.

ARIZONA: Huachuca Mountains, in Ramsey Canyon (J. H. Ferriss). Type and paratype 83257 A.N.S.P. Carr Canyon; Miller Canyon and Miller Peak.

The delicate shell of this snail is distinguished by its dense beautiful granulation and the faint spiral lines, rarely distinct, and in some specimens they are wanting.

The localities "Spring Canyon" and "Tucson" which have been given for *S. granulatissima* are to be deleted. Mr. Ferriss explained to me that the original lot was found in what is now known as Ramsey Canyon, where he collected in his first visit to the Huachuca. Mr. Ferriss also took specimens somewhere on the western slope of the Huachuca Range, west of the head of Tanner Canyon, but just where is not clear. The locality "Tucson" for various Huachuca Ashmunellas and Sonorellas was derived from National Museum labels on material collected many years ago, when that was doubtless the nearest settlement, and probably was headquarters of the collector. The work of Ferriss, Daniels and the author in that vicinity shows that none of them occur in the very different Tucson fauna.

Some of the shells from Miller Canyon are darker and richer in color than the types, approaching russet. A shell without the dark band was found in Ramsey Canyon. The umbilicus is sometimes wider than in the type, contained $7\frac{1}{2}$ times in the diameter.

(*Granulatissima*, most granulose.)

Sonorella granulatissima latior Pilsbry

Fig. 244.

Sonorella granulatissima latior Pilsbry, 1905. Proc. Acad. Nat. Sci. Phila., p. 264, pl. 18, figs. 24-28.—Pilsbry & Ferriss, 1910. Proc. Acad. Nat. Sci. Phila. for 1909, p. 501, pl. 19, figs. 4-6; pl. 21, fig. 6 (genitalia); text-fig. 2 (teeth).

This form is very similar to *S. granulatissima*, from which it differs in the usually larger size and the more depressed last whorl. The granulation is finer and less distinct than in typical *granulatissima*, and the umbilicus

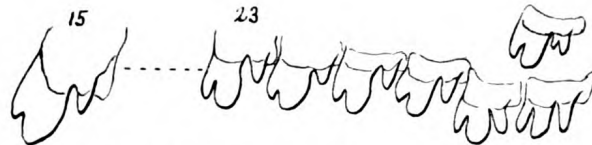
Fig. 244. *Sonorella granulatissima latior*.

is slightly wider, contained $6\frac{1}{2}$ times in the diameter. The suprapерipheral band is wide, and has no paler borders. There are $4\frac{3}{4}$ whorls, the last rather deeply deflexed. The embryonic shell is sculptured as in *S. hachitana*.

Height 11.5 mm., diameter 22.3 mm. Type.

Diameter 20.5 to 23.6 mm. Topotypes.

The genitalia have been examined in numerous examples from Tanner Canyon (Fig. 242: 6), Brown's Canyon, east fork of Salvation Ridge and Limestone Mountain. The characters are identical with those of *S. granulatissima*. All of them have the upper part of the vagina swollen, and there is no flagellum. Measurements of several alcoholic specimens are given in the table.

Fig. 245. Marginal teeth of *Sonorella granulatissima latior*, Tanner Canyon.

The radula has 38. 1. 38 teeth, with 10 laterals. The outer marginal teeth have the inner cusp deeply bifid, the outer one sometimes split (Fig. 245, Tanner Canyon).

ARIZONA: Huachuca Mountains in Tanner Canyon; Brown Canyon.¹ Type 87083 A.N.S.P. Also on the ridge between Tanner and Brown Canyons and south side of Limestone Mountain, east of Brown (J. H. Ferriss).

¹This canyon is indicated but not named on the U.S.G.S. topographic map; it lies between Tanner and Ramsey.

Sonorella danielsi Pilsbry & Ferriss

Fig. 243 b, c.

Sonorella danielsi Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila. for 1909, p. 500, pl. 19, figs. 13-15; pl. 21, figs. 5, 7; text-fig. 3; 1923, Proc. Acad. Nat. Sci. Phila., 75: 92.

Sonorella granulatissima (in part) Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., pp. 263-4, pl. 18, figs. 39, 40, 44, pl. 11, fig. 10 (Miller Canyon); pl. 18, figs. 36-38 (Ida Canyon).

The shell is more depressed than *granulatissima*, chamois or slightly more brownish, with a conspicuous dark band without pale borders, the early whorls flesh-colored; surface glossy, the granulation of the last whorl very weak, nearly effaced, spiral incised lines well developed above the periphery (Fig. 246). Umbilicus wider than in *granulatissima*.

Height 10.3 mm., diameter 19.3 mm.; whorls $4\frac{1}{2}$.

The animal is slaty-blackish, the back paler, brownish-gray, collar of mantle dark slate. The sole is slate colored at the sides, the middle gray, but the areas are not bounded by lines. The lung has faint venation; pulmonary vein breaking up into several large branches.

Genitalia (Fig. 242: 5, 7). The penis is very large, stout, subcylindric, half the length of the vagina or longer. It collapses at the base, where not filled by the verge, and has several strong longitudinal folds inside. It contains a long cylindric verge which is abruptly truncate at the end and wrinkled-areolate throughout. There is no flagellum. The long vagina is rather slender throughout, with an annular swelling or node about midway of its length; it is longitudinally rugose within, the rugae coalescent at the node. Figure 242: 7 was drawn from a drowned specimen which had not been in alcohol (no. 94318).



Fig. 246. *S. danielsi*. Miller canyon ($\times 7$).

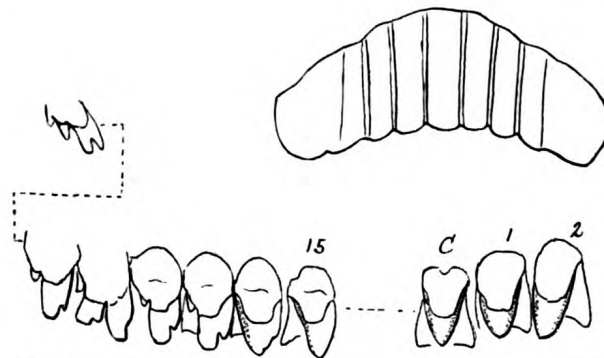


Fig. 247. Jaw and teeth of the type of *Sonorella danielsi*.

“The jaw has six or seven very low, wide ribs, parted by narrow intervals. The radula has about 47, 1, 47 teeth. In most rows the fifteenth tooth has an ectocone. No marginal teeth with the ectocone bifid were seen. The nineteenth tooth, in the radula figured, is abnormal. One of the outer marginals is shown above it.” (Fig. 247.)

ARIZONA: Southeastern part of the Huachuca Mountains at 6000 to over 7500 feet; on the eastern slope on Miller Peak, in Ash and Montezuma Canyons; on the southwestern slope in Bear Creek, Ida Canyon, Cave and Copper Canyons (J. H. Ferriss), Type 94318 A.N.S.P., from head of Bear Creek.

Forms with the ground-color not yellow but pale brown (as in *granulatissima*) occur in Ida Canyon, Cave Creek and Ash Canyon.

This species replaces *granulatissima* in the southeast end of the Huachuca Range. It differs from *S. granulatissima* chiefly in the genitalia, the larger penis and the shape of the vagina being constant features in the series of both species dissected. Specimens have been dissected from five lots, from the head of Bear Canyon (Fig. 242: 5, 7), east fork of Cave, and from Miller Peak. One individual of several from the latter place seems to have the very minute bud-like vestige of a flagellum.

(Named in honor of Mr. L. E. Daniels, who accompanied Mr. Ferriss and the author in the expedition of 1910.)

MASCULUS new subgenus

Shell as in *Sonorella s. str.* except that the more or less granulose embryonic shell is without the diagonal threads of the *hachitana* group, or has only slight traces of them. The penis is enormously developed, its length (in alcoholic preparations) exceeding the diameter of the shell.¹ Verge long, with minute duct.

TYPE: *S. virilis* Pilsbry.

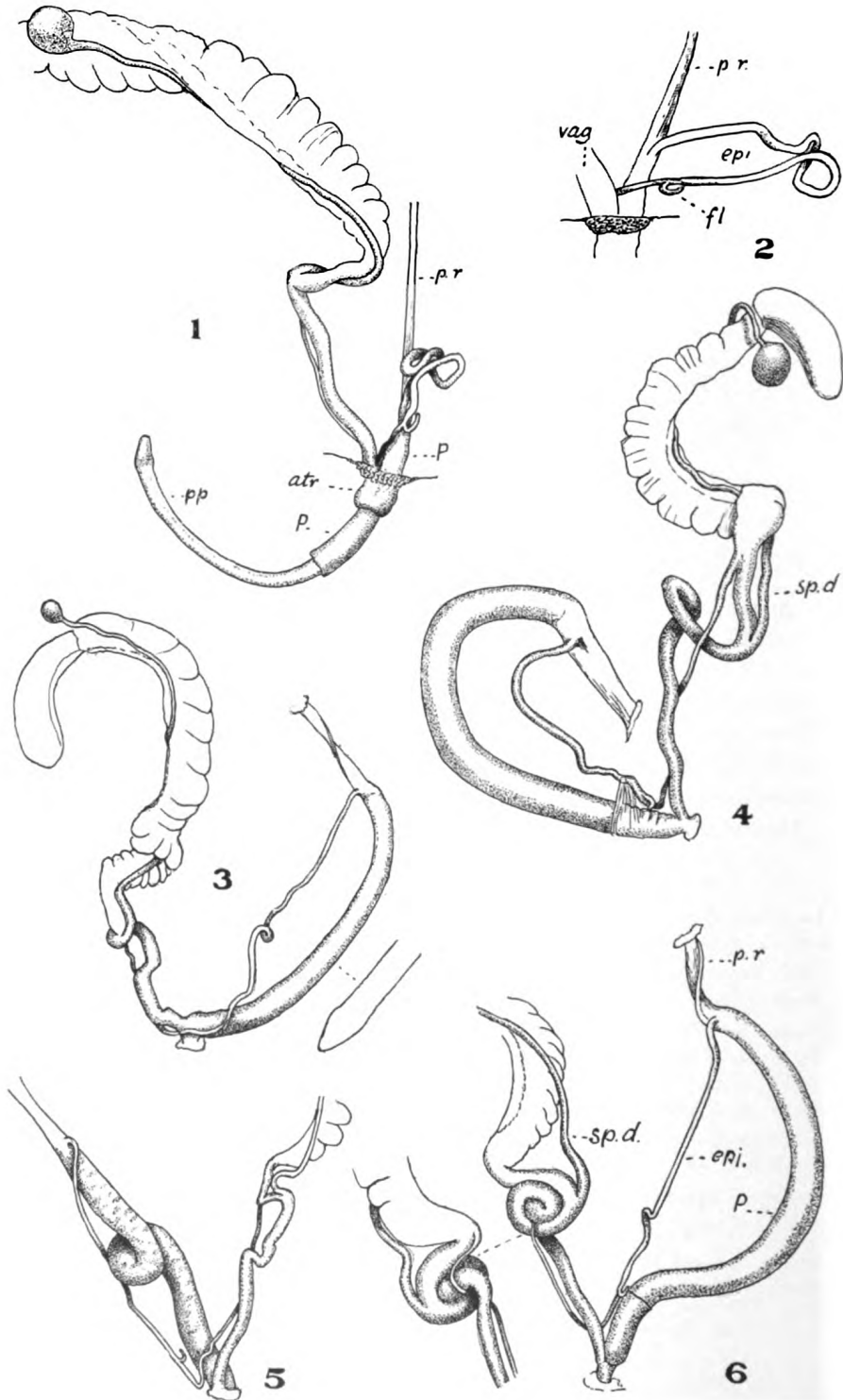
These species are distributed in southeastern Arizona from the Chiricahua Mountains west to the Santa Ritas, and from the Rincons south to the Huachuclas.

(*Masculus*, masculine.)

Key to species by characters of the genitalia

- 1. Length of the penis decidedly exceeding diameter of shell2
 Length of penis somewhat less than diameter of shell*S. insignis*
- 2. Penis longer than the vagina3
 Penis shorter than the vagina, both very long*S. rinconensis*
- 3. Verge nearly as long as the penis4
 Verge one-third to one-half the length of penis, more or less; epiphallus shorter than penis5
 Verge one-fourth to one-fifth length of penis; epiphallus longer than penis ..*S. dalli*
- 4. Large species*S. virilis*
 Small species*S. micra*
- 5. Penis and verge quite slender; large species*S. santaritana*
 Penis and verge rather stout; small species*S. parva*

¹ In *S. insignis* the penis, in alcoholic preparations, falls short of the diameter of the shell, but otherwise it appears to belong here. Possibly *Masculus* should be divided further. The very long penis has been used to approximate species some of which seem otherwise diverse. The subject requires further investigation.



Sonorella virilis Pilsbry

Fig. 249.

Sonorella virilis Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 266, pl. 17, figs. 15-20; pl. 20, figs. 21, 22 (genitalia); pl. 23, fig. 21 (jaw). Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 69, pl. 2, figs. 1-6; pl. 5, figs. 4, 6.

Sonorella virilis circumstriata Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 267, pl. 18, figs. 48-50; pl. 20, fig. 19.

The shell is openly umbilicate, umbilicus contained about 6 times in diameter; pale brown, lighter around the umbilicus, with a dark band above the periphery, and visible on about $2\frac{1}{2}$ whorls above the suture, with borders a trifle paler than the ground color. Whorls $4\frac{1}{2}$, the earlier $1\frac{1}{2}$ forming a minutely rugose embryonic shell. The next 1 or $1\frac{1}{2}$ whorls are striate, the striae appearing slightly broken into granules. The last whorl has the usual

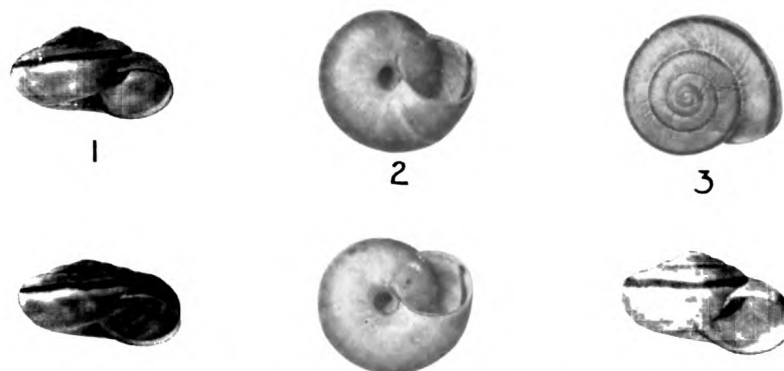


Fig. 249. *Sonorella virilis*. Lower right figure, head of Rucker Canyon; the rest, Cave Creek Canyon.

slight growth-lines, and near the end some spiral lines are visible in the vicinity of the suture. The whorl descends rather deeply in front, and is well rounded peripherally. The aperture is rather large, oblique and rounded, the upper, outer and basal margins about equally arcuate. The outer and basal margins of the thin lip are slightly expanded.

Height 10.3 mm., diameter 19.7 mm.; umbilicus 3.1 mm.; aperture 9.3×10.3 mm.

There are no longitudinal lines on the sole. The pebbly-granose back and the eye-stalks are blackish-gray, becoming much paler dirty brownish-white on the sides and tail. Dorsal grooves are but weakly indicated, and there is no longitudinal median line on the tail.

The kidney is wedge-shaped, 15 mm. long. Pericardium 5.5 mm. long.

Genitalia (Figs. 248: 4, 6). The penis is relatively enormous, more than double the length of the vagina, and much longer than the spermatheca and its duct. It has the usual thin wall, enclosing a fleshy verge nearly as long as the penis. The epiphallus also is very long, slender and con-

Fig. 248. 1, *Sonorella micra*, the penis and verge extruded; 2, same specimen, epiphallus extended; 3, specimen with penis withdrawn. 4, 6, *S. virilis*, Cave Creek. 5, *S. virilis leucura*. Atr., atrium; epi, epiphallus; fl, flagellum; p, penis; pp., verge; pr., penial retractor; sp.d., spermathecal duct; vag., vagina.

volved. The vagina is much convoluted. The spermatheca has the usual globular shape; and its slender duct, while long, is shorter than in other species of equal or greater size.

The jaw (Fig. 140, lower right) has four broad ribs grouped near the middle.

ARIZONA: Chiricahua Mountains, from Pinery and Paradise Canyons south to Rucker, Shake and Horseshoe Canyons, 5500 to about 9000 feet (Ferriss and Pilsbry), Type 79622 A.N.S.P., from Rucker Canyon (V. Owen).

This is an abundant snail in situations where there is shade, humidity and rock cover. The umbilicus is wider than in any other Chiricahuan species except *S. optata*, which differs by the strongly developed oblique threads of the embryonic shell. The pale borders of the band are usually inconspicuous, but sometimes distinct.

The type was "from the Chiricahua Mts.," not definitely localized, but it agrees so fully with Rucker Canyon shells that this canyon has been selected as type locality. In a long series taken there by Cyril Harvey and the author the extremes are 18 and 21 mm. in diameter. The smallest and largest from Cave Creek, in rather dry and also humid stations, are 16 and 22 mm. I have shown (1910, p. 71) that the shells reach larger size in humid, shaded places, and the smallest occur only on sunny, southern slopes.

The type does not show the sculpture of the embryonic $1\frac{1}{2}$ whorls distinctly. In a young topotype a very narrow space at the top is smooth; curved radial ripples follow, soon becoming interrupted, and there is a band of granules along the inner suture. The second half whorl has fine, wavy radial wrinkles, with indistinct, subregularly spaced points, scar-like, or like very low papillae. These are visible on $1\frac{1}{2}$ post-embryonic whorls also. There are no oblique threads, as in the *hachitana* group.

The most notable features of the species are found in the reproductive organs. Measurements in mm. follow:

Species	Penis	Verge	Epiphallus	Flagellum	Vagina	Spermatheca and duct	Penial retractor	Diameter of shell	Museum No.
1. <i>S. virilis</i>	29	24	18	..	23	..	6.5	19	94,335
2. "	30.5	29	19	0.7	26.5	31	6	20	94,332
3. "	34	29	22	1	16	24	..	19.5	79,622
4. "	30	..	22	..	19.5	..	..	22	97,409
5. "	27	..	..	..	..	..	..	22	97,409
6. "	28	..	..	..	..	..	..	19	97,408
7. <i>S. v. leucara</i>	31	28	15	0.6	17	26	..	21	94,331
8. "	28.5	25	21	0.6	21	..	..	23	99,682
9. "	25	21.2	19	0.6	15	25	..	19	99,681

1, 2, Cave Creek; 3-6, Rucker Canyon; 7-9, White Tail Canyon.

The form described as *circumstriata* was defined when very few specimens were known. Further collections over the whole range, made by Mr. Ferriss and the author, show that its characters are merely individual. The development of spiral impressed lines varies widely in almost any large lot.

(*Virilis*, virile.)

Sonorella virilis leucura Pilsbry & Ferriss

Fig. 250.

Sonorella virilis leucura Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 72, pl. 2, figs. 7-9; pl. 5, fig. 5 (genitalia).

The shell is decidedly more depressed than *S. virilis*, though the spire is about equally convex; the umbilicus is wider; the aperture is smaller, and the ground-color is paler, subopaque, whitish, tinted more or less with brown, nearly white on each side of the dark band, and pale around the umbilicus. Embryonic and neanic stages: There are $1\frac{3}{4}$ embryonic whorls. The depressed tip is smoothish, followed by only a few radial wrinkles; following embryonic whorl is roughened with low granules lengthened in a radial direction, or short, irregularly waved or vermiculate radial wrinkles; over these there is a pattern of grains in regular squares at first, but soon forming protractive rows, the grains becoming indistinct. On the first post-embryonic whorl the fine striae are more or less interrupted or minutely



Fig. 250. *Sonorella virilis leucura*, Whitetail Canyon.

indented in places. The post-embryonic whorls as far as the fourth whorl are clothed with very short deciduous hairs, so delicate that the slightest attempt to clean the shell removes them, and they probably never persist in the adult stage. All immature specimens taken by us in November, from diameter 10 mm. on, have a strong callous rib within the lip-edge. Adult stage: There are $4\frac{1}{2}$ whorls in small, $4\frac{3}{4}$ in large individuals of the type lot, slowly increasing at first, the last whorl seen from above about twice as wide as the penultimate. The lip is blunt with rusty edge, but not thickened within. The outer margin is slightly expanded, the basal a trifle more so; parietal callus rather thick at the edge, straight. The umbilicus contained about $5\frac{1}{2}$ times in the diameter.

Height 11.8 mm., diameter 23.6 mm.; aperture 10 x 11.5 mm.

The sole is tripartite in color, the central area, half the total width, being pale isabelline, the side areas gray. The foot is gray above, darkest on the back; top of the tail of a dirty yellow tint.

Genitalia (Fig. 248: 5) as in *S. virilis*, measurements on page 380.

ARIZONA: Chiricahua Mountains on the southern side of Whitetail Canyon (Pilsbry and Ferriss, 1906), Type 99682 A.N.S.P. Also Jhus Canyon. North branch of Pinery Canyon. (Witmer Stone, 1919.)

This is the only *Sonorella* on the southern side of Whitetail Canyon, living on steep slopes varying from northeast to north or northwest. It occurred (in November) rather deep under rocks, and excepting on the more arid slopes and ridges, colonies may be found where suitable shelter occurs throughout the length of the canyon, generally rather high on the slopes, but in at least one case only about 20 feet above the bed of the canyon. The more favorable slopes are sparsely wooded with pinyon below, oak and a few long-leaf pine above. The ridges and slopes with southern or eastern exposure are barren or nearly so. The rock is limestone, mostly with covering of earth and fine stone, and there are no rock slides.

The lots taken show that the shells respond to favorable conditions of shade and moisture by reaching a larger size. In a lot of 25 from high on the ridge, where it is very dry with little shade, the extremes are 18 and 20 mm. in diameter, the mode at 18.75 mm. In another lot of 26, from the bottom of a deep ravine, densely wooded, the extremes are 21.5 and 25.2 mm., mode at 23 to 24 mm. Further details are given in our paper of 1910.

(Λευκός, white, οὐρά, tail.)

Sonorella micra Pilsbry & Ferriss

Fig. 251.

Sonorella micra Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 75, pl. 2, figs. 10-12; pl. 5, figs. 1-3 (genitalia).

The shell is small, thin, the umbilicus contained nearly 6 times in the diameter; pale brownish-corneous, a little paler around the umbilicus, and with scarcely perceptible pale borders above and below the dark chestnut band above the periphery; only slightly glossy. Spire very low. The embryonic shell consists of $1\frac{1}{2}$ convex whorls; after the smooth apex, there are a few arcuate radial ripples; and the rest of the embryonic shell has irregular



Fig. 251. *Sonorella micra*. Type at left.

rugosities or asperities, short, but longest in a radial direction; over these there are granules arranged as in *S. v. leucura*. When absolutely unworn they bear delicate hairs in young shells. The following post-embryonic whorls are delicately striate, and as far as the beginning of the fourth whorl, fresh and uncleaned young shells have close, short and very delicate hairs. The last whorl has delicate growth-lines, but no trace of spiral striae, it is rounded at the periphery and descends a little in front. The aperture is oblique, rounded. The peristome is thin, outer margin scarcely

noticeably expanded, basal margin somewhat more so; columellar margin rather broadly dilated and brought forward. The parietal callus is short, thin and transparent.

Height 7.8 mm., diameter 14.5 mm.; aperture 7.3 mm. wide, 7 high; whorls 4½.

The animal in alcohol is pale grayish, darker on the back. Sole with the usual pale central area and slightly darker side areas, not defined by lines.

The genitalia of a drowned specimen in good condition from Station 10 is drawn in Figure 248: 1, 2. The penis was exerted in all of this lot. Except in being smaller and more slender, the organs resemble closely those of *S. virilis*. The penis in this figure is shown partially everted, the long verge (pp.) projecting. The flagellum is well developed for a *Sonorella*. Figure 248: 3 represents the organs of another specimen, from Station 17, with the penis normally retracted. The end of the verge is shown in outline. Measurements in mm. of two specimens follow:

Penis	Verge	Epiphallus	Flagellum	Vagina	Spermatheca and duct	Penial retractor	Diameter of shell	Museum No. of shell
17	14	10.5	0.6	8	16	8+	14.8	94,334
14	11	13	0.5	9	17	4.5	14	94,330

ARIZONA: Chiricahua Mountains, on the north side of Whitetail Canyon, in slides of igneous rock (rhyolite), (Pilsbry and Ferriss, 1906), Type 94334 A.N.S.P.

This is the smallest *Sonorella* yet known from the Chiricahuas. It is allied to *S. virilis* by the genitalia and the indistinct sculpture pattern on the embryonic whorls, but differs by its diminutive size, thin shell, comparatively narrower umbilicus and the absence of distinct white borders along the brown band.

S. micra occupies the north side of Whitetail Canyon to the exclusion of *S. virilis leucura*, which lives on the opposite or south side. It lives in "slides" of angular, dark purplish-gray rock (rhyolite), and was found only deep in the rocks, where they rest on the earth below. The slopes are mainly toward the south and west, hence exposed to the direct sun, rarely shaded to any extent by the small trees. The snails are found from the bottom of the canyon, 5500 feet, to about 7000 feet, where they occur over the crest of the Maverick Peak ridge, in an extensive slide sloping northeast. The type locality, Station 10, is below the great cliffs along Indian Creek. The lower stations are easily accessible, but the higher call for arduous climbing and, from the nature of their haunts, the work of quarrying the snails out is severe.

We secured but few living specimens, but many dead shells, more or less fresh, show the species to be remarkably constant. Aside from small

differences in elevation of the spire, no variation in form is noticeable. In the type station the diameter runs from 12.7 to 15.2 mm., the mode at 14 to 15 mm. In another lot the mode is at 14 mm.

S. micra occurs associated with *Ashmunella lepiderma* in the same rock slides. Both are modified in the same manner, the shell differing from allied species in being smaller, thinner, dull, with a greater or less development of cuticular processes. The reduced size in comparison with the species on the opposite side of the canyon is without much doubt due to the sun-scorched exposure. We have not found that living on igneous rock has any tendency to dwarf *Sonorellas*, though the tenuity of the shell may fairly be attributed to that condition.

On the southern side of the canyon we found a few dead specimens among limestone rocks about 20 feet above the bed of the canyon, below the junction of Indian Creek.

(Μικρος, little.)

***Sonorella parva* Pilsbry**

Fig. 252.

Sonorella granulatissima parva Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 264, pl. 18, figs. 45-47.—Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila. for 1909, p. 501, pl. 19, figs. 10-12.

Sonorella parva Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 93, pl. 8, figs. 2, 3 (genitalia).

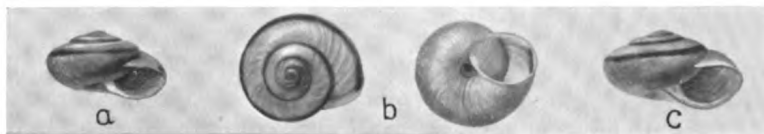


Fig. 252. *Sonorella parva*, type and paratypes.

Shell with the sculpture of *S. granulatissima*, but much smaller, and subangular at the periphery. Whorls $4\frac{1}{2}$, convex, parted by well-impressed sutures, the last moderately descending in front. The band is wide, without pale borders, and is visible on two or two and a half whorls. Umbilicus contained 7 times in the diameter in the type, nearly 8 times in a larger specimen.

Sculpture: after the smooth apex, there are some radial wrinkles to the end of the initial half whorl; the whorl following is very minutely, densely, evenly reticulate-pitted; in oblique light in certain places faint traces of fine, close oblique lines may sometimes be made out. The following neanic whorls are microscopically densely granulose, as in *S. granulatissima*, but on the last whorl this granulation becomes very weak or almost disappears.

The last whorl is bluntly subangular in front, or at least somewhat compressed there; it descends rather deeply to the aperture. Aperture is strongly oblique, rounded, somewhat wider than high, the margins approaching. There is sometimes a very low, oblique callus pad or "tooth" on the parietal wall, further in and nearer the periphery than is usual in helices.

This tooth is visible in all adult shells from Station 281, but seems to be only occasional in other lots. It is present but excessively weak in the figured type, but is well developed in a paratype.

Height 9.5 mm., diameter 16.1 mm.; $4\frac{1}{2}$ whorls. Type.

Height 9.2 mm., diameter 16.7 mm.; $4\frac{1}{2}$ whorls.

Height 10.2 mm., diameter 18.3 mm.; $4\frac{1}{2}$ whorls.

The animal is plumbeous black above; sole with a wide isabella colored central area, sharply defined, and dusky side areas. Genital organs are relatively large. The penis is long with a short sheath, thin-walled, containing a long fleshy verge having numerous slender longitudinal ridges, the end abruptly truncate. Penial retractor short, on the epiphallus, which is twisted around the retractor, the basal part thickened. No flagellum. The vagina is long (Fig. 253: 2, 3). Measurements of two specimens follow:

(a), length of penis 20, verge 14, epiphallus 12, penial retractor 8, vagina 16 mm. (b), penis 25, verge 12, penial retractor 8, vagina 21 mm.

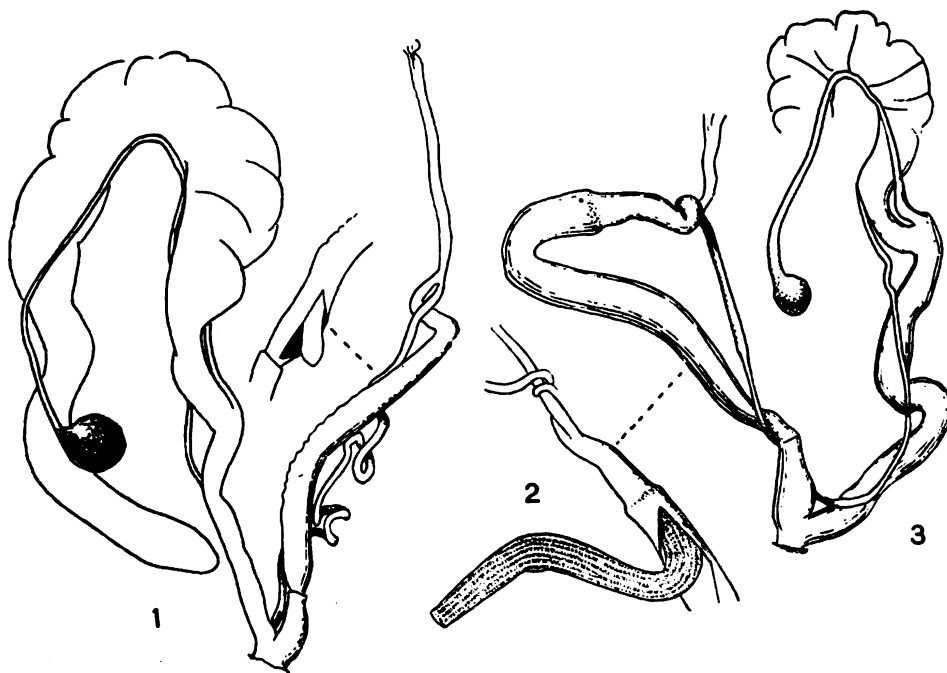


Fig. 253. 1, *Sonorella insignis*. 2, 3, *S. parva*.

ARIZONA: Foothills of the northwestern end of the Huachuca Mountains in the district of the Manila mine (Ferriss, 1904), Type 87114 A.N.S.P.

This little snail is distinguished by the granulose surface and the more or less distinctly subangular periphery in front. It is smaller than *S. granulatissima*, more depressed, without trace of oblique lines on the embryonic whorls, and it differs further by the longer penis and verge. The

incipient "tooth" on the parietal wall is a very unusual feature in *Sonorella*, but occurs also, and more strongly developed, in *S. dalli*. The largest shell seen, 11.3 x 18.6 mm., is from cliffs on the south side of a deep canyon a mile north of Manila mine hill.

(*Parvus*, small.)

Sonorella insignis Pilsbry & Ferriss

Fig. 254.

Sonorella insignis Pilsbry & Ferriss, 1919, *Nautilus*, 33: 21; 1923, *Proc. Acad. Nat. Sci. Phila.*, 75: 94, pl. 3, fig. 3, pl. 8, fig. 1 (genitalia).

The shell is much depressed, openly umbilicate, the umbilicus contained nearly $5\frac{1}{2}$ times in the diameter; solid, opaque, whitish stained with light pinkish-cinnamon above and in places on the base, banded with chestnut-brown, the band broad, situated well above the periphery. Surface with little gloss, having coarse, unevenly developed, very low plications in the direction of growth lines, and mainly confined to the last whorl; under the microscope traces of rather coarse, well separated spiral impressed lines may be deciphered in some places on the upper surface. No protractile threads are visible on the embryonic shell in the adult or nearly adult shells. The last whorl descends rather deeply to the aperture, which is oval with converging margins, very slightly expanded.



Fig. 254. *Sonorella insignis*.

Height 9.7 mm., diameter 20.7 mm.; $4\frac{1}{2}$ whorls. Type.

Height 8.8 mm., diameter 19 mm. Topotype.

Height 10.3 mm., diameter 21.7 mm. Topotype.

Genitalia (Fig. 253: 1, type) characterized by the long male organs. The large verge is $\frac{3}{4}$ the length of the penis, with a bluntly conic end. The penis is slender basally, enclosed in a short sheath. Flagellum very small but distinct. Vagina shorter than penis. Lengths of organs as follows:

Penis	16.5 mm.	Epiphallus	24 mm.
Verge	12.0 mm.	Vagina	10 mm.
Penial retractor	8.5 mm.	Spermatheca and duct ...	25 mm.

ARIZONA: Whetstone Mountains, Pima County (J. H. Ferriss), Type 44040 A.N.S.P.

This species is readily known by its depressed shape and coarse sculpture, similar to *S. dalli* of the neighboring Huachuca mountains. It is not closely related to any described form, but by the very large penis and verge, and the apical sculpture it resembles the group of *S. virilis*.

A very old specimen has a distinctly calloused parietal wall and thickened lip, much as in some *Oreohelices*. The extremes of size are 16.7 and 22 mm. in diameter. The low, retractive folds of the last whorl are often closer than shown in the figure. In a young shell showing the embryonic sculpture perfectly there is a moderately large smooth space at the tip, after which it is closely, finely wrinkled radially, the wrinkles irregular and interrupted, over them are rather sparsely scattered little tubercles, part of them lengthened in a spiral direction, or near the outer suture, in slightly descending but irregular trends.

It appears to be generally spread in the Whetstone Range, small mountains north of the Huachucas, and connected therewith by the 4500 foot contour. It was nowhere found in abundance.

(*Insignis*, notable.)

Sonorella rinconensis Pilsbry & Ferriss

Fig. 255.

Sonorella rinconensis Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila. for 1909, p. 517, fig. 1 (shell); pl. 22, fig. 1-3, 5, 7 (anatomy).

The shell resembles *S. ashmuni* Bartsch in shape. It is pale brown fading to white around the umbilicus, with a broad chocolate shoulderband, widely whitish-bordered above and below. The surface is smoothish, marked with delicate growth-lines, and under the lens some faint spiral lines may be traced on the last whorl near the suture. The embryonic shell of $1\frac{1}{2}$ whorls has a very small smooth tip, followed by a granulose area, then the pattern becomes areolate, formed of many spiral series of short, hyphen-like little tubercles, between them fine radial wrinkling; near the outer

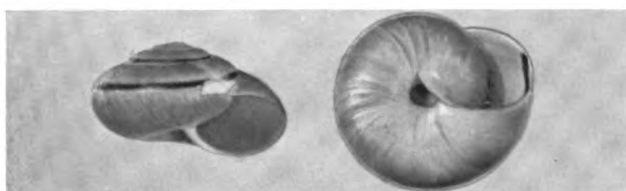


Fig. 255. *Sonorella rinconensis*, type and paratype.

edge of last embryonic half whorl there are decurrent threads (*hachitana* sculpture). Most of this sculpture is lost in adult shells. The whorls increase rather slowly to the last, which is much widened, and well rounded peripherally. It descends a little in front. The aperture is rotund-lunate; peristome slightly expanded, dilated at the columella as usual. Umbilicus about as in *S. ashmuni*.

Height 16 mm., diameter 26.5 mm., width of umbilicus 4 mm.; whorls fully 5.

The penis is extremely long and slender, and contains a very long verge. Its lower end is enveloped in a sheath. The retractor muscle is inserted distally on the lung-floor, as usual. The vagina is excessively long, longer

than the penis, and of about equal diameter throughout (slightly over 1 mm.). The spermatheca is globular, its duct much shorter than the vagina. The organs of an individual drowned and dissected fresh measure: length of penis 55 mm., verge 31, epiphallus 22, flagellum 1.2, vagina 70, spermatheca 31 mm. (Fig. 256 D).

The liver is maroon colored when fresh.

The jaw (Fig. 256 c) has six or seven strong ribs, projecting on both margins.

The radula has 26, 15, 1, 15, 26 teeth (Fig. 256 A, B). The central and lateral teeth are unicuspid, the cusps stout and obtuse, longer than the basal plates. At about the sixteenth tooth an ectocone appears. Towards the outer edge of the radula the inner cusp becomes bifid; and in many but not all of the outermost six or eight marginals the ectocone is split into two or three denticles.

ARIZONA: Rincon Mountains, Pima County, at Mica Mountain, Rincon Peak and Wrong Mountain, above 7500 feet (J. H. Ferriss), Type 94313 A.N.S.P., from Rincon Peak.

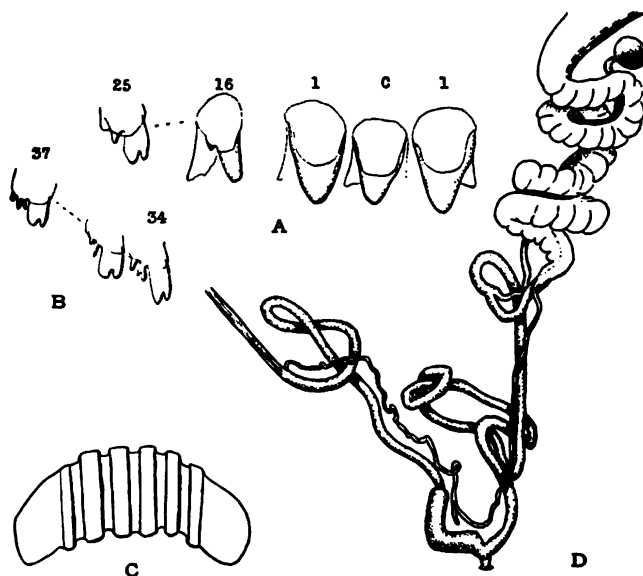


Fig. 256. *Sonorella rinconensis*, A, B, teeth, C, jaw, D, genitalia of type.

Conchologically this form stands very close to *S. ashmuni* Bartsch, from Richinbar, south of Prescott, Arizona. That species has not been dissected, but it appears most closely related to *S. compar* of the same district, which has genitalia of the type found in the *hachitana* group, while *S. rinconensis* has the penis and vagina excessively lengthened. While quite unlike any known form, it seems nearer to *S. virilis* than to other species which have

been dissected, but differs from that by its relatively shorter verge and by the vagina, which is much longer than the penis, while in *S. virilis* the penis is longer. The shells are quite diverse.

The sculpture of embryonic whorls was described from a half-grown specimen, as it is almost effaced in adults.

The Rincon Mountains, lying about 25 miles east of Tucson, have peaks over 8000 feet, and are connected with the Santa Catalinas somewhat above the 4000 foot contour. Where worked, the mountains are rather dry and the rock granitic, said to be of pre-Cambrian age. Shells were scarce; only a few minute forms and *S. rinconensis*, which was found sticking to large rocks and boulders.

Sonorella santaritana Pilsbry & Ferriss

Fig. 257.

Sonorella santaritana Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 393, pl. 9, figs. 1-3; text-fig. 4.

The shell is depressed, umbilicate, the width of umbilicus contained about 6 times in diameter of shell, solid, between cinnamon-buff and pinkish-buff, becoming whitish on the base, and having a chestnut-brown shoulder band bordered with white.

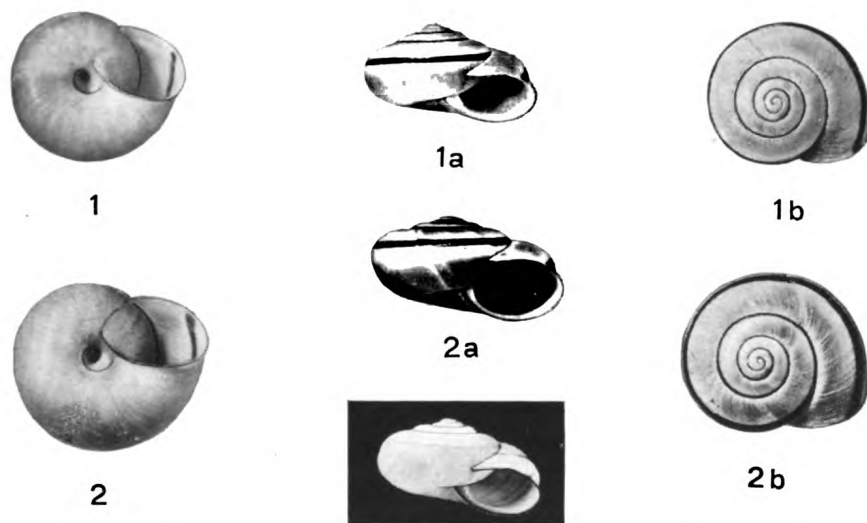


Fig. 257. *Sonorella santaritana*, 1-1b the type; all from Walnut Canyon, Santa Rita Mountains.

The surface is rather glossy. Embryonic shell of $1\frac{1}{2}$ whorls; after a short initial smooth stage, the surface becomes radially rippled, then densely granular, the granules lengthened in an obliquely spiral direction, becoming longer with the growth of the embryo, the last $\frac{2}{3}$ whorl of the embryo marked with forwardly descending and ascending threads forming V-shaped figures, their intervals densely, subregularly wrinkled radially.

The post-embryonic whorls have very fine, inconspicuous growth lines and excessively faint spiral lines on the last whorl, above and at the periphery. The spire is very low conic. Whorls $4\frac{1}{2}$, convex; the last descends deeply in front. The aperture is very oblique, small; peristome narrowly expanding, pale brown at the edge, the margins converging, so that the thin, transparent parietal callus is short. In the last whorl the umbilicus enlarges to about double its previous width.

Height 13.3 mm., diameter 23 mm., width of umbilicus 4 mm.; aperture 11 x 12 mm.

Genitalia (Fig. 258). The penis and vagina are extremely long. Penis is rather slender, and lies in three folds in the body. It has a basal sheath, and a slender, conspicuously annulate verge, one-third the length of the penis or longer. The flagellum is well developed for *Sonorella*. The penial retractor is inserted at the apex of penis and base of epiphallus. The vas deferens is slender throughout. Measurements in mm. follow:

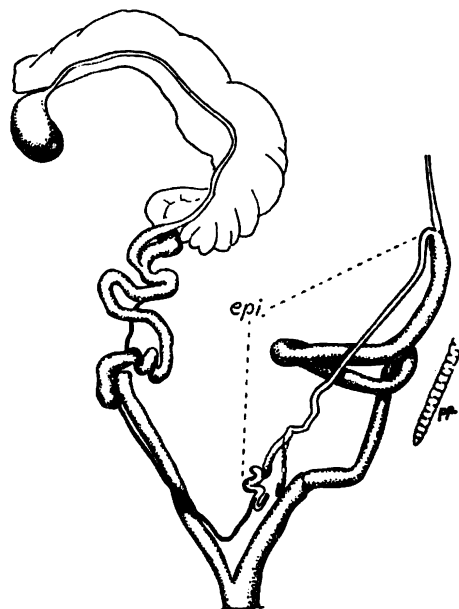


Fig. 258. Genitalia of *S. santaritana*. epi., epiphallus; pp., end of the verge.

Station	Penis	Verge	Epiphallus	Flagellum	Penial retractor	Vagina	Spermatheca and duct	Diameter of shell
5	33	...	22	1.5	14	29	28	23
5	40	13	27	..	..	34	..	22.3
12	27	...	26	1.8	15	33	..	23.5
9	31	12.5	..	..	18	36	..	20
10	41	17	18+	2	15	36	27	22.5

ARIZONA: Santa Rita Mountains, in Walnut Canyon (a branch of Agua Caliente Canyon) at about 6000 feet elevation (Ferriss, Daniels and Pilsbry, 1910), Type 112105 A.N.S.P. Also taken between 6000 and 7000 feet, near the head of Agua Caliente Canyon; in Madera Canyon, from about 5700 to nearly 7000 feet, and in the head of Josephine Canyon, near the ridge connecting Mt. Hopkins and Old Baldy, at about 6500 feet.

S. santaritana differs from other species of the Santa Ritas by its wider umbilicus, the more approaching ends of the lip, and especially by the great length of penis and vagina. In the characters of the genitalia it is nearest to *S. rinconensis* P. and F. but that species differs by having a still longer

vagina, and a more capacious shell with larger aperture and relatively smaller umbilicus. *S. dalli* and *S. virilis* are somewhat related to *santaritana*, but differ in characters of both genitalia and shells.

This is the most abundant and widely distributed *Sonorella* of the part of the Santa Rita Range which we explored.

In size, specimens from Walnut Canyon measured from 19 to 25.8 mm. diameter, but only in one colony were such small ones found; the minimum size in other colonies is about 21.5 mm.

A beautiful albinistic individual (lower figure) was taken in Walnut Canyon. It shows very faint traces of the shoulder band, and the embryonic shell is faintly buff, but otherwise it is pure white. Genitalia as in the colored form.

SONORANAX new subgenus

The length of the penis much exceeds the diameter of the shell; verge short, thin-walled, hollow, containing an inner tube; epiphallus longer than the penis. Shell with apical sculpture of the *hachitana* type.

TYPE: *S. dalli* Bartsch.

(Sonora + Avaξ, Prince of the Sonoran zone).

***Sonorella dalli* Bartsch**

Figs. 259, 260.

Epiphragmophora hachitana (in part) Dall, 1896, Proc. U.S. Nat. Mus., 19: 339-340, pl. 31, figs. 7, 10.

Sonorella dalli Bartsch, 1904, Smiths. Misc. Coll., 47: 193, pl. 31, fig. 1.—Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila. for 1909, p. 498, pl. 19, figs. 1-3, pl. 22, figs. 4, 6, 8 (anatomy); 1923, Proc. Acad. Nat. Sci. Phila., 75: 92, fig. 10.



Fig. 259. *Sonorella dalli* showing parietal teeth.

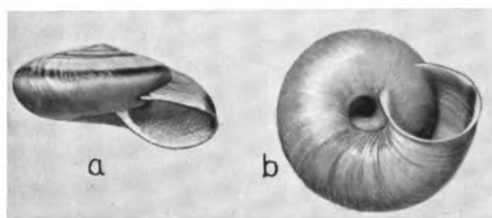


Fig. 260. *Sonorella dalli*.

“Shell large, depressed, light-brown horn color above, lighter below, with a broad band bordered on each side by a lighter zone encircling the whorls a little above the periphery. This band can be seen on all the ephobic whorls above the suture. Nepionic¹ portion a little less than half a whorl, somewhat flattened and outwardly sloping, marked by a few moderately strong transverse wrinkles. The neanic stage embraces $1\frac{1}{2}$ turns; the incremental lines are moderately well-marked, very wavy, and closely placed; the characteristic super sculpture of this part is extremely

¹ The terminology of growth-stages used in this description does not agree with that adopted in this work.

fine, with the lines placed so closely that the complete effect at first appears granular. The ephobic stage consists of three depressed, moderately rounded whorls, which are less convex above than below and are marked by many strong incremental lines and numerous microscopic granulations. The last whorl is considerably deflected at the aperture and shows a tendency to become angular at the periphery. The aperture is moderately large, sub-circular, very oblique, expanded and slightly reflected; columella moderately expanded at base and scarcely reflected over the rather large umbilicus, which appears open to the summit. The type measures: maj. lat. 26.5 mm., min. lat. 21.1 mm., alt. 12 mm.; aperture maj. lat. 11.8 mm., alt. 10.5 mm.; umbilicus about 4 mm." (Bartsch.)

The penis (Fig. 261 B) is extremely long, slightly enlarged distally, its walls thin, with most minute and close transverse rugae. It contains a smooth verge tapering to an obtuse apex, and about one-fifth the length of the penis. The verge is hollow with rather thin walls. Within it a slender tube runs from the epiphallus to the apex, where it opens by a lateral pore. This tube is lightly attached to the wall of the verge. It is indicated by dotted lines in Figure 261: v. The epiphallus is extremely long, terminating in a short flagellum. The penial retractor muscle, 7 mm. long, is inserted

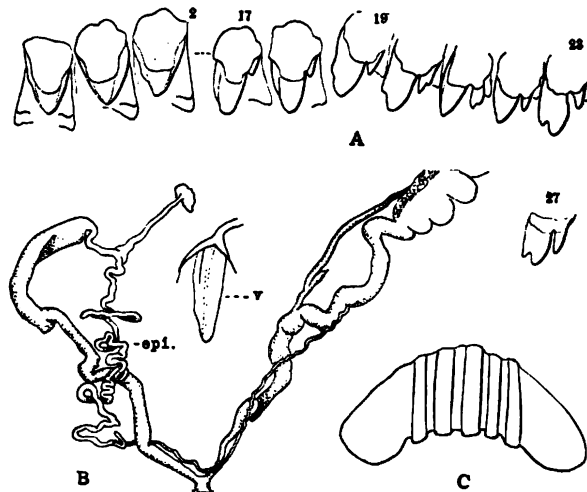


Fig. 261. *Sonorella dalli*, A, teeth; B, genitalia; C, jaw. epi, epiphallus; v, verge.

upon it 4 mm. from the end of the penis. The long vagina has a slender neck, enlarging moderately above. The spermatheca is globular, on a duct much shorter than the penis. In one specimen dissected it bears a minute diverticulum about 1 mm. long, 2 mm. from the base of the duct. In another individual no diverticulum was found, so that it is probably abnormal or pathologic. The measurements in two individuals preserved in formalin follow: (a), length of penis 39, verge 8, epiphallus 49, flagellum 4, spermatheca 34 mm. (b), penis 41, verge 9, epiphallus 60, flagellum 3, vagina 25, spermatheca 27 mm.

The jaw (Fig. 261 c) has five strong ribs grouped in the middle half of its length.

The radula has about 41, 1, 41 teeth (Fig. 261 A). The central and lateral teeth have mesocones only; on the seventeenth an ectocone appears. On the outer marginal teeth the inner cusp or sometimes both cusps are bifid, but the ectocone is not split into several cusps as in some other species.

ARIZONA: Huachuca Mountains in Tanner Canyon¹ (Maj. E. A. Mearns, U. S. A.), Type 130009 U.S.N.M.

The large size and much depressed form, the rather coarse folds of the last whorl and comparatively wide umbilicus, are characteristic. The excessive length of penis and epiphallus, and especially the hollow, thin-walled verge containing a separate duct or tube (a structure unique in the genus), are characters which set *S. dalli* apart from other known *Sonorellas*.

The embryonic shell seems to consist of 1½ whorls, as usual. The tip is smooth, followed by the usual curved transverse ripples. After the first half turn the surface is densely, finely wrinkled radially, the wrinkles irregular and largely broken into granules. Over this sculpture in some specimens may be seen a series of very delicate, weak and close threads running forward spirally and upward on the inner portion of the whorl, downward on the outer, meeting in a V near the middle. This thread sculpture is rarely developed distinctly. The post-embryonic whorls of the spire are more or less flattened, the first one sometimes weakly granulose. The last whorl has low, coarse, retractive folds, weak or obsolete on the base. The diameter varies from 23 mm. with 4½ whorls to 28 mm. with 5 whorls. Ferriss has one specimen of 20.4 mm. diameter.

Adult specimens often have two low calluses on the parietal wall some distance within, generally weak and hard to see, but rarely they are thick, forming white teeth, which converge forward and are weakly connected, as in Figure 259. In one place near the middle of the canyon about 20 percent of the specimens possessed teeth.

Dall's *sonorella* has been collected in Tanner Canyon only, at from 6000 to 7500 feet.

(Named for a great malacologist and steadfast friend.)

MYOTOPHALLUS new subgenus

The inner tube of the penis is slender, but it is enveloped in an extremely thick muscular sheath, tapering posteriorly, length of the whole about one-fifth the diameter of shell or less. Epiphallus long. Flagellum minute, bound with the vas deferens. Vagina very short. Apical sculpture of the *hachitana* type.

TYPE: *Sonorella fragilis*, central Arizona.

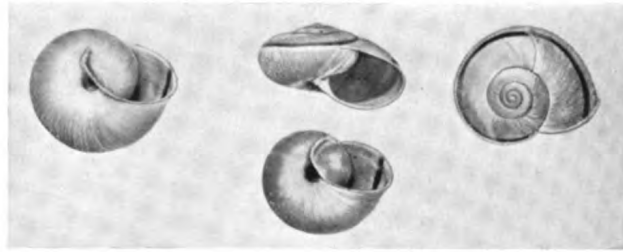
(Μῦωτὸς, muscular, φαλλὸς, male organ.)

¹ This has also been known locally as "Garden Canyon."

Sonorella fragilis new species

Fig. 262.

The shell is moderately depressed, narrowly umbilicate, umbilicus contained $8\frac{1}{2}$ to 11 times in the diameter; very thin and fragile; light pinkish cinnamon colored, fading on the base, and slightly lighter on both sides of the pecan-brown shoulder band. Surface is rather glossy, with light wrinkles of growth on the later whorls. Embryonic $1\frac{1}{2}$ whorls with a very

Fig. 262. *Sonorella fragilis*, type (above) and paratype.

small smooth area at the apex, followed by some coarse, unequal radial wrinkles, after which it is granulose near the upper suture, the rest with rather widely spaced, forwardly descending and ascending threads, very weak radial wrinkles between them. Part of the first post-embryonic whorl has inconspicuous papillae in oblique series. The last whorl is very

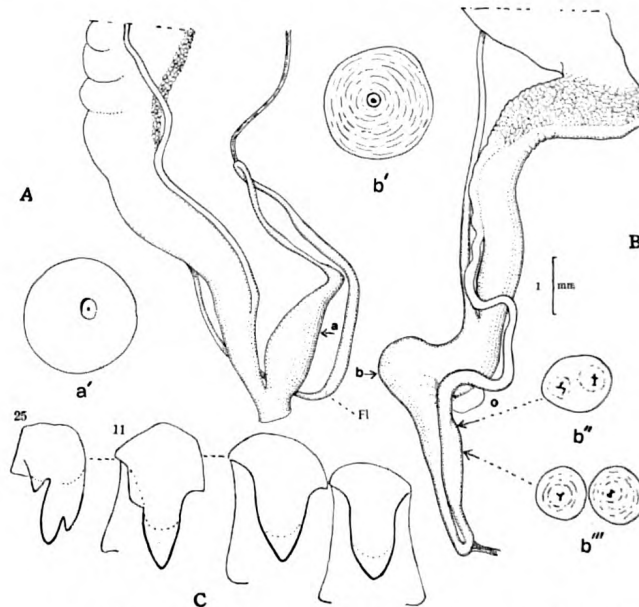


Fig. 263. *Sonorella fragilis*. A, B, anterior part of genitalia of two individuals. C, teeth. a', section of penis at point marked a; b', section at point marked b. b'', section at flagellum; b''', sections of epiphallus; fl, flagellum; o, external orifice of genitalia.

wide, scarcely descending in front. The aperture is ample; peristome thin, narrowly expanded, dilated at the columellar insertion. Parietal callus thin, but thickened at the edge in most old shells.

Height 11.8 mm., diameter 18.5 mm., aperture 10 x 10.5 mm.; $4\frac{1}{2}$ whorls. Type.

Height 9.4 mm., diameter 17.2 mm.

Two specimens preserved in strong alcohol are so contracted that satisfactory dissections were not made. The anterior parts of genitalia are drawn in Figure 263 A, B. The penis is enveloped in a very thick, muscular sheath arising near the base. The epiphallus is slender anteriorly but more or less enlarged towards the end. The flagellum is only weakly perceptible externally. I did not see a verge, which must be minute. It should be looked for with serial sections when further material is available.

The radula has 34-1-34 teeth, about 10 laterals. The central and lateral teeth are single cusped, 11th tooth with an ectocone, marginals with the inner cusp bifid, the outer cusp sometimes twinned on a few teeth but usually simple (Figure 263 c). The jaw has 6 rather weak ribs.

ARIZONA: Cliff ruins, Roosevelt Lake, Gila County (J. H. Ferriss), Type 166733 A.N.S.P.

This delicate species is well distinguished by the fragile, narrowly umbilicate shell, with the last whorl but slightly or not descending in front, the aperture quite large.

Subfamily HUMBOLDTIANINAE

The structure of the dart apparatus is unique. The globose shell with simple, unexpanded lip is also unlike any other American snail, resembling the typical section of *Helix* in form, but with a different three-banded color pattern. The band above the periphery is probably homologous with that of most other Helminthoglyptidae, but the other bands do not correspond to those of other genera. The single genus of this subfamily is confined to the Mexican plateau and the adjacent part of Texas.

HUMBOLDTIANA Von Ihering

Humboldtiana Von Ihering, 1892. Zeitsch. f. Wissensch. Zool., 44: 472, for *Helix humboldtiana*.—Pilsbry, 1927, Proc. Acad. Nat. Sci. Phila., 79: 165.

The shell is usually rather thin, globose, of few (4 to $4\frac{1}{2}$) whorls; typically 3-banded. Embryonic shell formed of $1\frac{1}{2}$ whorls, the initial half whorl, or all, smooth; subsequent whorls more or less wrinkled along growth lines, and more or less granulose. Aperture large, rounded-oval, strongly oblique, peristome reflected partly over the narrow umbilicus but elsewhere only slightly or not expanded.

The foot is voluminous, sole very broad, tail not keeled or serrate above. The mantle collar is very broad, with small body-lobes before and behind the pneumostome and a short but well developed lobe on the left side (Fig. 266: 3).

“Genitalia (Fig. 266): The penis contains a large verge; retractor muscle is inserted near the base of the rather long epiphallus, and attached distally

to the diaphragm; flagellum long. There are four dart sacs around the vagina, the darts circular in section, hollow and very thin; mucous glands four, but conerescent in a ring around the vagina, their ducts incorporated in the vaginal wall, opening into lumen of vagina about on a level with the insertion of the dart sacs. The spermathecal duct is very long, provided with a branch or 'diverticulum' which lies on the opposite side of the oviduct from the spermatheca. Talon simple, imbedded in the albumen gland" (Fig. 264).

The jaw varies from strongly to very weakly ribbed. Probably the individual variation is considerable.

The radula is of ordinary helicoid type; teeth of the middle field unicuspid, or the laterals may have small ectocones; on the transition teeth an endocone is usually represented by a notch in the long cusp, and the marginals vary from bicuspid to tricuspid, or have the endo- and ectocones divided or subdivided.

The lung (Fig. 270: 6, *H. ultima*) is relatively short, the pulmonary vein divided into several large branches anteriorly; venation chiefly developed in front and along the intestinal side. Kidney very long and narrow, extending well behind the pericardium.

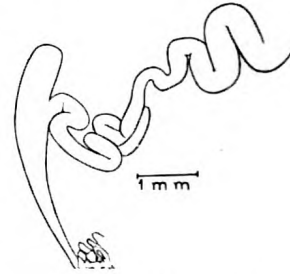


Fig. 264. *H. buffoniana*. Proximal end of hermaphrodite duct and talon freed from the albumen gland.

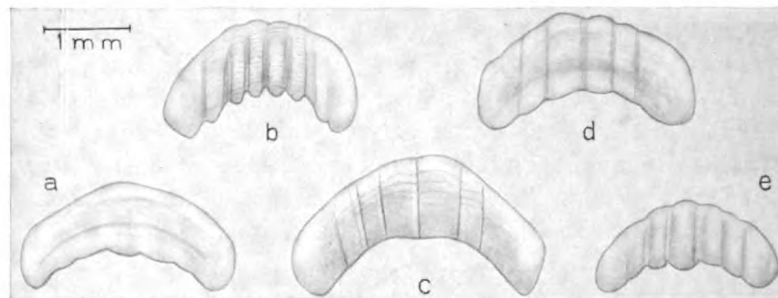
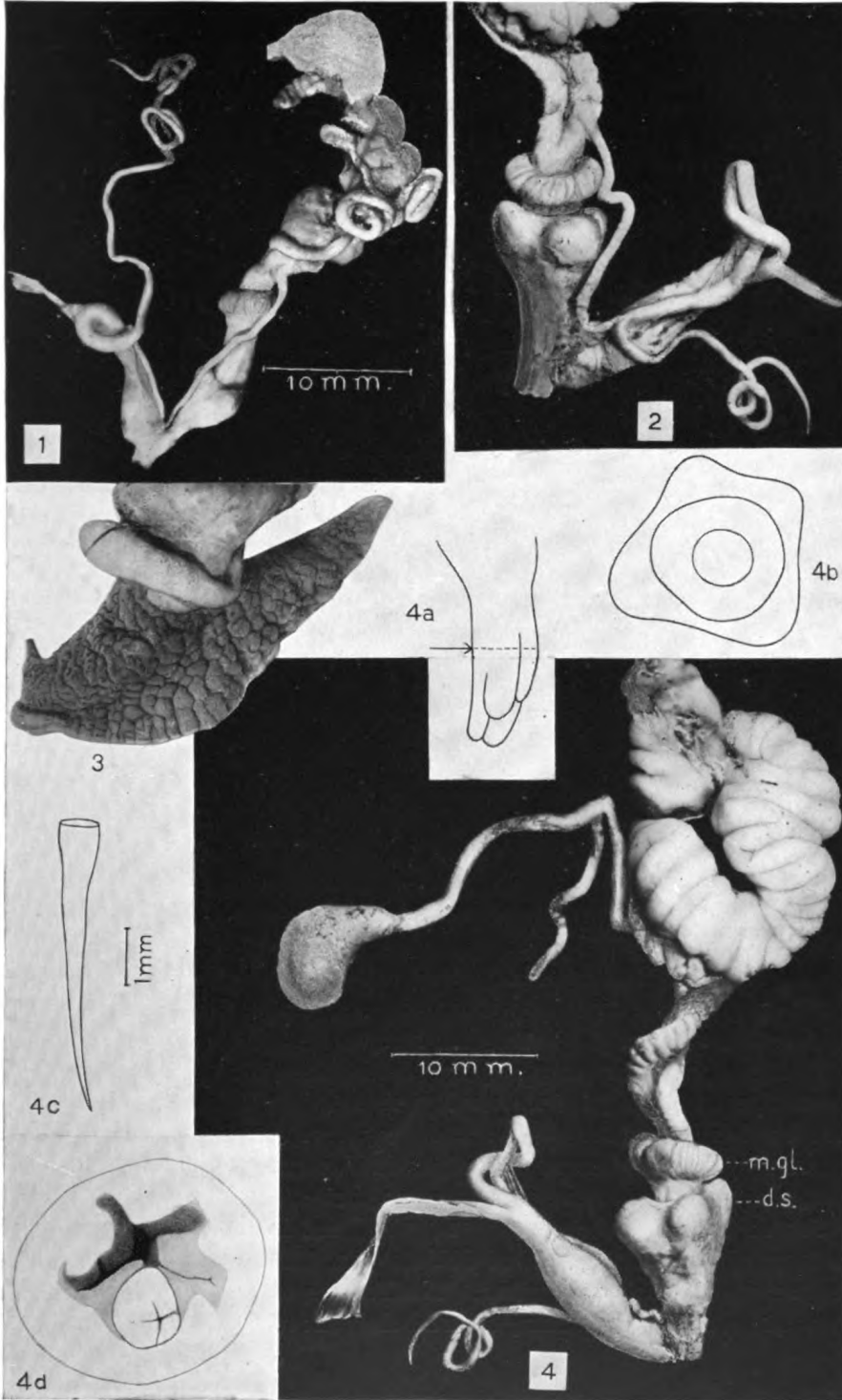


Fig. 265. Jaws of: a, b, *Humboldtiana texana*; c, *H. buffoniana*; d, *H. ultima*; e, *H. chisosensis*.

Distribution.—Mountains of the plateau of Mexico south to Mexico, D. F.; Texas in the Big Bend of the Rio Grande, the Davis Mountains, and the southern end of the Guadalupe Mountains along and just over the New Mexican boundary.

In the Eastern Sierra Madre in the states of Nuevo Leon and Coahuila it seemed that oaks and limestone were essential factors for the existence of

Fig. 266. 1, genitalia of *Humboldtiana texana*. 2-4d, *H. buffoniana*; 3, foot of alcoholic animal, reduced; 2, 4, upper and lower sides of genitalia; 4a, verge; 4b, diagrammatic section at dart sacs; 4c, dart; 4d, section of penis and verge at point marked on 4a; ds, dart sacs; m.gl., mucous glands. (Figs. 1-4 from photographs.) See p. 397.



Humboldtiana; but near Mexico, D. F., they live in high coniferous forest at 10,000 feet elevation, and in western Chihuahua in volcanic rock, the vegetation scanty and mixed. In Texas they inhabit rather humid spots in an arid country, but some (*H. texana* and *H. cheatumi* var.) occur in very dry places.

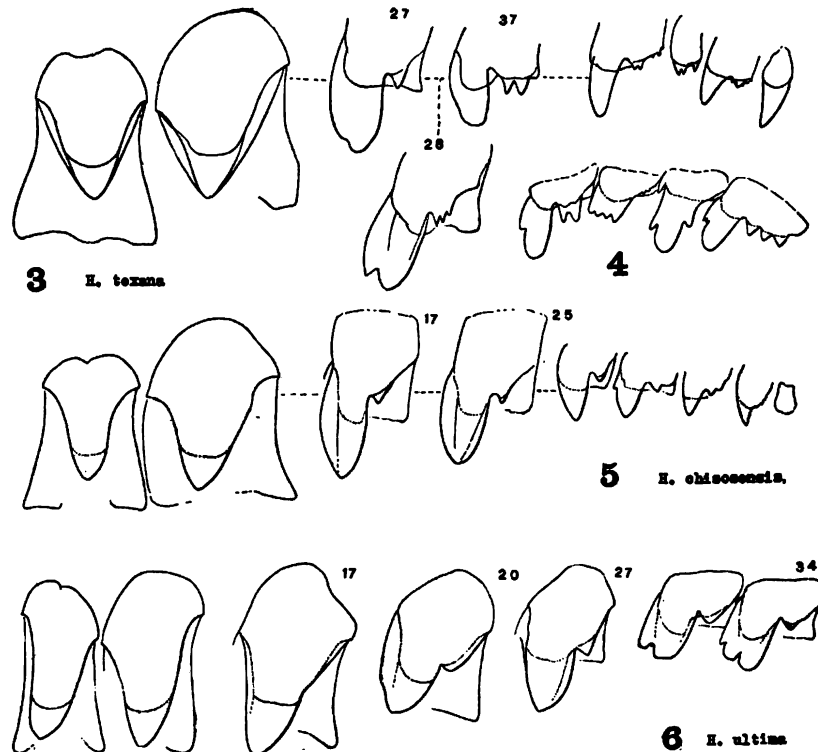


Fig. 267. 3, *Humboldtiana texana*, type. 4, *H. texana*, no. 142043. 5, *H. chisosensis*. 6, *H. ultima*.

Humboldtiana is a remarkably isolated genus by the formation of its dart apparatus, and especially of the mucous glands, the incorporation of their ducts in the walls of the vagina being an unique structure.

The banding is peculiar among American helices, the bands having about the positions of bands 2, 3 and 4 of the pentataeniata European helices. The third band is immediately below the periphery. In *Leptarionta* and the Andean *Epiphragmophoras*, as well as in Japanese *Euhadras*, the lower band, when present, is situated lower than that of *Humboldtiana*.

Further details of the anatomy may be found in the Proceedings of the Academy of Natural Sciences of Philadelphia, 1927, pages 165-178, where Mexican species also are described. The Texan species fall into two groups: (1), with the mucous gland ring situated close above the summits of the dart

sacs, *H. ultima*; and (2), mucous gland ring separated from the dart sacs by a distance equal to or exceeding the length of the sacs, *H. chisosensis* and *H. texana*. The position in our other species is not known.

Key to Species of Humboldtiana

1. Shell distinctly variegated with opaque whitish streaks as well as three dark bands...2
 Shell three-banded on a yellowish ground, without whitish streaks, and with very little granulation or none.3
2. Copiously streaked and maculate with buff and whitish on an isabella colored ground, with very little granulation anywhere; Guadalupe Mountains.....*H. ultima*
 White to light yellow with darker streaks, the dark bands usually irregular or unequal; penult whorl with distinct granulation, gradually disappearing on last whorl; diam. 20-26 mm.; northern Brewster Co.*H. texana*
 Darker, with strong, subequal dark bands; finely but distinctly granulose as far as the lip; diam. about 25 mm.; Davis Mts.....*H. palmeri*
 Brown with light streaks, some white lines and three subequal dark bands; diam. about 27 mm.; Presidio Co.*H. högeana praesidii*
3. Embryonic whorl smooth; shell with wide, dark bands on a chamois ground; smoothish, glossy, depressed; Chisos Mts.....*H. chisosensis*
 Embryonic whorls closely, minutely costulate radially, with some granules; Davis Mts.4
4. Subglobose, with some weak granulation in places on the upper surface.
H. cheatumi
 More depressed; no granulation on last two whorls.....*H. ferrissiana*

Humboldtiana chisosensis Pilsbry

Figs. 268, 270: 8.

Humboldtiana chisosensis Pilsbry, 1927, Proc. Acad. Nat. Sci. Phila., 79: 182, figs. 5, 10; pl. 12, figs. 7-9; pl. 14, fig. 8.

The shell is thin, obliquely umbilicate, chamois colored, with three wide carob-brown bands. The surface is glossy, smoothish, having fine growth wrinkles and a minute, nearly effaced granulation, scarcely perceptible in some places and wanting on the base. Initial 1½ whorls glossy, nearly



Fig. 268. *Humboldtiana chisosensis*, type and paratype.

smooth. Whorls convex, the suture descending deeply to the aperture. The aperture is strongly oblique, rotund-oval. Peristome thin, triangularly dilated half over the umbilicus.

- Height 25 mm., diameter 33 mm.; 4 whorls. Type.
- Height 25 mm., diameter 31 mm. Lost Mine Peak.
- Height 19 mm., diameter 25 mm. Lost Mine Peak.

TEXAS: Chisos Mountains, Brewster County, in rock slides on steep slopes and in recesses of the crags along the summit to the left of Naill's ranch house (Pilsbry and Ferriss) Type 132385 A.N.S.P. Also at "Lost Mine Peak" near Moss Well (Morgan Hebard).

The chief variation is in size and the banding, the lower band being narrow occasionally, although usually as wide as the others. It differs from *H. texana*, which is similar in genitalia, by the smoothish surface, persistent though thin periostracum, different color, the more expanded last whorl, giving the shell a greater diameter relative to the height, and by the simple cusps of the marginal teeth.

The reproductive system (Figs. 272: 10, 10 a) does not differ materially from that of *H. texana*. The diverticulum of the spermathecal duct is shorter, as seen in the detail, upper right side of Fig. 272: 10. Measurements follow: Penis 7 mm. Epiphallus 11 mm. Flagellum 47 mm. Spermatheca and duct 50 mm. Diverticulum 3 mm.

The jaw (Fig. 265 e) has four or five wide ribs, the median ones moderately strong, denticulating the cutting margin.

Radula (Fig. 267: 5). The central tooth has a rather narrow cusp shorter than the basal plate. The inner laterals are decidedly wider, with stouter cusp. An ectocone appears on the 12th tooth; on the other side, a little further forward, on the 14th. It becomes well developed further out, and is bifid on some of the marginal teeth. The mesocone as a rule remains simple throughout, though rare individual teeth may show a small endocone, as in the fourth from the edge in the row figured. This absence of entocones or emargination appears to be an important character of the radula of this species. In different places on opposite sides I count 37 and 44 side teeth.

The Chisos Mountains at Oak Canyon, about 4500 feet elevation, have many long slides of coarse or fine rock, about as steep as such material will stand; elsewhere with more or less covering of agave, large yuccas, a sharp-edged bear grass, with a few pinyons and junipers; high up very few small groups of stunted aspens. *Humboldtiana chisosensis* was found in the rock slides and among vegetable debris and rocks in narrow, dark ravines in the summit cliffs, where there is a somewhat copious growth of herbaceous plants and small deciduous trees and saplings. Mr. Hebard found this *Humboldtiana* in oak forest on the summit of Lost Mine Mountain, (7550 ft.), about two miles south of their camp at Moss Well.

***Humboldtiana ferrissiana* Pilsbry**

Figs. 269 c, d.

Humboldtiana ferrissiana Pilsbry, 1928, Nautilus, 41: 82; 1935, Proc. Acad. Nat. Sci. Phila., 87: 2, pl. 1, figs. 5, 6.

The depressed-subglobose shell is narrowly, obliquely umbilicate, rather thin, white under a thin yellow periostracum (between maize yellow and chamois) with three carob-brown bands, the lower one rather weak and interrupted. The surface is glossy; first half whorl smooth, the following whorl finely closely radially costulate-granose; next whorl with traces of

fine granulation in places; later whorls have irregular growth wrinkles and some narrow whitish streaks on the larger wrinkles. The whorls increase rapidly, and the last one descends rather deeply to the aperture. The aperture is oblique; peristome thin, the outer and basal margins very narrowly expanded, the columellar margin broadly, triangularly reflected over the umbilicus.

Height 26 mm., diameter 32.3 mm.; $4\frac{1}{3}$ whorls. Type.

Height 22 mm., diameter 29 mm.; 4 whorls.

TEXAS: Miter Peak, Davis Mountains, at about 7500 feet, in a rock slide (J. H. Ferriss), Type 144338, paratypes 144339 A.N.S.P.

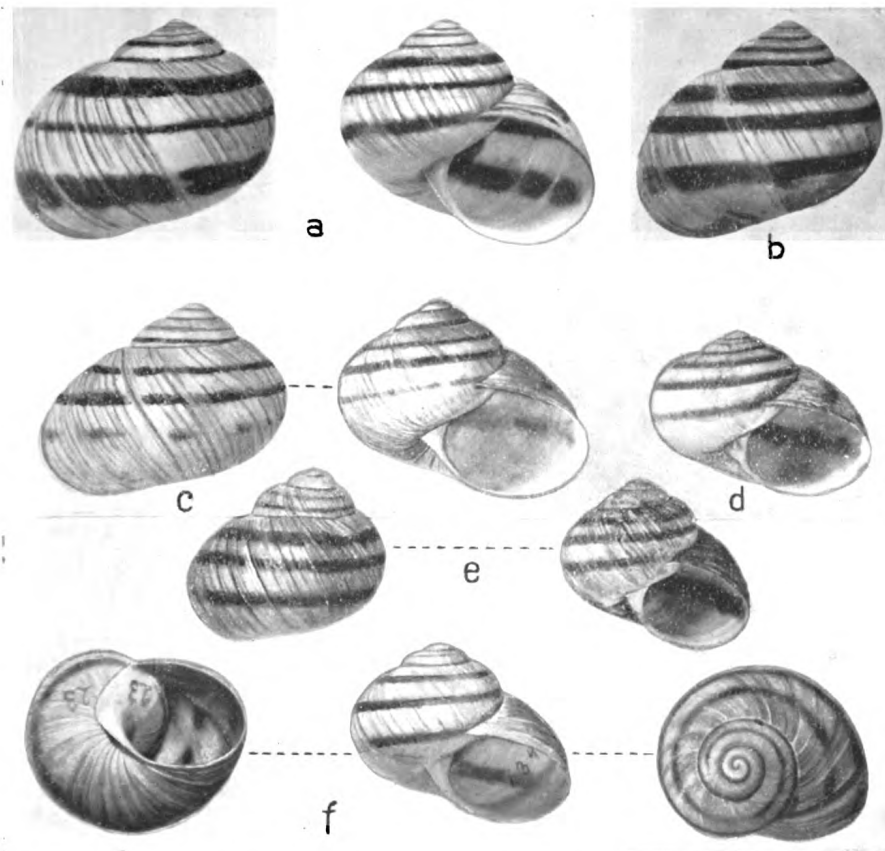


Fig. 269. a, *Humboldtiana cheatumi*, type; b, Blue Mountain. c, d., *H. ferrissiana*. e, *H. palmeri*. f. *H. h. praesidi*. a, c, f, types; d, e, paratypes.

This snail is closely related to the Mexican *H. högeana*, but entirely different in color. It is similar to *H. chisosensis* in shape, but there is more granulation of the spire in that species, and its embryonic whorls are practically smooth. *H. cheatumi* has a decidedly more rotund body-whorl

and more granulation. Though about 30 were taken, few have the periostracum, and none were found alive. Davis Mountain snails are hard to find in dry weather.

Humboldtiana högeana praesidii new subspecies

Fig. 269 f.

The depressed-subglobose shell is rather narrowly, obliquely umbilicate, of a quite dilute pecan-brown with paler or whitish streaks and on the last whorl a few white retractively radial lines, and three subequal chestnut-brown bands. The initial half whorl is flat, smooth, next whorl with very fine, close, weak, regular radial striae. Subsequent whorls are rather strongly convex, the last descending deeply in front. Surface with irregular wrinkles of growth, a few of the larger ones white; there is no granulation. The oval aperture is strongly oblique, whitish and banded within, brown towards the lip. The thin peristome is expanded in the basal margin, broadly dilated over the umbilicus; columella and the short parietal callus are light ochraceous buff.

Height 22.7 mm., diameter 27.6 mm.; 4 whorls.

TEXAS: Near San Carlos (J. D. Mitchell); near San Carlos mine (J. A. Singley), Type 134160 U.S.N.M. Rim Rock Mountains (W. F. Cummin); all in Presidio County.

H. högeana (Von Martens)¹ is a widely spread snail in the state of Chihuahua, from the low mountains around the city to the Sierra Madre in the west. It is minutely granular on the spire, usually larger than *praesidii* and more variegated. The five specimens from two localities of *H. h. praesidii* in the National Museum do not show any granulation. The smallest adult, from near San Carlos, measures height 21.5 mm., diameter 27 mm., no. 464907; the largest, from Rim Rock Mountains, height 21.9 mm., diameter 29 mm. They are all dead shells, more or less faded. The first two localities mentioned above are probably one place.

Humboldtiana cheatumi Pilsbry

Fig. 269 a, b.

Humboldtiana cheatumi Pilsbry, 1935, Nautilus, 48: 93.—Cheatum, Nautilus, 48: 115.

The globose shell is light yellow with blackish carob-brown bands, the upper and lower ones at least twice the width of the middle band. There are nearly 1½ embryonic whorls, the first half turn smooth, the rest with weak radial ridges set rather sparsely with granules. Weak traces of granulation are visible in places on the spire, becoming obsolete or nearly so on the last half whorl; otherwise there are only rather coarse wrinkles along lines of growth. The peristome is somewhat expanded in the basal curve, becoming broadly, triangularly reflected above, more than half concealing the umbilicus.

Height 29 mm., diameter 33.5 mm.; 4 whorls.

TEXAS: Davis Mountains, at head of a small canyon tributary to Limpia Canyon, about 5 miles north of Fort Davis (E. P. Cheatum), Type

¹ *Helix humboldtiana* var. *högeana* E. von Martens, 1892, Biologia Centrali-Americana, Land and Freshwater Mollusca, pp. 146, 148, pl. 7, figs. 20, 21; Chihuahua (Höge).

164095 A.N.S.P., paratypes 163877 A.N.S.P. and in collection of E. P. Cheatum. North side summit of Blue Mountain, 7300 feet (Pilsbry and Harvey).

Of the other species described from the Davis Mountains, *H. palmeri* Clench & Rehder is distinctly granulose throughout the last whorl except around the umbilicus. It is also much smaller, and the bands are subequal. In *H. ferrisiana* Pilsbry the last whorl is more depressed, the aperture more oblique, the middle band as wide as its fellows, and there is no granulation on post-embryonic whorls.

Of the type locality Professor Cheatum states that "at the head of this canyon was an abandoned water-wheel. Seepage water from the spring above fed the small stream in the canyon bed. The collecting area was well shaded by a group of Texan oaks (*Quercus texana*). An intensive search of four or five hours by four people netted only seven living specimens and six dead shells. The living snails were taken from the sides of the large rocks beneath the rocky ledges, all apparently restricted to the shaded area."

The specimens from Blue Mountain (Fig. 269 b) are somewhat higher than the type lot, and the middle band is about equal in width to the others. Two measure: height 29.8 mm., diameter 30.7 mm., and 31, 32.5 mm., both with 4½ whorls. The largest shell (imperfect) has a diameter of 36 mm. They were taken deep in coarse, angular igneous rock close to the summit, the place being arid, with hardly any shade from the low bushes.

Humboldtiana palmeri Clench & Rehder

Figs. 269 e; 270: 7.

Humboldtiana palmeri Clench & Rehder, 1930, Nautilus, 44: 12, pl. 2, figs. 1-4.—
Pilsbry, 1935, Proc. Acad. Nat. Sci. Phila., 87: 2, pl. 1, fig. 11.

"Shell thin but strong, subglobose, whorls 4, umbilicate, buckthorn brown in color with occasional irregular straw yellow mottlings along growth lines. Three seal-brown bands encircle the shell. The young shells, of 3½ whorls are somewhat lighter, honey yellow in color. First half whorl smooth, following ¾ whorl finely rugulose-granulose, following whorls distinctly granulose even over the last quarter of the final whorl; granulations extend over the base though somewhat less distinct. The whorls marked by irregular growth wrinkles, the granulations continuing over the wrinkles. Whorls convex, increasing rapidly, the last whorl descending slightly. Aperture oblique, and appearing almost circular; peristome thin, only occasionally very slightly thickened on the inside. Columellar margin strongly reflected over the umbilicus. Interior nacreous-whitish, bands showing through distinctly." (Clench & Rehder.)

Height 22 mm., diameter 26.1 mm., aperture 16.1 x 14.4 mm. Type.

Height 20.5 mm., diameter 23.7 mm. Paratype.

Height 23 mm., diameter 24 mm. Paratype.

TEXAS: Head of Madera Canyon at 7,350 feet, Mt. Livermore, Davis Mountains, Jeff Davis County (Ernest J. Palmer). Type M.C.Z. 79779.

H. palmeri is closely similar to *H. texana* Pils., being indistinguishable from it in size and shape; but the Davis Mountain shell is decidedly darker

colored, buckthorn brown to chamois, and the three dark bands are all equally broad and distinct; moreover, the granulation of *palmeri* is strongly developed, extending over the last whorl to the peristome and weakly upon the base; the umbilicus is a little larger than in *texana* and the shell thinner. Figures are from a paratype, 151227 A.N.S.P.

"The Davis Mountains are . . . a group of rugged mountains, some peaks being isolated, and others arranged in irregular groups separated by deep canyons and high cliffs. They are of igneous rock, except for an exposure of sandstone in one place, and for some beds of Comanchean limestone on the northern slopes of the mountains. The highest peak is Mt. Livermore also known as 'Baldy Peak', which has an elevation of 8,382 feet. Several canyons lead up to this peak, and this species was found at the head of Madera Canyon, which is on the north side of the mountain, at a height of approximately 7,350 feet." (Clench and Rehder.)

Humboldtiana texana Pilsbry

Figs. 270: 5, 271.

Helix (Pomatia) humboldtiana Val., Stearns, 1891, Proc. U. S. Nat. Mus., 14: 96 (Altuda, Texas, in soil thrown out by a prairie dog, William Lloyd).

Humboldtiana texana Pilsbry, 1927, Proc. Acad. Nat. Sci. Phila., 79: 179, figs. 3, 4, 8-9a; pl. 12, figs. 9-11; pl. 14, fig. 5.

The shell is moderately strong though thin, very narrowly obliquely umbilicate, globose, wider than high. Color white with narrow streaks and patches of cream color (due to the thin periostracum which is mainly deciduous on the wrinkles), the $1\frac{1}{2}$ embryonic whorls cream color. The last whorl has three bands, the middle one carob brown, the others between cinnamon-brown and russet, narrower, somewhat interrupted. After the



Fig. 271. *Humboldtiana texana*, type and paratypes.

smooth initial half whorl the surface has a minute sculpture of pits and radial wrinkles. Post-embryonic whorls are finely granulose, the granulation disappearing on the base and the last third of the last whorl. The last whorl is rather strongly irregularly wrinkled along lines of growth. The whorls are convex, the last rapidly increasing, its suture descending to the aperture. The rotund-oval aperture is strongly oblique, white and banded within. Peristome rather thick, cream colored, slightly expanded basally and on the columellar margin, dilated and partly covering the narrow umbilicus.

Height 22 mm., diameter 24 mm.; $4\frac{1}{2}$ whorls. Type.

Height 19 mm., diameter 21 mm.; 4 whorls. Topotype.

Fig. 270. 5, *Humboldtiana texana*. 6, *H. ultima*, pallial tract. 7, (upper right), *H. palmeri*. 8, *H. chisosensis*. See p. 405.



Height 23.6 mm., diameter 26.3 mm. 34 miles below Marathon.
Height 27 mm., diameter 28 mm. Housetop Mountain.

TEXAS: Along the highway east of Marathon, at Housetop Mountain, 15 to 20 miles east, Type 134171 A.N.S.P. Also about 25 miles east, and south side of valley near water tank about 34 miles east (James H. Ferriss).

The specimens from about 34 miles east of Marathon retain most of the periostracum, and the lip is less thickened than in the type lot. The amount of granulation on the last whorl varies somewhat individually in *H. texana*; in some examples there may be very little or scarcely any. Over 60 specimens have been examined.

The localities known for *H. texana* are probably all between 3900 and 5000 ft. in a short-grass country with rather barren, rocky hills, on which there is sometimes more or less small oak or other deciduous growth. *Humboldtiana* occurs here in places with very little shelter, and which would usually be passed by the collector as probably unproductive.

The genitalia (Fig. 272: 8-9a) differ in no important respect from *H. chisosensis*. In both there is a rather long space, 7 mm., between dart sacs and mucous gland ring; the dart sacs are more or less markedly unequal; the flagellum is over twice the length of penis and epiphallus, the penial retractor muscle is rather short, and the diverticulum arises only a short distance from the spermatheca, about at the distal fifth of the total length of the organ.

The penis has several fleshy folds two of them extending nearly to the distal end of the cavity, the others wanting in the upper third. The large verge nearly fills the cavity at first (Fig. 272: 8d), rapidly diminishes in diameter, and extends throughout the cavity to the anterior contraction of the walls. The four mucous glands, though their glandular bodies are independent, are united together and to the vaginal wall as in Figure 272: 8b (a somewhat oblique section near the base of the ring). Their ducts penetrate the quadrants into which the vaginal wall is divided by its cavity (Fig. 272: 8c, section immediately above the dart sacs, with outlines of the latter). The dart sacs are unequal, as shown in the outlines, Figures 272: 8c, 9a. Lengths of the organs follow: Penis 7 mm. Epiphallus 11 mm. Flagellum 42 mm. Spermatheca and duct 55 mm. Diverticulum 9 mm.

The jaw (Fig. 265 a) has several low ribs, scarcely noticeable except by transmitted light. Radula (Fig. 267: 3). The centrals are of the usual form, with cusp decidedly shorter than basal plate. Laterals shaped as in *H. chisosensis*; the cusps overhang laterally (at least in the row drawn). Mesocone becomes emarginate or bifid about at the 27th tooth, but it is not uniformly so, and is simple on part of the marginals. The ectocone appears

8a, spermatheca and diverticulum of its duct; 8b, somewhat oblique section cut at point marked b in fig. 8, through base of the mucous glands and vagina (in center); 8c, section cut at point marked c on fig. 8, through vagina and ducts of mucous glands immediately above dart sacs, with outlines of the latter; 8d, section of penis and verge at point marked d on fig. 8, looking distad, and 8e same looking proximad. 9, *H. texana* (no. 142043); 9a, section of vagina and mucous glands cut at point marked a on fig. 9, with outlines of dart sacs. 10, *H. chisosensis*, with details of spermatheca and diverticulum, and section above dart sacs with outline of the latter at 10a. See p. 407.

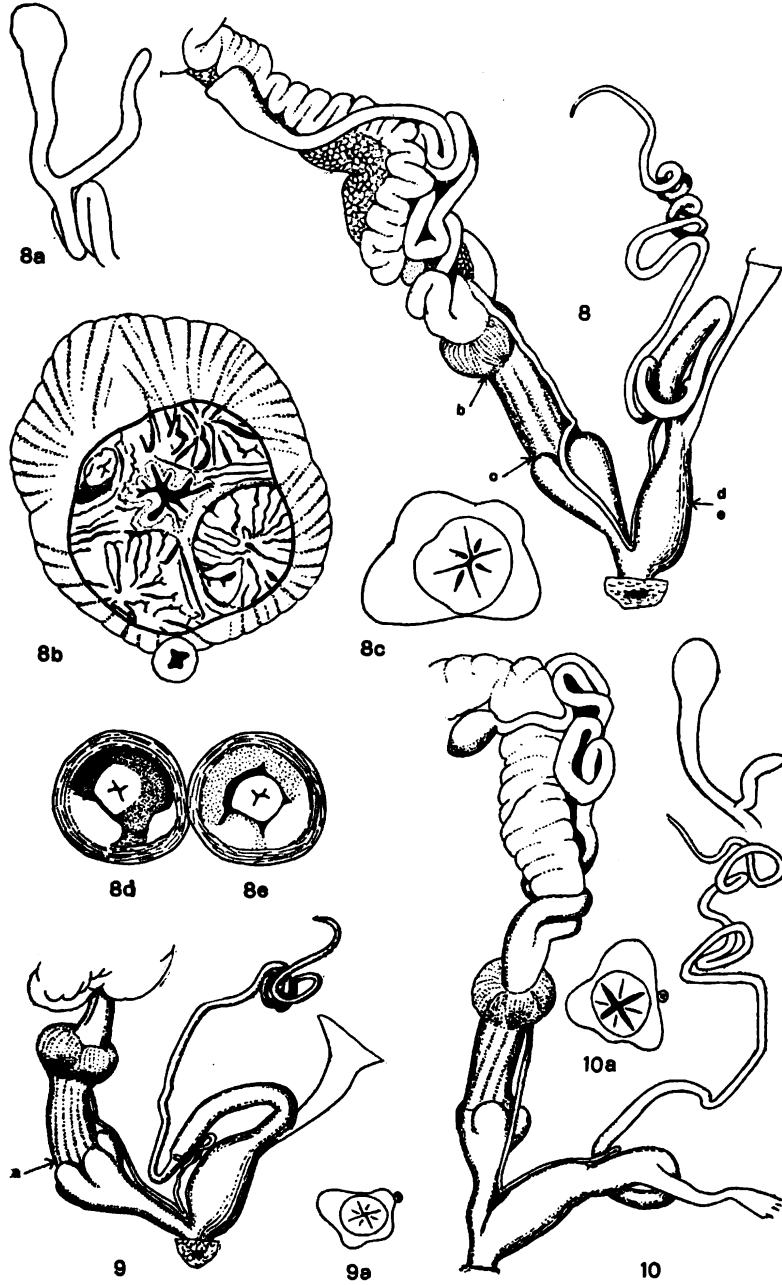


Fig. 272. 8, genitalia of *Humboldtiana texana*, type. (See footnote, p. 406 for legend.)

from the 11th to the 15th tooth, and is often bifid or trifold, and on the outer marginals this cusp may be represented by a varying number of minute denticles, often unequal. The marginals are often quite irregular, and abnormally formed cusps are frequent in two radulae examined. Side teeth 43. The tendency of the ectocones to appear early on the laterals and to become divided and subdivided on the marginals appears to be the chief differential character of the teeth of this species.

A series (no. 142043) sent in without definite locality, but from somewhere along the same road, consists of thin shells, 20 to 22 mm. in diameter, often retaining practically all of the thin, cream-buff periostracum, and having the lip scarcely at all thickened. Ectocones or traces of them are on all of the side teeth. The genitalia (Fig. 272: 9, 9a) and a group of outer marginal teeth (Fig. 167: 4) are figured; also the jaw (Fig. 265 b) which is strongly ribbed, as in *H. Fischer's* figure of the jaw of *H. humboldtiana*, differing remarkably from the jaw of the type. In the radula the ectocone is slightly indicated on the first lateral teeth, and is distinctly seen on the 4th or 5th. A group of outer marginals of this radula is drawn in Figure 267: 4.

A specimen (118366 U.S.N.M.) collected by Wm. Lloyd at Altuda, Brewster County, Texas, from soil thrown out by a prairie dog, is larger than other *texana* seen, height 29 mm., diameter 29.5 mm., 4½ whorls. The granulation extends over the whole shell except in an area around the umbilicus, as in *H. palmeri*. It may possibly represent a subspecies, but sufficient material is not available for judging the value of distinctions now accepted in the *texana* series.

Humboldtiana ultima Pilsbry

Fig. 273.

Humboldtiana ultima Pilsbry, 1927, Proc. Acad. Nat. Sci. Phila., 79: 184, figs. 6, 12; pl. 12, figs. 12-14; pl. 13, fig. 4.

The shell is narrowly umbilicate, depressed-globose, thin. Chamois colored where the thin periostracum is unworn, with many white lines along growth lines and more or less white or whitish mottling, and encircled with three carob-brown bands. Initial half whorl smooth, the next whorl with weak, microscopic radial wrinkle-pitted sculpture. Later whorls with irregular rather weak growth wrinkles, and between them, in some places only, a fine dense granulation, wanting on the base. The whorls are strongly convex, the suture of the last descending rather deeply to the aperture. The aperture is oblique, rounded-oval, approaching circular. The peristome is dirty buff, very slightly thickened at the edge, dilated half over the umbilicus.

Height 25 mm., diameter 30.3 mm.; 4 whorls. Type.

Height 23 mm., diameter 25.5 mm.; 4 whorls. Station 240.

Height 20.5 mm., diameter 23.3 mm.; 3½ whorls. Station 240.

TEXAS, NEW MEXICO: Canyons at high elevations in the Guadalupe Range, southeast of Orange, N. M., along the interstate boundary, the type

lot, 142330 A.N.S.P., from Station 241 east of the crest of the range, a smaller form from Station 240, west of the crest (Pilsbry and Ferriss).

The granulation is very much reduced in this species. The upper and lower bands are as wide as the central one or wider, not reduced as they are in *H. texana*. The small form from Station 240 resembles *H. texana*



Fig. 273. *Humboldtiana ultima*, type, paratype, and sculpture of last and penultimate whorls.

rather closely, but it has a larger aperture and scarcely a trace of granulation. The species is very distinct from all others anatomically, standing much nearer to Mexican than to the other Texan species.

Genitalia (Fig. 274). The penis and epiphallus are shorter than in *H. buffoniana*, the flagellum very much longer, about five times the length of penis and epiphallus. The dart sacs are inserted further up on the vagina, at about its middle. Mucous gland ring is very prominent and close above the summits of the dart sacs. The diverticulum arises nearer the spermatheca than in *buffoniana*, only about 10 mm. from the distal end. The lengths of the organs are as follows:

Penis 7 mm.
Epiphallus 11 mm.
Flagellum 96 mm.

Vagina and atrium 16 mm.
Spermatheca and duct 62 mm.
Diverticulum 6 mm.

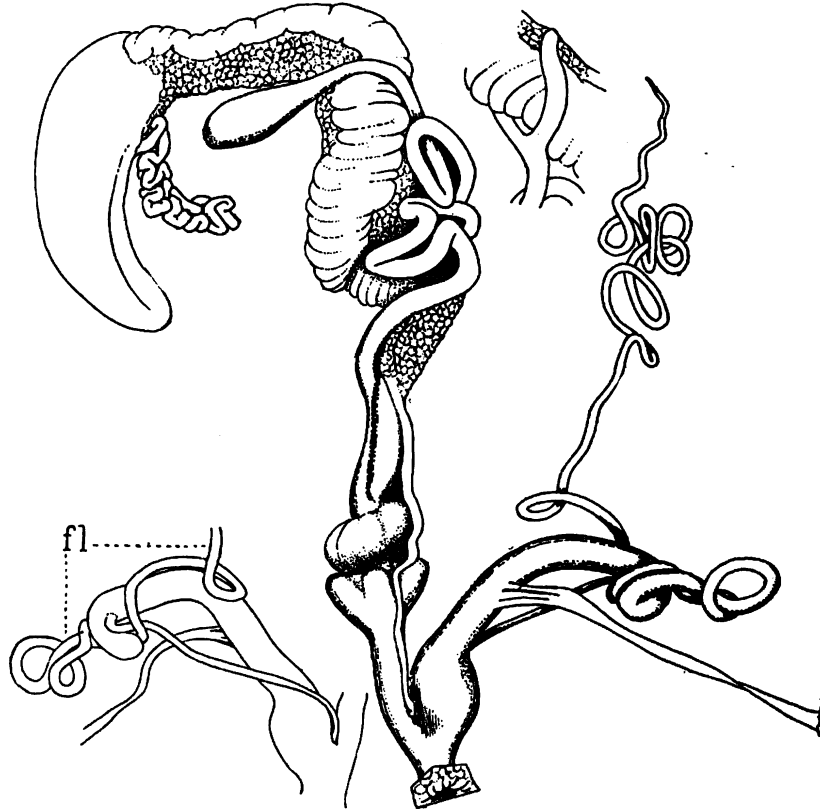


Fig. 274. Genitalia of *Humboldtiana ultima*, with detail of branch of spermathecal duct above, and of under side of penis below at left; fl, flagellum.

Jaw (Fig. 265 d) has about four very low, wide ribs, feebly scalloping the cutting margin.

Radula (Fig. 267: 6). The central tooth is very much narrower than the laterals, with the cusp nearly as long as the basal plate. It is asymmetrical, the cusp bent towards the left in the radula examined. The mesocones of side teeth are mainly simple, only the short outer ones have an endocone indicated. The ectocone appears on about the 23d lateral and is simple on all of the marginal teeth. I count 47 side teeth. This radula is peculiar in the genus for its narrow centrals and the undivided ectocones of the marginals.

(*Ultimus*, the last—northward.)

Family IV. CAMAENIDAE

Epiphallophora Pilsbry, 1892, Proc. Acad. Nat. Sci. Phila., p. 397.

Epiphalloгона (*Camaeninae*) Pilsbry, 1895, Man. Conch., 9: xxxii; Index to Helices, p. 124.

Camaenidae Von Möllendorff, 1898, Abh. Naturf. Ges. Görlitz, 22: 90.

Pleurodontidae Von Ihering, 1912, Jour. Acad. Nat. Sci. Phila., (2), 15: 479.—Thiele, 1931, Handb. der Syst. Weichtierkunde, p. 676.

Helices without dart apparatus; penis continued in an epiphallus and a flagellum (the latter sometimes vestigial or wanting); spermathecal duct not branched.

This group of helices has been accepted by systematists in the sense of the original definition, though it has been enlarged by the inclusion of genera unknown or not dissected at the time it was instituted, and various family names have been used for it. In 1895 these snails were termed Epiphalllogona, to separate them from the preceding families, which collectively form the superfamily group Belogona.

While the Epiphalllogona apparently form a natural group, several subordinate structural types are included, and further investigation is required to show whether all of its genera are to be retained in the single family Camaenidae, or divided among several families. In case further division is made, our genera shall form the families Ammonitellidae and Oreohelicidae. Pending further study of Asiatic and East Indian epiphalllogonous helices our west American representatives are here left in the Camaenidae as subfamilies.

It does not appear practicable, at present, to define this group of helices briefly, in a way to exclude presumably belogonous helices which have lost the dart apparatus. However, the shells are rather different; they do not have the five-banded pattern, or the single shoulder band, common in belogonous helices, but plain and many-banded shells occur in both groups. In many genera the shells are large and solid.

Helices of this stock seem to have had an early radiation in Mesozoic time, reaching Australia, perhaps with the marsupials, and spreading to Europe, where they are known in the Eocene by *Dentellocaracolus* and other genera. The presence of *Oreohelix* in the Upper Cretaceous of Alberta is evidence of an early advent in America.

Although tropical American helices such as *Pleurodonte*, *Polydontes* and *Zachrysia* have been recognized since 1895 as part of the epiphalllogonous series, the relation of our Ammonitellid and Oreohelicid snails to this group has been overlooked up to this time. The genera have been scattered among Polygyridae and belogonous helices.

The widely deployed West Indian and South American genus *Pleurodonte* is represented in the Lower Miocene Silex Beds of Tampa Bay, Florida, by one or two species described (1890) as *Helix*, but later referred to *Pleurodonte* (Dall, 1915, U. S. Nat. Mus. Bull., 90: 23-4). They do not seem directly referable to any of the West Indian subgenera, and the subgenus *Pleurodontites*, with the type *P. haruspica* (Dall), is here proposed for them. The species are *P. haruspica* (Dall), and with some doubt, *P. diespiter* (Dall). "*Pleurodonte*" *ehippina* Cockerell, 1915, Bull. Amer. Mus. Nat. Hist., 34: 119), from the Sand Coulee Eocene, Wyoming, does

not appear to me to be pleurodontid, but better material is needed for an estimate of its place.

C. T. Simpson liberated specimens of the Cuban *Zachrysia auricoma* and *Pleurodonte marginella*, with other Cuban snails, in his place at Little River, Florida, at the north end of Biscayne Bay (*Nautilus*, 1919, 32: 104). I do not know that any still survive.

In the Recent fauna of our mountain and Pacific states this group is represented by two strongly characterized subfamilies, which have the following characters in common:

Shell umbilicate, with the outer and basal margins of the lip not expanded or reflected; penis without a verge; spermathecal duct long; talon exposed; kidney short or medium; jaw striate or plaited, not ribbed; marginal teeth bicuspid (cusps rarely notched).

And the following differential characters:

AMMONITELLINAE: Shell discoidal, one-colored, with somewhat zonitid texture, the periphery rounded at all stages of growth. An accessory sac arises at junction of vagina and oviduct; the talon is very long.

OREOHELICINAE: Shell depressed to pyramidal, opaque, dull or with little gloss, banded or plain, striate or roughly sculptured, the periphery carinate or angular in immature stages. No accessory sac on vagina or free oviduct; talon simple, of moderate size.

Subfamily OREOHELICINAE new subfamily

OREOHELIX Pilsbry

Oreohelix Pilsbry, 1904, *Nautilus*, 17: 131; 1905, *Proc. Acad. Nat. Sci. Phila.*, p. 268 (type *Helix strigosa* Gld.); 1916, p. 340; 1917, p. 42; 1934, 85: 383 (anatomy and catalogue).—Henderson and Daniels, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 315; 1917, p. 49.—Henderson, 1918, *Proc. Malac. Soc. Lond.*, 13: 21; 1924, *Univ. Colo. Studies*, 13: 109; 1936, 23: 87.

Helix, *Patula* and *Pyramidula* of some authors.

The shell is umbilicate, usually depressed but varying from discoidal to pyramidal, of 4 to 6 tubular or carinate whorls; earthy, with thin periostracum or none (except in subg. *Radiocentrum*); typically two-banded (but with many bands to none); embryonic whorls carinate, with radial striae or riblets and usually some spiral sculpture; neanic stage with the periphery angular or carinate. Aperture rounded or angular, toothless, the peristome blunt or sharp, the columellar margin dilated, lip otherwise not expanded or reflected.

The sole is undivided, foot granulose, with a pair of dorsal furrows and usually a distinct genital groove; tail depressed. Lung with venation chiefly on the cardiac side. Kidney short, little longer than the pericardium; secondary ureter closed throughout.

Genitalia (Figs. 277, 282). Penis rather large, truncate posteriorly, containing no verge or distinct papilla; epiphallus well developed, the vas deferens either terminal or inserted sublaterally on the convex end (which represents a flagellum). The vagina is rather long. Spermatheca globose, on a long duct. The talon is a rather large, curved sac, usually pigmented.

Free muscles. The right ocular band passes between penis and vagina, and after union with the right anterior pedal muscles becomes united with the columellar band. The combined left ocular and left anterior pedal band is free throughout, as is the pharyngeal band. The penial retractor attaches to both penis and epiphallus (or in *Radiocentrum* to epiphallus only); posteriorly being inserted on the diaphragm (Fig. 275).

Jaw strong, arcuate, its face vertically finely striate (Fig. 276). Radula with the central and inner lateral teeth either unicuspid, or with weak or well developed ectocones; transition and marginal teeth bicuspid, the mesocone and ectocone simple as a rule, but rarely the cusps may be notched (Fig. 277: D, F).

Distribution.—Southern Saskatchewan and British Columbia south through the mountain states to western Chihuahua; with outlying species westward in Catalina Island, California, and eastward in the Black Hills, South Dakota, and the loess of eastern Iowa.

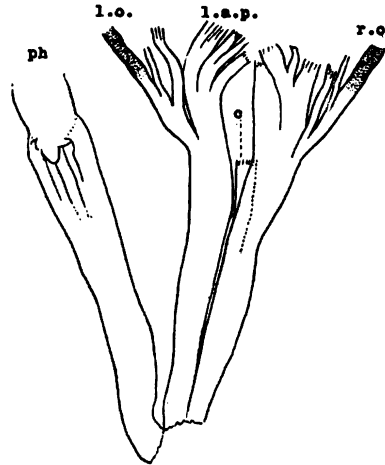


Fig. 275. Free muscles of *Oreohelix strigosa*. c, columellar band; l.a.p, left anterior pedal; l.o., left ocular; ph, pharyngeal; r.o, right ocular.



Fig. 276. Jaws of: left, *Oreohelix chiricahuana*; middle, *O. strigosa depressa*; right, *O. clappi*.

The two-banded pattern, one band immediately below the periphery, the other on the upper surface, appears to be an ancestral feature of the genus, as it occurs in most of the species. In part of the species bands tend to be weak or to disappear, and many colonies of species ordinarily well banded are found in which bands are weak or wanting in part or all of the shells. J. Henderson has noted "that where the banding is weak or wanting on some specimens and strong on others from the same colony, the faintness or absence of bands is most pronounced on the last whorl. This would be interpreted, under the recapitulation theory, to indicate that the color banding is an ancient character of this genus and is in process of disappearing." Sometimes accessory bands are developed, as in typical *O. strigosa* and *O. subrudis*. Occasionally albino shells occur in colonies of colored shells.

Sinistral shells are found more frequently than in our other genera of helices. The aperture is usually toothless, but a low, tooth-like callus within the baso-columellar margin of the lip occurs occasionally in *O. strigosa buttoni*, *O. s. nogalensis* and *O. peripherica*; being variable and apparently too small for any defensive function, its meaning is problematic.

In dealing with an *Oreohelix* of unknown or uncertain identity an examination of the penis is most important, as this shows at once which

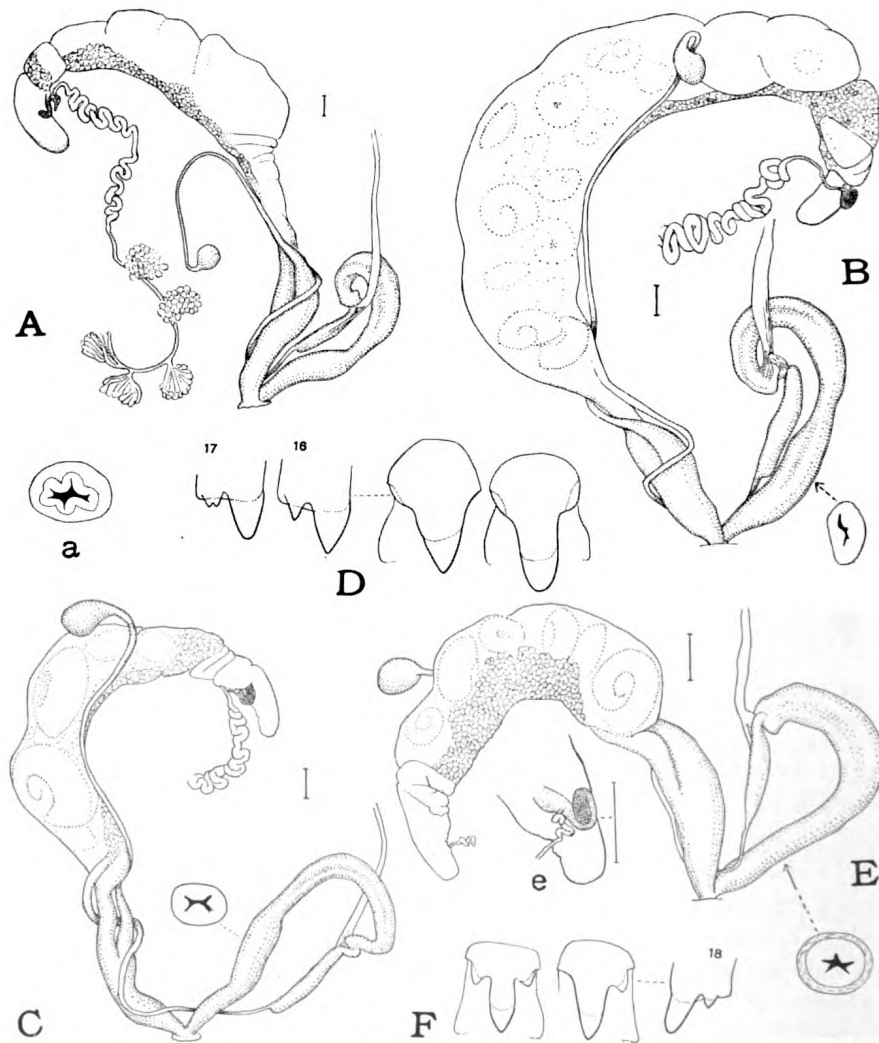


Fig. 277. A, *Oreohelix strigosa* f. *goniogyra*; at a, a section of lower part of penis. B, *O. haydeni perplexa*. C, *O. idahoensis*, cave near Lucile. D, E, *O. pygmaea*; at e lower side of albumen gland and talon. F, *O. chiricahuana*, central, first lateral and a marginal tooth. Scale lines = 1 mm.

group of species is concerned. Within the wide-spread *strigosa-haydeni-idahoensis* group I have found no satisfactory anatomic criteria, the sculptural characters of the shell remaining the best we have, but examination of the penis separates them at once from the almost equally extended *yavapai* and *subrudis* groups, in which the shells are often perplexingly similar.

Bionomics.—The genus of “Mountain Snails” comprises nearly all of the large land shells of the Rocky Mountain states and Great Basin. They are calciphilous, most of them restricted to limestone outcrops and their vicinity. “The edges of coarse, angular limestone talus protected from rapid evaporation by overhanging bushes, formed the cover for some of the finest colonies we have seen, the snails occupying crevices among the rocks. At other localities they were abundant under vegetation on limestone slopes totally devoid of talus, and in a few instances they were found in talus where no limestone was observed, though it is almost certain that the soil or rock must have contained a fair percentage of lime in such cases.”¹

In Arizona some dark colored species with conspicuous periostracum are found deep in rock slides, with *Sonorella* and *Ashmunella*; but as a general rule the *Oreohelices* live near the surface, with a single stone, a bit of bark or a few leaves for cover. Flourishing colonies are sometimes found in situations which seem the least favorable, as *O. hachetana* on the bare, sun-baked, 8300 foot summit of Hacheta Grande, or *O. yavapai extremitatis*, found by Henderson on the barren face of a limestone ledge in Shell Creek Canyon, Wyoming. The opaque, whitish and earthy texture of *Oreohelix* shells of the semiarid states is a protective adaptation to the strong light of a high country with little shade. It is a character common to snails exposed to strong insolation all over the world.

A few species, *O. clappi* and *O. barbata*, live only where deep rock slides in shaded ravines afford constant humid conditions. These shells have color and texture like snails of moist regions. *O. subrudis*, which has a chalky white shell in dry regions, is thin and dark colored in the aspen zone of the Black Range, N. M., living on densely wooded slopes where the forest humus is deep and moist. Henderson notes that at Grand Mesa, Colorado, *O. subrudis* was found “several times on the trunks of aspens ten feet or more from the ground, which is very unusual.”

Variation.—Many of the species of *Oreohelix* are extremely variable in size, height of spire, degree of carination, width of umbilicus and in color. It would be easy to select shells from single colonies showing differences such as in any other of our genera of helices would be thought specific. This has led to a multiplicity of names for selected forms which by themselves appear separable, but in large series from the same colonies are seen to merge through many nuances into one another.

¹ Henderson and Daniels, 1916.

The diversity seen when different colonies are compared is often more perplexing. How much is directly traceable to the special local conditions? How much is of racial significance? In the absence of experimental evidence these questions often remain matters of judgment rather than of demonstration.

Striking disparity in size has often been misleading. Thus, Dall described the small mountain snail of the peaks of the Huachuclas as var. *concentrata*, referring large shells from lower levels to *strigosa*. Later collections show that complete intergradation occurs, the smaller shells being from exposed or otherwise unfavorable situations, sometimes in pure colonies. Similarly in Colorado, colonies of small *O. s. depressa* have been called var. *minor* or *concentrata*. J. Henderson writes: "it is not at all uncommon to find a colony in which those individuals living under the best cover are large and robust, while those at the edges where cover is scant are dwarfed." On the Kaibab Plateau, *O. s. depressa* may vary from about 10 to 25 mm. diameter in the same immediate vicinity, sometimes in different parts of the same large colony, sometimes in different colonies. It should be added that only a few species have been observed to vary in size so widely.

From these considerations it follows that the assigned rank of "species", "subspecies" and "forms" is less definite in *Oreohelix* than in more conservative genera.

Paleontology.—*Oreohelix* has been recognized in the Lower Eocene of New Mexico and Wyoming, the Miocene of Oregon and the Upper Cretaceous and Paleocene of Alberta, the following species being recorded. For literature see J. Henderson: Fossil Non-Marine Mollusca of North America, 1935, p. 138.

OREOHELIX ANGULIFERA (Whiteaves). *Patula angulifera* Whiteaves, 1885. Upper Cretaceous, Pincher Creek Alberta.

OREOHELIX OBTUSATA (Whiteaves). *Patula obtusata* Whiteaves, 1885. Upper Cretaceous, St. Mary and Saunders formations, Alberta.

OREOHELIX THURSTONI (Russell). *Helix* (*Pyramidula*?) *thurstoni* Russell, 1926. Upper Cretaceous, Saunders formation, and Paskapoo Paleocene, near Calgary, Alberta.

OREOHELIX ROTUNDATA Russell, 1931. Upper Cretaceous, Saunders formation, Fallentimber Creek, Alberta.

OREOHELIX GRANGERI Cockerell and Henderson, 1912. Lower Eocene, Big Horn Basin, Wyoming.

OREOHELIX MEGARCHE Cockerell and Henderson, 1912. Eocene, Big Horn Basin, Wyoming.

OREOHELIX (?) LECONTEI (Stearns). *Pyramidula lecontei* Stearns, 1902. Lower Miocene, John Day Basin, Oregon.

OREOHELIX NACIMIENSIS (White). *Helix nacimientensis* White, 1886. Puerco and Torrejon Eocene, New Mexico.

OREOHELIX N. STEINI Cockerell, 1914. Torrejon Eocene, east fork Torrejon Arroyo, New Mexico.

The Cretaceous species are referred to this genus with some doubt, as the material is not in perfect condition, yet those I have seen certainly appear to belong here. *O. megarche* and *O. nacimientensis* are decidedly larger than any of the modern species. The last is referred to the subgenus *Radiocentrum* by Cockerell and Henderson on account of the sculpture of the early whorls, well preserved in some examples.

It is extraordinary that so ancient a genus is now in a stage of prolific speciation. So far as known, it has occupied its present area and northward since Upper Cretaceous times.

History.—The first *Oreohelix* was discovered in 1841 by naturalists of the U. S. Exploring Expedition, and was described as *Helix strigosa* by A. A. Gould in 1846. In their work of 1869, Binney and Bland recognized three species: *Helix strigosa* Gld., *H. cooperi* W. G. B. and *H. idahoensis* Newcomb. In 1878, Binney (Terr. Moll. 5: 157-) transferred the group to the genus *Patula*. He reduced *cooperi* W. G. B. and *haydeni* Gabb, 1869, to varieties of *strigosa*, and added the species *hemphilli* Newc. This arrangement was retained in Binney's Manual of 1885. After this, the remarkable series from Idaho and Utah collected by Henry Hemphill caused Binney (1886, Bull. Mus. Comp. Zool., 13: 26; 1892, Bull. Mus. Comp. Zool., 22: 169) to view the entire series of forms then known as varieties of *strigosa*. This view was generally accepted, as Mr. Binney was conceded to be the leading authority of his time on American land snails.

It will be noted that relatively few species, from only a part of the area of the genus, were known to Binney and Hemphill. In dealing with the forms described prior to 1890 modern authors have returned to Binney's earlier opinion, and regard *strigosa*, *cooperi*, *idahoensis*, *haydeni* and *hemphilli* as species.

In 1893 (Man. Conch., 9: 42) I proposed to unite all patuloid snails (including the oreohelices) under *Pyramidula*, the prior name then believed to belong to that group. It was an unfortunate idea, for further research has shown that neither *Pyramidula* or *Oreohelix* are related to the "Patulae" (Endodontidae).

On receiving living animals collected by Ferriss in 1902, it was noticed that the foot lacked the pedal grooves proper to "*Patula*" (that is, *Discus* and *Anguispira*), being holopod, like that of the Helicidae, and in 1904 the generic name *Oreohelix* was proposed. The first catalogue of species under the new name was published in 1916.

In recent years the genus has been diligently collected and studied in Colorado, Utah, Montana and westward by Junius Henderson, whose publications are often quoted herein. Species of Arizona and New Mexico

are known chiefly by the collections and papers of J. H. Ferriss and the author. Large collections made by H. Burrington Baker in Idaho are briefly reported on in this work.

Classification.—The species of *Oreohelix* are classified as follows:

1. Embryonic shell of one and one-half radially costulate whorls; penis short, widened distally, the internally plicate part very short; epiphallus about as long as the penis; oviparous.....Subgenus *Radiocentrum*
Embryonic shell of more than two whorls at birth, variously wrinkled and striate; epiphallus much shorter than the penis; viviparous. Subgenus *Oreohelix* s. str.; 2.
2. Internally plicate part of the long penis decidedly less than half of the entire length.
Group of *O. strigosa*
Internally plicate part half, or more than half, of the total length of penis.....3.
3. Anterior half of penis not, or but slightly, swollen.....Group of *O. subrudis*
Anterior half of penis decidedly swollen.....Group of *O. yavapai*

Key to Species of Oreohelix

The Oreohelices vary so widely and show so many cases of parallel and of convergent evolution that the construction of a trustworthy key will be a difficult task. Meantime, the grouping given below may be of some use to those beginning work on the genus.

- A. Embryonic shell strongly ribbed radially, of about 1½ whorls (Fig. 357: 5d, 6).
Subgenus *Radiocentrum*
- AA. Embryonic shell of about 2½ whorls, which are striate and usually with spiral lines (Fig. 338: 13, 14).....Subgenus *Oreohelix* s. str.
 - B. Shell having coarse spiral sculpture.
 - C. Colorado and Utah to Montana and Idaho.
O. haydeni and subspecies; *O. tenuistriata*
 - CC. Southwestern New Mexico.
 - D. Strongly depressed, spirals low.....*O. metcalfei concentrica*
 - DD. Less depressed, spirals cord-like.....*O. pilsbryi*
 - BB. Shell having coarse striae, wrinkles or ribs along lines of growth.
 - C. Pyramidal, strongly carinate.....*O. peripherica wasatchensis*
 - CC. Lens-shaped, strongly carinate.
 - D. Heavily ribbed, diam. 10-15 mm.....*O. idahoensis baileyi*
 - DD. Irregularly wrinkle-ribbed, whorls flattened, larger.
 - Mission Range, Montana.....*O. elrodi*
 - Black Range, New Mexico.....*O. metcalfei radiata*
 - CCC. Moderately elevated, with round or subangular periphery.
 - D. Very heavily ribbed.....*O. idahoensis*
 - DD. Finely ribbed to coarsely striate.
 - Northeastern Utah.....*O. peripherica*
 - Wyoming, Montana.....*O. pygmaea*
 - DDD. With coarse, irregular ribs.....*O. peripherica weberiana*
 - BBB. Shell smoothish or striate along growth lines, often with fine spiral lines.
 - C. Periphery strongly angular or carinate.
 - D. Rather large, about 18 to 25 mm.
 - Northern Arizona to Montana.....*O. yavapai*
 - Western Idaho.....*O. strigosa goniogyra*
 - Black Range, New Mexico.....*O. metcalfei*

- DD. Diameter about 10 to 16 mm.
 Bitter Root Mts., Montana.....*O. amariradix*
 Eastern Nevada.....*O. hemphilli*
 Northern Arizona and New Mexico to Montana.....*O. yavapai*
 Charleston Mt., Nevada.....*O. handi*
- DDD. Diameter about 9 to 10 mm.
 Mission Range, Montana.....*O. alpina*
 Garrison, Montana.....*O. carinifera*
 Utah.....*O. eurekensis*
 Northern Arizona and New Mexico.....*O. yavapai*
 Northeastern San Bernardino County, California...*O. californica*
- CC. Periphery angular in front or rounded throughout.
 Washington to western Montana..*O. strigosa*; *O. junii*; *O. jugalis*
 Eastern Nevada.....*O. nevadensis*
 White Mountains, New Mexico.....*O. strigosa nogalensis*
 Western New Mexico.
O. metcalfei hermosensis; *O. m. cuchillensis*; *O. swopei*
 Southeastern Arizona.....*O. concentrata*
 Mountain states generally..*O. strigosa* subspecies; *O. hendersoni*;
O. subrudis; *O. tenuistriata*

Subgenus OREOHELIX s. str.

The embryonic shell consists of over two whorls which are radially striate, with usually some spiral sculpture. Penis with the anterior part internally ribbed or with irregular fleshy bodies, posterior part papillose. Reproduction viviparous.

(*'Opsios.* of mountains, + *Helix.* Mountain snails.)

OREOHELIX STRIGOSA GROUP

Oreohelix strigosa (Gould)

Figs. 278, 279: 1-11.

- Helix strigosa* Gould, 1846, Proc. Boston Soc. Nat. Hist., 2: 166; 1852, U. S. Expl. Exped., 12: 36, pl. 3, fig. 41; in Binney, 1851, Terr. Moll., 2: 210, 3: 29, pl. 26a.
Patula strigosa Gld., W. G. Binney, 1878, Terr. Moll., 5: 157, pl. 26a.
Patula strigosa var. *parma* Hemphill, 1890, Nautilus, 4: 17 (Spokane Falls, Washington).
Patula strigosa var. *subcarinata* Hemphill, 1890, Nautilus, 3: 133.—Binney, 1890, 3d Suppl., Bull. Mus. Comp. Zoöl., 19: 215, fig.; 4th Suppl., Bull. Mus. Comp. Zoöl., 22: 171.
Patula strigosa var. *bicolor* Hemphill, 1890, Nautilus, 3: 133.—Binney, 1892, 4th Suppl., Bull. Mus. Comp. Zoöl., 22: 172, pl. 4, fig. 7.
Patula strigosa var. *lactea* Hemphill, 1890, Nautilus, 3: 134.—Binney, 1892, 4th Suppl., Bull. Mus. Comp. Zoöl., p. 172, pl. 4, fig. 8.
Patula strigosa var. *picta* Hemphill, 1890, Nautilus, 4: 16.—Pilsbry, 1890, Man. Conch., 8: 118, pl. 41, figs. 1, 2.
Oreohelix strigosa canadica Berry, 1922, Canada Dept. of Mines, Bull. no. 36, p. 6, pl. 1, figs. 6-7 (Columbia River valley, Donald Station, B. C.).
Oreohelix strigosa delicata Pilsbry, 1934, Proc. Acad. Nat. Sci. Phila., for 1933, 85: 386, pl. 14, figs. 17-24.
Oreohelix strigosa Gld., Pilsbry, 1904, Nautilus, 17: 131, footnote; 1934, Proc. Acad. Nat. Sci. Phila. for 1933, 85: 383, figs. 1-8 (genitalia), pl. 14, figs. 1-11, 31.—Henderson, 1929, Univ. Colo. Stud., 17: 88; fig. 44; 1936, 23: 91.

"Shell orbicular, slightly, and about equally, convex above and beneath, broadly umbilicated, surface irregular, and roughened above by indentations and coarse lines of growth, and by occasional fine revolving lines; smoother and shining beneath. Color ashy gray, somewhat mottled with dusky, or altogether rusty brown above, with, usually, a single, faint, revolving band on the middle of each whorl, and often with numerous bands, unequal in



Fig. 278. *Oreohelix strigosa*. Type figures (after Binney-Gould).

size and distance, beneath. Whorls five, moderately convex, the last one carinated at its commencement and deflexed near the aperture, which is circular, with the lip simple and nearly continuous; suture well impressed. Greatest diameter nine-tenths of an inch; axis two-fifths of an inch." (Gould.)

BRITISH COLUMBIA: Donald Station, C. P. railroad, west of the crest of the Rocky Mts. (J. B. Tyrell).

WASHINGTON: Grand Coulée; 15 miles north of Ellensburg, Cade County; 8 miles north of Yakima, Yakima County; Springdale, north of Spokane (J. Henderson). Around Spokane (Hemphill, Olney and others). Junction of Entiat and Columbia Rivers (A. G. Smith).

OREGON: North and east of Milton, Umatilla County (H. B. Baker).

IDAHO: East slope Selkirk Mts., between Sand Point and Colburn, Bonner County (H. B. Baker). Rathdrum (Hemphill), for form *subcarinata*. Coeur d'Alene River, opposite Cataldo, Shoshone County; 11 miles up Orofino Creek, Clearwater County 8-900 feet; North Lapwai, Nez Perces County; south of Stites; Squaw Creek and Race Creek, 2700 to 3200 feet, and White Bird, all in Idaho County (H. B. Baker).

MONTANA: Prospect Creek west of Thompson Falls, Sanders County, 2500-3500 feet (H. B. Baker). Blackfoot River, 2 miles above Milltown, and Hell Gate River at Byrne Resort (J. Henderson). Bitter Root Mts., Ravalli County and Warm Spring Canyon, Deer Lodge County (L. E. Daniels).

The locality was originally given as "interior of Oregon," which then included Washington; later, "along Puget Sound", which was certainly

Fig. 279: 1-31, *Oreohelix strigosa* (Gld.). 1, Paratype of *parma* Hemph., Spokane Falls, Wash.; 10898. 2, *Oreohelix strigosa*, Spokane Falls; 10897. 3, 3a, *Oreohelix strigosa*, "Bowl and Pitcher" near Spokane; 158428. 4-8, *Oreohelix strigosa*, 8-10 miles up Squaw Creek, west of Riggins, Idaho; 158431. 9, *Oreohelix strigosa*, lower two miles of Squaw Creek; 158437. 10, 11, *Oreohelix strigosa*, near Stites, Idaho; 143696. 12-16, *Oreohelix strigosa* form *goniogyra*, quarter mile above mouth of Race Creek, near Riggins, Idaho; Fig. 12, type; 158421. 17-21, *Oreohelix strigosa delicata*, four miles up S. fork Walla Walla Canyon, above Milton, Oregon; 158425. 22-24, Same, 1-3 miles up N. fork; 158424. 25, 26, *Oreohelix strigosa variabilis*, Celilo, Oregon. Part of original lot collected by Hemphill; 143699 and 10896. 27, *Oreohelix strigosa variabilis*, two miles below Rufus, Oregon; 147024. 28, 29, 30, *Oreohelix strigosa* form *subcarinata*, paratypes; Rathdrum, Idaho; 62284, 62321, 62390. Fig. 28, no. 62284, is type of "var. *picta*" Hemph. 31, *Oreohelix strigosa* (Gld.), four miles above Colville, Wash.; 147021. 32, 33, *Oreohelix strigosa cooperi*, Spearfish Creek, 1-3 miles above Spearfish, South Dakota. 34-38, Same, near Savoy, Lawrence Co., South Dakota; 158410. See p. 421.

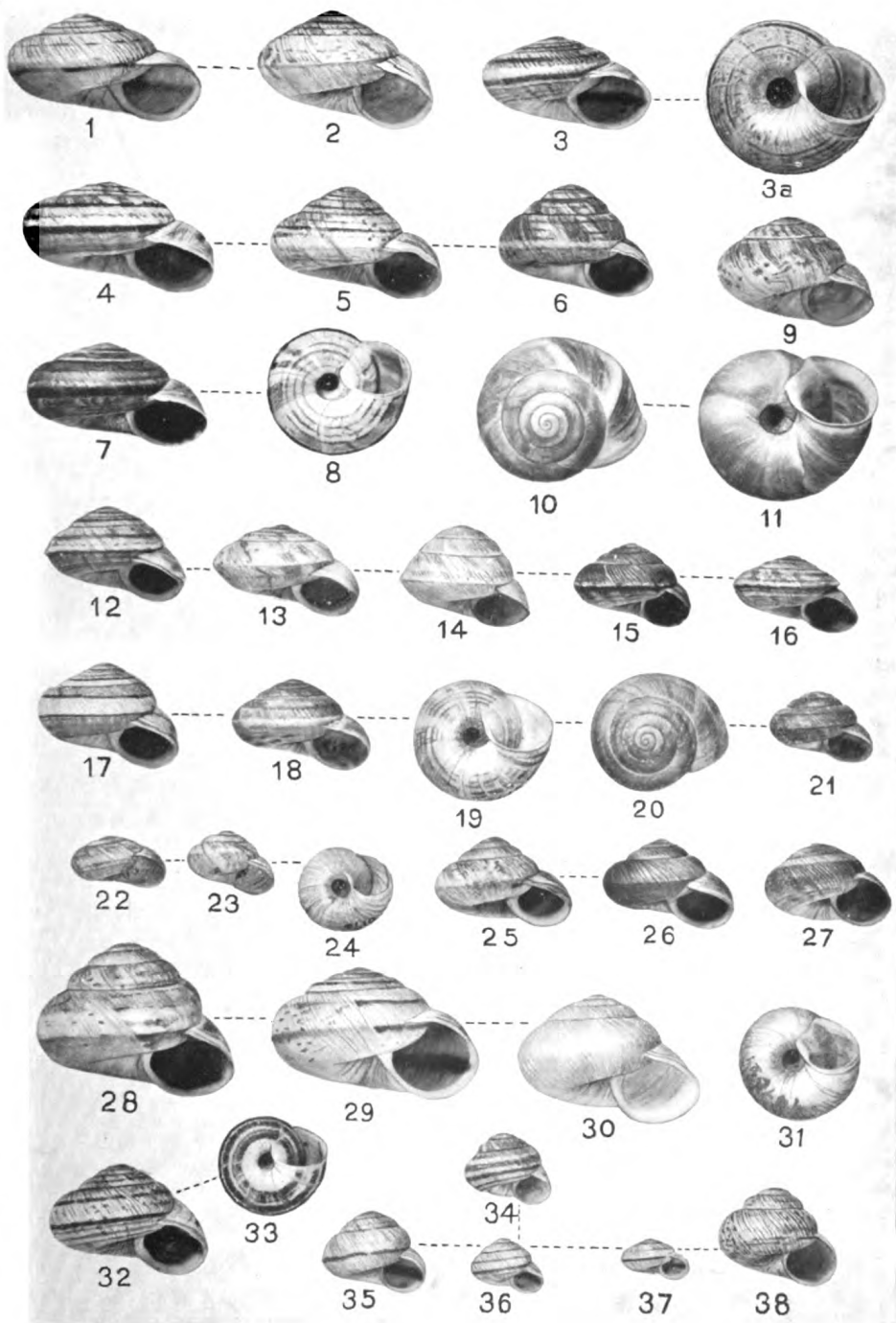


Fig. 279.

wrong, and "Columbia River", where the species is known to occur. Mr. Allyn G. Smith has discussed this question (*Nautilus*, 50: 73-77), and from a study of the Exploring Expedition narrative he concluded that "it seems logical to assume that the type locality of *O. strigosa* can be fixed definitely in the valley of the Columbia River, probably at the point where the Entiat River enters it, or at least not far from that point." It appears that "the north bank of the Columbia for several miles above and below the Entiat is close to the valley wall, which is precipitous and covered towards its base with talus slides that would afford excellent cover for *Oreohelix*." In 1931 Mr. A. G. Smith collected specimens in rock slides at the confluence of the Entiat with the Columbia and also four miles north of the mouth of the Entiat. This is at, or in the immediate vicinity of, the place where the river was crossed by Lieut. Johnson's party of the Exploring Expedition.

(*Strigosus*, lean.)

The typical form of the species is mainly characterized by the rather depressed shell with the last whorl strongly angular in front of the aperture, the angle disappearing on the last half or three-fourths whorl. Besides the two bands usual in the genus there are often numerous lighter bands on the base and more or less irregular mottling throughout. The striation is typically rather strong and irregular, with more or less spiral striation. The embryonic shell of $2\frac{1}{2}$ whorls has weak spirals on the last part, or sometimes almost none.

Within the area defined above, *O. strigosa* is an abundant snail, but owing to local conditions in Oregon and Washington its range appears to be markedly discontinuous. Aside from such size and texture variations as may be attributed to the factors of humidity, nature of the country rock, etc., directly, which may properly be called "forms," and which are often conspicuous in the plastic *Oreohelices*, there is sometimes local differentiation of a nature not apparently traceable to such causes, which should have recognition in formal nomenclature. A case in point is *O. strigosa goniogyra*, which seems to be an incipient subspecies.

The form found around Spokane, Washington (Fig. 279: 1-3a), is practically typical *strigosa*. It is solid, angular in front, calcareous, irregularly but rather strongly striate, with distinct spiral lines above, variable but usually present also on the base (Fig. 338: 13), white with gray or pale brown mottling, with or without bands. Hemphill's var. *parma* was based on large specimens. Mrs. Olney collected specimens more elevated than most of Hemphill's and often more strongly carinate (Fig. 279: 2). At "Bowl and Pitcher," on Spokane River, Prof. Henderson and Dr. H. B. Baker found it a little smaller with more color (Figs. 279: 3, 3a).

Height 14.3 mm., diameter 26.3 mm.; umbilicus 5.5 mm. Figure 279: 1.
Height 16 mm., diameter 25 mm.; umbilicus 6 mm.

Height 13 mm., diameter 23.5 mm.; umbilicus 4.4 mm.

Height 12.5 mm., diameter 22 mm.; umbilicus 4 mm.

Farther north the size diminished to diameter 18.6 mm. in specimens from 14 miles north of Springdale, and 17 to 20 mm., the umbilicus $\frac{1}{4}$ the diameter or a little less, in a lot from 4 miles above Colville (Fig. 279: 31), both collected by Junius Henderson. The spiral striation varies in these lots from distinct to almost wholly obsolete.



Fig. 280. *Oreohelix strigosa canadica*, enlarged and actual size. (After Berry.)

These specimens approach closely to the single shell found about 200 miles farther north described as *O. strigosa canadica* Berry (Fig. 280) from Donald Station in the Columbia River valley west of the crest of the Rockies, the type being 2882 of the Victoria Memorial Museum. It does not seem to possess any differential characters of racial significance.¹

Form *subcarinata* Hemphill. (Fig. 279: 28, 29, 30.) This name applies to the very large shells found in a colony at Rathdrum, Idaho, characterized chiefly by large size, often high spire, the weakness or absence of peripheral angulation, the dull surface, and the weak sculpture. Those figured measure: 21 x 27.5 mm., 18 x 29 mm., 17.5 x 25.3 mm. Color variable;

¹ The description of *O. strigosa canadica* follows:

"The shell is of moderate size, broadly conical, with an obtuse apex. The surface is rather strongly *satiny*, but roughened by the irregular, coarse, and very crowded lines of growth. Spiral sculpture is represented by a few obscure and intermittent traces on the upper surface of the whorls, becoming wholly obsolete below. The periphery is strongly subangular, quite acutely so up to the body whorl, but becoming more obtuse near the aperture. The umbilicus is wide and well-like, contained about six times in the diameter of the shell, its interior visible to the apex, and its circular outline but little discommoded by the slight reflection of the inner lip. The outer lip is thickened and bevelled a little, but not reflexed. The ground colour of the shell is white, tending toward pale greyish vinaceous, with specks and mottlings of cacao brown and brownish vinaceous, the whole merging to sorghum brown on the apex. There are weak traces of three major brownish-vinaceous bands, and several basal minor ones, the uppermost of the former being traceable well up the spire. The embryonic shell is sculptured by weak radial wrinkles, which gradually develop into a fine, rather irregular ribbing, but any spiral sculpture originally present is eroded to the merest trace in the specimen seen. Maximum diameter of type, 19.1; minimum diameter 16.2; altitude, 11.5; diameter of umbilicus, 3.5 mm.; number of whorls, 5½" (Berry).

"This demure mountain snail is of plain appearance, offers no very striking peculiarities, and yet seems incapable of reference to any of the races or subspecies heretofore recognized. The shell characters seem about as conclusive as such things can be in *Oreohelix*, that it belongs to the typical group of *O. strigosa*, and here possibly closer to Hemphill's *parma* from northern Washington than to anything else. From the latter it is readily distinguishable, however, by its much narrower umbilicus and smaller size" (Berry).

Hemphill has named patterns in the practically continuous series as follows: white throughout (*lactea*, Fig. 279: 30); two-banded with purplish brown (*subcarinata*, Fig. 279: 29); indistinctly zoned and clouded with brownish drab (*bicolor*); the same, with bands above and on the base (*picta*, Fig. 279: 28). Spokane *strigosa* reaches an equal diameter (27 mm.), but the whorls are less capacious and it is less elevated. "*Subcarinata*" is a misnomer, since it is scarcely subangular. The lectotype of *subcarinata* is 5229 C.A.S.; *lactea*, 5625 C.A.S.; *picta*, 5629 C.A.S.; *bicolor*, 5626 C.A.S.

A series taken by Dr. Baker on calcareous shales 3-6 miles up Prospect Creek, west of Thompson Falls, Montana, in rich forest at 2500-3500 ft., consists of shells varying from the "*subcarinata*" to the "*parma*" form; diameter 17 to 24 mm.

On the Salmon River, Idaho, *O. strigosa* occurs as far south as White Bird. Near Riggins it was collected by Dr. Baker in abundance. In the valley of Squaw Creek, 8-10 miles up, and over 5 miles west of Riggins, limestone outcrops in forest at 2700 to 3200 ft. (Fig. 279: 4 to 8). Angulation of the last whorl is only weakly present or sometimes hardly perceptible. Spiral striation is usually obsolete on the base. As in most colonies of *strigosa*, the height of the spire is quite variable, from about 54 to 64 percent, of the diameter in the shells figured.

Height 14.5 mm., diameter 26.8 mm.

Height 15.2 mm., diameter 24 mm.

Height 14.3 mm., diameter 25 mm.

Height 15.5 mm., diameter 21.8 mm.

Height 16.3 mm., diameter 25.3 mm.

Height 14.0 mm., diameter 20.3 mm.

In the valley of lower Squaw Creek, below forest at 1700-1800 feet, the shells are smaller, up to 20 to 21 mm. in diameter. They are less solid but similar in color patterns and shapes (Fig. 279: 9).

Form *delicata* Pilsbry. (Figs. 279: 17-24.) In northeastern Oregon near Milton there is a weakly characterized local race in which the spiral striation is often strongly developed above and beneath, producing a much more distinct granulation than in typical *strigosa*. The dark bands are often weak or wanting; the shell is rather thin, and as usual, variable in degree of depression. Specimens from Walla Walla Canyon above Milton, from the forks to 4 miles up the south fork (Figs. 279: 17-21) measure 15 to 20 mm. in diameter with 5½ whorls. The form from 2-3 miles up the north fork, on lava slides mainly facing south, is smaller and very thin, with banding very weak or wanting, and usually 12 to 15 mm. diameter, with 5 whorls (Figs. 279: 22-24). While this form is as distinct in appearance as many named subspecies of *Oreohelix*, it seems likely that its features of texture and size are ecologic, a response to the situation on lava. The genitalia agree with typical *O. strigosa*.

Specimens reported as *O. cooperi* from mountains in eastern Washington turn out to be another form of *O. strigosa*. A specimen from Cottonwood Canyon in the Blue Mountains east of Walla Walla, collected by J.

Henderson yields the following measurements: length of penis 18 mm.; of internally plicate part 6 mm.; epiphallus 5 mm.; shell 12 x 18.5 mm., umbilicus 3.2 mm. Other shells measure: 15 x 19.5 mm., and 13 x 20 mm. The last whorl is well rounded throughout, as in *cooperi* and *subrudis*. Shell solid. The surface is dull and eroded but shows irregular striae and minute spiral lines in the best preserved. There are two brown bands. These shells can hardly be referred to *O. s. cooperi* as they are separated from the range of that race by the whole Rocky Mountain system. They are apparently an undefined subspecies or race of *strigosa*, distinguished by the more amply rounded whorls; but material in better condition is needed.

On the western slope of the Bitter Root Mountains in Ravalli County, Montana, pygmy forms of *strigosa* were taken by L. E. Daniels in the mountains near Lake Como, 10,000 feet (?) and Camas Creek Canyon, 7-8000 feet (Fig. 281 a). The shells are angular in front, usually glossy, two-banded, rarely with any additional basal bands. Irregular striation and interrupted spiral lines are as usual in *strigosa*. Shells measure: Camas Creek, 9 x 14.5 mm., 5 whorls; 10 x 15 mm., umbilicus 5 times in diameter. Near Lake Como, 9.3 x 12 mm., umbilicus 7.4 times in diameter. Length of penis 11 mm., its internally ribbed part 4 mm.; diameter of shell about 14.5 mm. There are 4 or 5 ribs in the penis, two being wider than the rest.

In Lost Horse Canyon, 8000 feet, a larger and often more elevated form was found, nearly all with some brown lines on the base: 10 x 17.8 mm. 11.2 x 16 mm., and 13.5 x 19.1 mm. The more elevated shells look very much like *O. subrudis*, but the periphery is angular, as in the preceding smaller shells.



Fig. 281. *Oreohelix strigosa*; a, Camas Creek, Bitter Root Mts.; b, Warm Spring Canyon, Deer Lodge Co., Montana.

About 80 miles eastward in Warm Spring Canyon, Deer Lodge County, Daniels found practically the same form except that nearly all have some gray lines on the base (Fig. 281 b). These shells measure: 9.2 x 13.7 mm. to 9.7 x 16.6 mm., and from a place higher in the same canyon, 7.3 x 10 to 8.5 x 11.6 mm. Penis 9 mm. long, ribbed part 3.2 mm., diameter of shell about 12 mm. The preceding lots were recorded as *O. cooperi* by Vanatta (Proc. Acad. Nat. Sci. Phila., 1914, p. 368), but the anatomy is unequivocally that of *O. strigosa*.

The Montana shells taken by Henderson in places east of Missoula are rather small, diameter 15 to 19 mm.

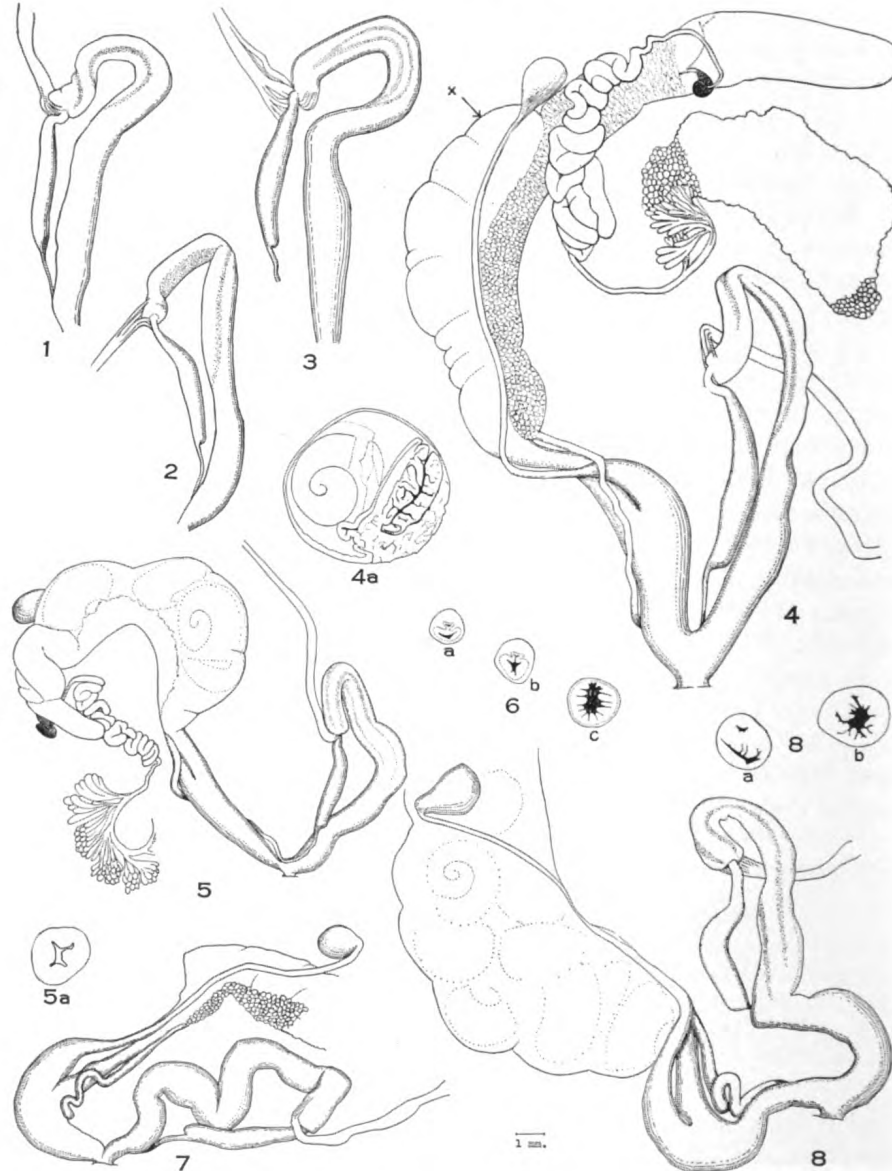


Fig. 282. *Oreohelix strigosa* and varieties. 1, 2: Race Creek, $\frac{1}{4}$ mile above mouth and 2 miles north of Riggins, Idaho Co., Idaho (penis of *O. strigosa goniogyra*). 3: Valley of lower 2 miles of Squaw Creek, near Riggins, Idaho. *O. strigosa*. 4: 8-10 miles up Squaw Creek. 4a, section at point marked x. *O. strigosa*. 5: Walla Walla Canyon above Milton, Oregon (Form *delicata*). 6a-c: Transverse sections near apex of epiphallus of *O. s. depressa* from Eldorado Springs, Colo. a, 0.25 mm. from end. b, 0.5 mm., and c, 1.4 mm. from end, showing union of the cavity of the vas deferens (above) with that of the "flagellum" (below). 7: *O. s. variabilis* J. Hend., 2 miles below Rufus, Ore. 8: *O. strigosa* from "Bowl and Pitcher," near Spokane, Wash., no. 147010. 8a, section near apex of epiphallus 0.5 mm. from end, and b, 1 mm. from end; cavity of vas deferens above, of "flagellum" below.

Genitalia of *O. strigosa* and its forms (Figs. 282: 5, 7, 8). The ovotestis is fasciculate and imbedded in the liver as usual. In the initial stage of functional activity it is sometimes very massive, and covered peripherally by the liver rather than imbedded in it, as in Fig. 4. Past the active stage the digitiform alveoli degenerate more or less. Hermaphrodite duct is large, complexly convoluted. Talon black, simple, recurved beyond the entrance of the hermaphrodite duct. Albumen gland from moderately large to quite small, dependent upon the stage of the reproductive cycle. The penis is very long, usually two-thirds to three-fourths the diameter of the shell, its anterior third or slightly more ribbed inside, the ribs and intervals usually minutely porous or spongy. The vas deferens enters the epiphallus at one side of the apex of the latter, not centrally, and it usually lies coiled around the vagina, as in Figs. 4, 5 and 7.

Measurements of the penis in millimeters follow:

Locality	Length penis	Length ribbed part	Diam. shell	Museum number
15 m. north of Ellensburg, Wash.	15	5.5	14-16	147011
Yakima R. 8 m. N. of Yakima, Wash.	12	4	19	147023
East of Walla Walla, Wash.	18.5	6	..	147013
Near base Blue Mts. E. of Milton, Ore.	13	5	16.4	147022
Walla Walla canyon above Milton, 2-3 m. up N. fork, lava slides	13	5	12.8	158427
Same, S. fork, bowlder piles	18.5	6.7	20	158426
Bowl and Pitcher, near Spokane, Wash.	17	5.5	24	147010
Near mouth Race Creek 2 m. N. of Riggins, Ida.	17	6	18.7	158422
Lower 2 m. of Squaw Creek, Riggins, Ida.	18	7	21.8	158434
Squaw Creek, 8-10 miles up	18	7	25	158433
“ “ “ “ “ “	20	7	26.5	158433
Prospect Creek, Sanders, Mont.	19	7	23	158416
<i>O. s. variabilis</i> , Rufus, Ore.	12.5	5	17.3	147024

Most of these characters are common to all of the northern *Oreohelices*, but the proportions of the penis only to species of the *strigosa* group. Specimens of the typical depressed *strigosa* form (Figs. 282: 1-4) do not differ from those of more compact *cooperi*-like shape (Figs. 282: 6, 9), the latter measuring 15 x 21.8 mm., umbilicus 4.2 mm. In the carinate race (Fig. 282: 12 to 16) and the small, delicate race from near Milton, Oregon (Fig. 282: 17 to 34) and in the small form from north of Yakima and that from north of Ellensburg, Washington, I could find no anatomical differences except size.

Three specimens opened from “Bowl and Pitcher,” near Spokane, Wash., differ by having the vas deferens passing up the left side of the vagina, not under and around it (Fig. 282: 8). In all other lots of the species examined the vas deferens lies as in Figures 282: 4 and 5.

The specimens from Stites, Idaho County, Idaho, those from near Dorsey, Shoshone County, Idaho, Prospect Creek, Sanders County, Montana, and no. 147013 from east of Walla Walla, Washington, also have the insertion of the vas deferens only slightly lateral on the epiphallus, and in one of those figured from Squaw Creek near Riggins (Fig. 282: 1) it is nearly

centrally terminal, though sections show that it is not terminal on the cavity of the epiphallus. A section of the epiphallus half a millimeter from the end shows a small duct continuing the vas deferens, which soon unites with the main cavity by way of a narrow cleft, as in the section 1 mm. from the end (Fig. 282: 8b). With these exceptions the lateral insertion is invariable in specimens examined.

One specimen of *O. strigosa* from near Milton, Ore., opened contained 18 embryo shells. Two from Squaw Creek, Idaho and one from "Bowl and Pitcher" near Spokane, Washington, contained each 13. Other individuals had fewer.

***Oreohelix strigosa goniogyra* Pilsbry**

Figs. 279: 12-16.

Oreohelix strigosa goniogyra Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 385, text-figs. 1, 2; pl. 14, figs. 12-16.

On lower Race Creek below forest, $\frac{1}{4}$ mile from the mouth and 2 miles north of Riggins, Idaho, on outcrops of greenish schist, elevation 1700-1800 feet, there is an isolated colony of *strigosa* in which the carination is exaggerated, acute in front and extending more or less strongly to the aperture. Spiral striation is usually well developed but in some individuals becomes subobsolete at the base. Color and markings vary from nearly uniform grayish white to profusely banded or mottled. The shape varies widely, the height from about 55 to 77 percent of the diameter. Penial structure as in *strigosa* (Figs. 282: 1, 2).

Height 13 mm., diameter 19.5 mm. Type (Fig. 279: 12).

Height 14 mm., diameter 18 mm.

Height 10 mm., diameter 18 mm.

About 7 miles up Race Creek at 2700 feet, on limestone outcrops in forest, the shells are large, like the *strigosa* of Squaw Creek, but are acutely carinate in front. It is a less modified colony of the race *goniogyra*.

This is apparently a modification of the local *strigosa* stock, but it is so conspicuous that it might as well be recognized by name. The reproductive system is drawn in Figure 277 A.

(Γῶνος, angle, γυρος whorl.)

***Oreohelix strigosa variabilis* Henderson**

Figs. 279: 25, 26, 27.

Patula strigosa var. *castaneus* Hemphill, Binney, 1886, 2d. Supp., Bull. Mus. Comp. Zoöl., 13: 32, in part; specimens from Celillo, Ore., only.

Oreohelix variabilis J. Henderson, 1929, Proc. Cal. Acad. Sci., (4), 18: 224, pl. 24, figs. 2, 3, 4; Univ. Colo. Stud., 17: 90.

O. s. variabilis J. Hend., Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 387, fig. 7 (genitalia); pl. 14, figs. 25, 26.

"Shell rather elevated, solid, whitish, variegated with small, irregular, very light-brown blotches; whorls $5\frac{1}{2}$, fairly convex, bluntly angled at the periphery, the angulation continuing at least to beginning of last whorl, but not to the aperture; transverse sculpture rather coarse, irregular striae, about as in *cooperi* and *depressa*, crossed by very fine, obscure, irregular, incised, spiral lines. Under a lens of good power the whole surface of the

last whorl appears rough and coarse. The last whorl turns more decidedly downward toward the aperture than in most species of *Oreohelix*, the ends of the peristome coming rather close together and being connected by a very thick callus, thus forming an almost continuous peristome. This feature is not entirely accidental, as it is as well developed in several other specimens, though on others the callus is thinner and the downward turn of the whorl not quite so pronounced. The aperture is very oblique, somewhat wider than high, the abrupt downward turn at the base giving the appearance of a strong rib within, parallel with the lip. Diameter 22 mm.; altitude 16 mm. The smallest example in this lot of 12 specimens has a diameter of 15 mm., altitude 11 mm." (Henderson.)

OREGON: Celillo (Henry Hemphill) Type 2987 C.A.S. 2 miles below Rufus (J. Henderson).

In this weakly differentiated race the spire is rather high and straightly conic, the peripheral angulation varies from distinct to subobsolete. The striation is strong, but the spiral lines are only weakly developed or wanting. The two principal bands of *Oreohelix* are wanting, though broad and narrow bands may be present. Color varies from white, closely mottled and streaked with pinkish cinnamon, to walnut brown with darker streaks. Professor Henderson took it at a place two miles below Rufus, Oregon, 15 miles above the Dalles, but these specimens (Fig. 279: 27) are hardly more elevated than usual in *O. strigosa*. Specimens dissected are from 2 miles below Rufus. The genitalia (Fig. 282: 7) are like *O. strigosa*. Penis 12.5 mm. long the internally five-ribbed portion 5 mm. long. Vagina 3.5 mm., very wide. Spermatheca and duct 13 mm. long, the duct much swollen near its base. The insertion of the vas deferens in the epiphallus is lateral.

***Oreohelix strigosa depressa* (Cockerell)**

Figs. 283: b-j.

Helix cooperi W. G. Binn. in part, Binney & Bland, 1869, L. & Fr. W. Sh. N. A., 1: 78, figs. 132, 136.

Patula strigosa Gld., in part, Binney, 1878, Terr. Moll., 5: 157, figs. 64 (lower), 65 (upper); 1885, Man. Amer. L. Sh., p. 165, fig. 152 (lower), 153 (upper).

Patula strigosa var. *minor* Yarrow, 1875, Wheeler Surv., 5: 931, nude name; cf. Henderson, 1924, Univ. Colo. Stud., 13: 112, and Pilsbry, 1934, Proc. Acad. Nat. Sci. Phila., 85: 409, "= *O. strigosa depressa* Ckll."

Patula strigosa cooperi var. *depressa* Cockerell, 1890, Nautilus, 3: 102.

Patula strigosa cooperi form *major* Cockerell, 1890, Nautilus, 3: 102; cf. Proc. Acad. Nat. Sci. Phila., 1916, p. 357.

"*Pyramidula*" *strigosa concentrata* Cockerell, 1903, Nautilus, 16: 106.

Oreohelix strigosa Gld., Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 272, pl. 11, figs. 14, 15 (embryonic shells), pl. 19, figs. 1, 3 (lung and genitalia), pl. 22, figs. 1-3 (teeth); pl. 23, fig. 25 (jaw); pl. 25, figs. 45-47 (shell).

Oreohelix strigosa depressa Ckll., Daniels, 1911, Nautilus, 25: 18; 1912, Nautilus, 26: 41, pl. 5, figs. 16-19.—Pilsbry & Ferriss, 1911, Proc. Acad. Nat. Sci. Phila., p. 186, pl. 13, 14.—Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 345, pl. 19, figs. 1-4, 6, 7; pl. 20, fig. 8 (genitalia).—Henderson, 1912, Nautilus, 25: 136.—Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., pp. 322-338; 1917, pp. 59-81.—Henderson, 1924, Univ. Colo. Stud., 13: 119, fig. 28 (see for references in full).—Chamberlin & Jones, 1929, Bull. Univ. Utah, 19: 61.

Oreohelix cooperi minor Ckll., Henderson, 1912, Nautilus, 26: 10 (specimens from McCoy, Colo.).

- Oreohelix strigosa depressa* form *toolensis* Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 323.—Pilsbry, *l. c.*, p. 345, pl. 21, fig. 5 (genitalia).
- Oreohelix strigosa toolensis* Henderson, 1924, Univ. Colo. Stud., 13: 121; 1936, Univ. Colo. Stud., 23: 92 (“*toolensis*”).
- Patula strigosa* var. *carnea* Hemphill, 1890, Nautilus, 4: 15.—Reprinted by Binney, 1892, 4th Suppl., Bull. Mus. Comp. Zool., 22: 174.
- Oreohelix strigosa depressa* (Ckll.) “var. *carnea*” (Hemph.), Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 325; 1917, Proc. Acad. Nat. Sci. Phila., p. 73.
- Oreohelix strigosa depressa* color-form *carnea*, Pilsbry, 1917, Proc. Acad. Nat. Sci. Phila., p. 43 (genitalia).
- Oreohelix strigosa carnea* (Hemph.), Henderson, 1936, Univ. Colo. Stud., 23: 91; mentions the label name “*corneus* Hemphill.”
- Helix strigosa* var. *corneus* Hemphill, 1890, Cat. North Amer. Shells, p. 15, name only.

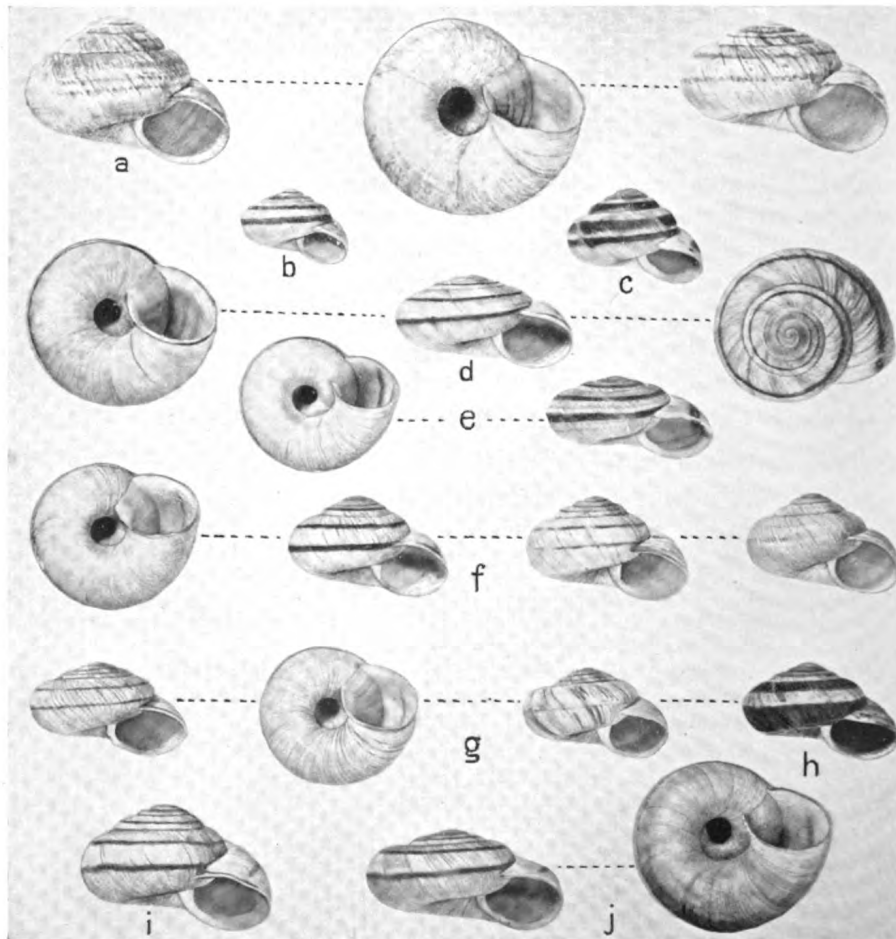


Fig. 283. a, *Oreohelix strigosa* form *capax*, McCammon, Idaho. b-j, *Oreohelix strigosa depressa*. b, McCoy, Colo.; c, 6 m. west of Aspen, Colo.; d, Williams Canyon, Colo.; e, southwest of Redstone, Colo.; f, Zion Canyon, Utah; g, h, Pecos Canyon, N. M.; i, Emigration Canyon, Utah; j, Navajo Mt., Utah.

“Shell flattish, max. diam. 21½, alt. 12½ mill. Specimens of this variety were sent to me by Miss A. Eastwood, who found them in a canyon near Durango. The same variety is figured by Binney, Man. Amer. Land Shells (1885), p. 166, fig. 153.” (Cockerell.)

The depressed shell is rather solid and has an umbilicus contained about 4 times in the diameter. Color, cartridge-buff, with pale pinkish-buff or cinnamon-buff streaks radiating from the suture, or sometimes an even tint there, and usually weaker streaks on the base, and with two narrow chocolate or darker bands, one below the periphery, the other on the upper surface; the space between them often whiter than the rest of the ground. The surface is rather finely and not strongly striate, the striae cut by fine spiral lines (often nearly or quite obsolete). There are about 2½ embryonic whorls, the first smoothish, second very finely striate, and towards the end with some weak, coarse spirals (usually lost in adult shells). The last whorl is rounded at periphery (or sometimes subangular or angular in front of the aperture), and it descends moderately in front. The aperture is almost as high as wide, the basal margin somewhat expanded; columellar margin dilated.

Distribution.—Billings, Montana, and southeastern Idaho to northern Arizona and New Mexico (Fig. 296) as follows:

MONTANA: Shiveley ranch, near Billings.

WYOMING: Bridger Pass; Rock Cut near Hilliard, and north of Knight.

IDAHO: Malad; Weston; McCammon; St. Charles Canyon.

UTAH: Bear Lake near Garden City; Logan Canyon; east of Brigham; Ogden Canyon; Bountiful; Weber Canyon; canyons around Salt Lake City; northeast of Springville; Tucker; near Provo; Spanish Fork, Utah County; southeast of Tooele and Stansbury range, Tooele County; Kamas and Woodland, Summit County; Vernal, Uinta County; Polar Mesa, Grand County; La Sal Mts., 10,000 ft., Blue Mts., and Navajo Mt., San Juan County; Cedar Canyon east of Cedar City, Iron County; Zion Canyon.

COLORADO: Most (probably all) of the counties west of a line from Larimer to Las Animas County; type locality, canyon near Durango.

NEVADA: Wheeler Peak, White Pine County.

ARIZONA: Kaibab Plateau, etc., north of the Colorado River, 5-8000 ft., Coconino County; southern slope of Navajo Mountain.

NEW MEXICO: 5 miles east of Zuñi, McKinley County; Canyon Diablo near Rowe. and Pecos Canyon, San Miguel County; Folsom, Union County.

The genitalia (Fig. 284: 3) do not differ materially from those of *O. strigosa* proper. The penis is very long, its internally ribbed part from one-third to two-fifths of the length. Measurements in mm. of examples from several lots, out of many examined, are as follows:

	Manitou, Colo.	Redstone, Colo.	Carbondale, Colo.	McCammon, Idaho	Salt Lake City, Utah	Ogden Canyon, Utah	Logan, Utah	Oquirrh Mts., Utah	Provo, Utah	Cedar City, Utah	Emigration Canyon, Utah	Form carnea	Form tooleensis
Penis	18.5	16	16.0	23.5	24	27.5	19.5	23	20.5	14.5	26.5	27	17
Ribbed pt.	6.5	5	4.5	7.0	8	9.0	5.8	8	8.5	5.0	11.0	11	5
Epiphall.	7.5	...	...	6.3	6	7.0	5.0	7	7.5	...	7.0	5	5
Shell	23.0	20.5	19.5	27.0	..	26.0	19.0	25	23.0	18	25.0	24	22

Genitalia of specimens from many localities have been figured in my papers of 1905, 1916, 1934.

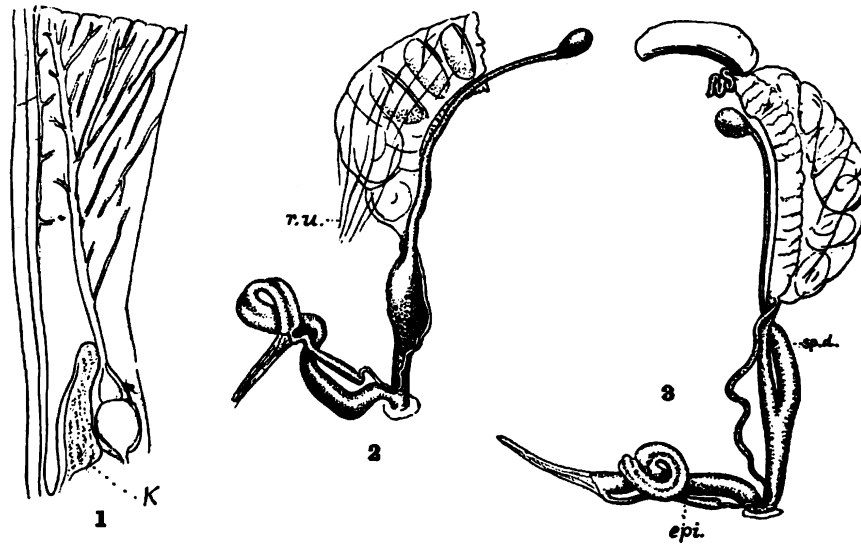


Fig. 284. 1, 3, pallial region and genitalia of *Oreohelix strigosa depressa*, Pecos, New Mexico. 2, genitalia of *O. elrodi*.

*O. s. depressa*¹ is generally lighter colored than *O. strigosa*, and bands on the base below the subperipheral are very rarely present. The striation is finer and weaker. The last whorl is more convex above in *depressa*, and is frequently rounded throughout, though often angular in front of aperture. According to records in hand, the geographic ranges of the two are rather widely separated; *strigosa* lies wholly west of the main chain of the Rocky Mountains in Montana, where *depressa* does not occur, the two races being separated by the vast lava flows covering eastern Oregon and southern Idaho, as on the map (Fig. 296).

O. subrudis inhabits most of the range of *depressa*, sometimes in the same colonies. It is a less depressed shell with sharper sculpture and usually part or all of the shells in a lot show bands on the base; yet there are ambiguous lots which can only be determined positively by examination of the penes. *O. s. cooperi*, which is anatomically like *depressa*, differs by its higher shape and smaller umbilicus, and it seems to be separated geographically, being mainly well east of the Rocky Mountain system.

Except in size, *O. s. depressa* is less variable than most of the genus. The two-banded pattern on a buff to white ground, which may be faintly to strongly suffused or flammulate with pinkish or cinnamon tint above, is the dominant coloring everywhere, though there are colonies in which

¹ The original publication of *depressa* was in a quasi quadrinomial form not authorized by the rules of nomenclature, but as the name passed into general use as a trinomial, and there is no competing name for the snail, to raise the question of its legitimacy would appear meticulous.

the bands are reduced or wanting¹ in most or all shells, and bandless individuals can be found in most large lots. Irregular grayish spots are often scattered on the base. Albino shells occur in some colonies, and reversed specimens are not rare.

Every grade from 10.5 mm. in diameter (Two-Springs Canyon, Kaibab Plateau), to 28.5 mm. (McCammon, Idaho), has been found, but intermediate sizes, 18 to 24 mm., prevail. In a 13 mm. specimen from McCoy, Colo. (Fig. 283 b), the genitalia were found typically proportioned for *depressa*, though very small, length of penis 4.4 mm., of its ribbed part 1.7 mm. Probably all Colorado shells which have been referred to var *minor* Cockerell and *concentrata* Dall (Nautilus, 16: 106) belong here.

The ordinary range of variation may be illustrated by a lot of 100 from Williams Canyon, near Manitou, Colorado. The diameter varies from 19 to 24 mm.; h/d index 52.27 to 63.3; width umbilicus from 4.9 to 5.1 times in diameter. 10 have the zone between upper band and suture moderately darkened; 2 have the base somewhat clouded with purplish-brown; 2 have a cinnamon-buff band on the base, and 2 are bandless; the rest, 84 per cent, have the typical two-banded pattern (Fig. 283 d). Some large lots are less varied than this in color, other lots are more variable.

Specimens from near Hermosa, ten or twelve miles north from the type locality, are the strongly depressed, openly umbilicate typical form similar to that illustrated in Figure 283 j. One measures 11.4 x 22.7 mm.

In northern Utah most shells have the typical two bands with very light ground, but often bandless examples with them, the size varying with the colonies, about 18 to 25 mm. Southeast, in the Blue Mountains, San Juan County, a lot from the pass 3½ miles west of Innes' sawmill the diameter is from 14.5 to 23 mm. Farther southwest, on Navajo Mountain, the *depressa* are large and often much depressed with wide umbilicus, height 13.3, diameter 26 mm., h/d index 51, umbilicus exactly 4 times in diameter. In southwestern Utah *depressa* is locally abundant and *subrudis* is wanting. In Cedar Canyon, 11½ miles eastward from Cedar City, the shells are from 17 to 21 mm. in diameter, all of typical color. In Zion Canyon similar shells, 18 to 19 mm. in diameter in some colonies, up to 24 mm. in others (Fig. 283 f). Nearly all have strong bands, but in rare individuals they are wanting. These shells have been referred to *cooperi* by some authors, but they have the characteristic anatomy of *depressa*. Two measure: 14 x 22.2 mm., umbilicus 4.9 times in diam., and 13.7 x 19.2 mm., umbilicus 5.4 times in diameter.

In northern New Mexico the shells generally resemble those of southern Colorado, but in Pecos Canyon, San Miguel County, Ferriss found some of

¹ Cf. Cockerell, 1889, Nautilus, 3: 9: "Hemphill also mentions a white variety of *Patula strigosa* Gld., from Utah, which may be called var. *alba*." This was probably a bandless *depressa*, but without locality or further details it is not determinable.

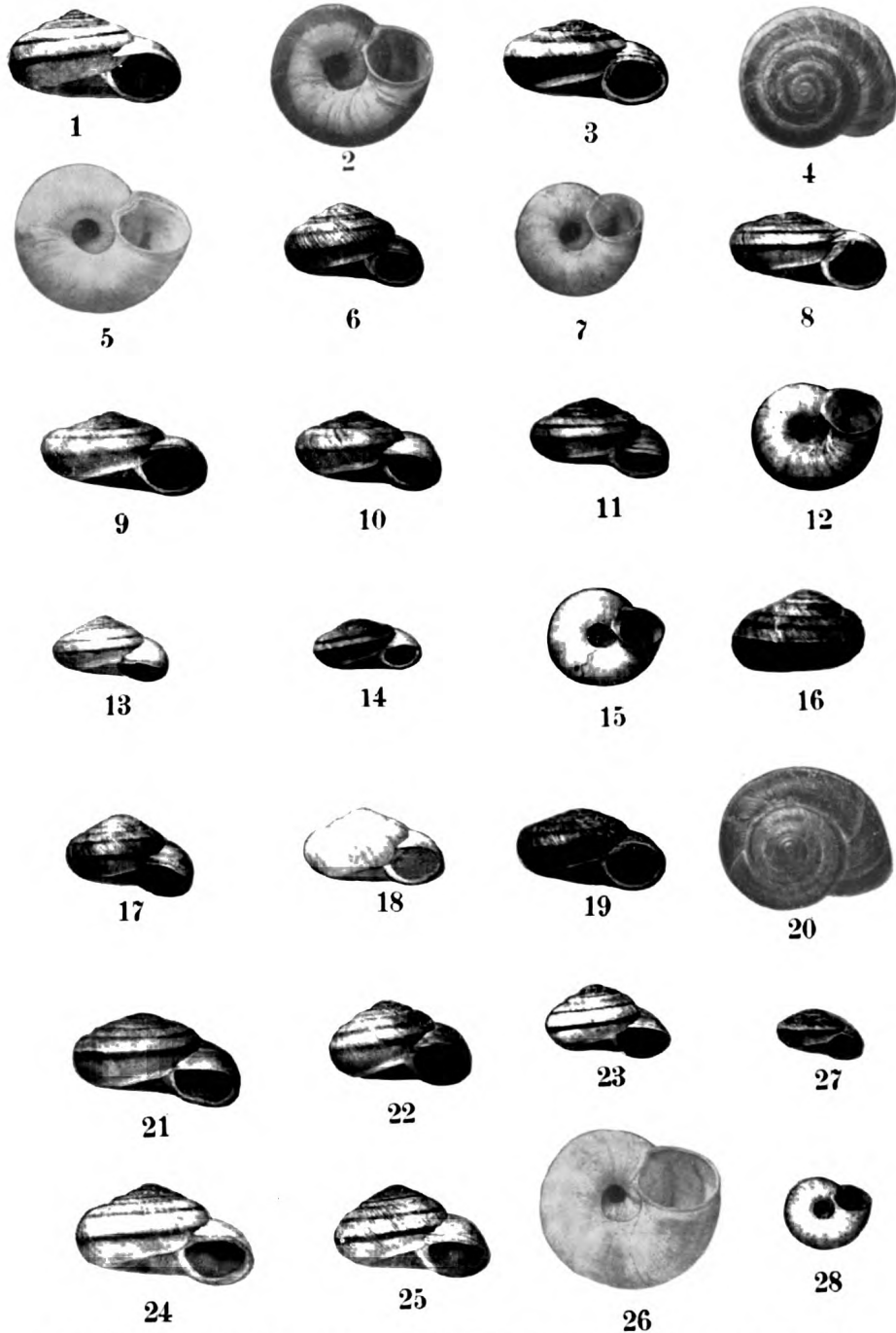


Fig. 285. *Orcohelix strigosa depressa*, Kaibab Plateau, Arizona. 1-5, Jacob Canyon; 6-9, Warm Spring Canyon; 10-15, Shinumo Canyon; 16-18, Moquitch Gulch; 19, 20, Snake Gulch; 21-26, Quakingasp Canyon; 27, 28, head of same.

carob brown color, with lighter radial streaks and a white zone above the periphery (Fig. 283 h) together with the two-banded pattern (Fig. 283 g, right).

In northern Arizona, north of the Colorado River only, the typical two-banded pattern is abundant in canyons of the Kaibab and Powell Plateaus (Fig. 285). In some districts, as along the western escarpment of Powell Plateau, there is a marked tendency to lose the dark bands. In some other places albinos occur in colonies composed chiefly of well-colored shells. There is a tendency in many places to produce more compactly coiled shells than typical *depressa*, the spire being higher and the total diameter and the umbilicus smaller in some individuals. This culminates in shells which have the shape of *O. subrudis*, found in a few stations with normal *depressa*. In Snake Gulch at 5500 feet, rather small shells with the periphery acutely angular in front occur; diameter 14.5 to 17 mm.

As elsewhere, the size usually does not vary greatly in one colony. They run 23 to 25 mm. diameter, more frequently about 18 mm., or in some situations, frequently but not always especially arid, the shells are conspicuously dwarfed, 10.5 to 14 mm. diam. (Fig. 285: 13-15, 27, 28).

The only record for the state of Nevada is Baker's Creek, east slope of Wheeler Peak, near Lehman's cave, southeastern White Pine County, collected by Dr. Emmet Rixford. I have examined the animal; length of penis 12 mm., of its ribbed part 4 mm.

Form *carnea* Hemphill.¹ (Fig. 286.) The shell is typically more elevated than *O. s. depressa*, with whorls of larger caliber; color vinaceous-buff or light vinaceous-cinnamon, indistinctly mottled and streaked with light buff, usually bandless but sometimes with two narrow bands; also varying to nearly white with gray marbling above. Umbilicus as in *depressa* or narrower.

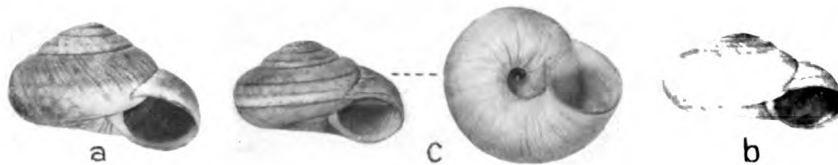


Fig. 286. *Oreohelix strigosa depressa* form *carnea*. a, b. Salt Lake City specimens collected by Hemphill. c, northeast of the University of Utah.

"Height $\frac{3}{8}$ inch, greater diameter $\frac{7}{8}$ inch" (Hemphill).

Large specimens from Hemphill measure 17.5 x 25.7 mm., 13 x 24.3 mm.; others from City Canyon, 15.5 x 20.8 mm., 15 x 24 mm., 13.7 x 19.7 mm.

Hemphill's locality was "near Salt Lake", probably City Canyon where others have found it. Henderson collected it in Dry Canyon, about a mile

¹ Since Hemphill used the name *corneus* (horn-colored) in his collection, according to Henderson, and in his sale catalogue, it seems possible that *carnea* (flesh-colored), as originally printed, was a typographic error; but if so, he did not choose to correct it.

from the University of Utah, near Salt Lake City, in scrub oak and mountain maple thickets on limestone. Also, upper slopes of Red Butte Canyon (L. A. Giddings).

The typical form seems quite distinct by the elevation of the spire and the larger caliber of the well rounded whorls, but it varies to the proportions of *depressa*. In genitalia an elevated example from City Canyon does not differ from *depressa*; length of penis 27 mm., of internally ribbed part 11, of epiphallus 7 mm. The distal part has a trilobed section.

Form *capax* Pilsbry & Henderson. (Fig. 283 a). In Idaho very large shells were found about six miles up Harkness Canyon, directly east of McCammon, below the first limestone ledge, under leaves and small stones. This form is allied to *depressa* by its anatomy, but is on the average much less depressed, the whorls more convex, and few are strongly banded, though most of them show some traces of color bands, and a number exhibit several faint, narrow bands below, such as are so common on *O. subrudis*, but not so usual in *depressa*. The upper surface is marbled with a tint between cinnamon-buff and avellaneous. They have a thin deciduous cuticle, lost on the base and partly above. Three measure: 18 x 28.5 mm., 18.7 x 27 mm., and 16.5 x 27.5 mm. Except by the larger size it resembles form *carnea*.

It occurs on a steep slope in limestone slides almost concealed by a heavy cover of conifers with an undergrowth of mountain maples and various shrubs. This place is at the springs near a great white cliff plainly visible from McCammon. (*Oreohelix strigosa capax* Pilsbry & Henderson, 1937, Nautilus, 50: 101).

(*Capax*, roomy, capacious.)

Form *tooeleensis* Henderson & Daniels. (Fig. 287.) "This form differs from *depressa* chiefly in the color, which is almost invariably a dead, chalky white, in all the material from three colonies northeast of Tooele, Utah, giving the specimens the appearance of dead, weathered shells, in this respect quite unlike the colonies of *depressa* from southeast of Tooele and elsewhere.



Fig. 287. *Oreohelix strigosa* form *tooeleensis*.

Shell depressed (in a few examples quite elevated); whorls 5 to 5½, convex; suture well impressed; spiral striae minute; transverse sculpture slightly less pronounced than in typical *depressa*, especially below; color bands narrow, sometimes strongly marked, but usually rather faint or wanting, one barely below and the other well above the periphery, strong on immature examples; first embryonic whorl smooth, second and third minutely transversely striate, with numerous spiral striae rippling the transverse sculpture

above and below and increasing in strength with the growth of the whorls. Type, in the University of Colorado Museum, greater diameter 19 mm., lesser 16.5 mm., alt. 11.5 mm. Co-type (112864 a) in Academy of Natural Sciences of Philadelphia, greater diameter 19.6 mm., lesser 17.2 mm., alt. 11.4 mm. Co-type, in L. E. Daniels' collection, greater diameter 23 mm., lesser 20 mm., alt. 13.5 mm." (Henderson and Daniels.)

Genitalia as in *O. s. depressa*.

UTAH: Abundant in the small gulches about six miles northeast of Tooele, north of the smelter, under grass and other vegetation about limestone ledges. Four sinistral specimens were found.

Oreohelix strigosa montrosensis new subspecies

Fig. 288.

The shell is narrowly umbilicate, the umbilicus contained about $5\frac{1}{2}$ times in the diameter, with conoidal spire and somewhat inflated last whorl. Cartridge buff with cinnamon-buff spire, and narrow bands or suffusion of the same on the upper surface of the last whorl (other specimens having

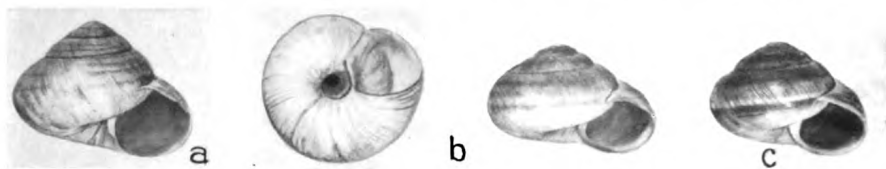


Fig. 288. *Oreohelix strigosa montrosensis*.

cinnamon-brown bands). The surface is irregularly and rather sharply striate, striae cut by moderately strong but irregular spiral lines (varying to quite weak in some individuals). Embryonic shell of about $2\frac{1}{2}$ whorls is very finely striate, with a few spirals on the last half-whorl. The last whorl descends but little in front, and is well rounded.

Height 18 mm., diameter 22.8 mm., umbilicus 4 mm.; $5\frac{3}{4}$ whorls. Type.
Height 15.1 mm., diameter 21.8 mm., umbilicus 4 mm.; $5\frac{1}{2}$ whorls.

COLORADO: Montrose, Montrose County, among leaves under chapparal, mainly *Rhus triloba* and Clematis, along ditches, in a very hot, arid region, on adobe soil without rocks (E. Bethel, Aug. 1907), Type 94797, paratypes 94235 A.N.S.P.

This snail might with some reason be considered a species, since it is quite distinct by the small umbilicus and large caliber of the last whorl. Up to this time it is known by a single lot, of which I have seen 18 specimens. It was found in large numbers.

It has been referred hitherto to *O. "cooperi"* [*subrudis*] by Professor Henderson and myself, but the anatomy, examined in several examples, turns out to be that of the *strigosa* group. The penis is 21 mm. long, the internally ribbed part 7 mm. in one specimen, the ribs being very low and granulose; the longer posterior part is papillose in the usual oblique pattern. Another specimen has the penis 17 mm., the ribbed part 5 mm. long. Those opened contained embryos.

Most of the immature shells and some adults have cinnamon-buff bands on the base. In one shell there is a brown line on the penult whorl in the position of the upper band of *depressa*. In some the cinnamon-buff tint of the upper surface extends upon the last whorl, where it is locally intensified. Others have a broad cinnamon-brown band below the suture, another below the periphery, and in one shell the latter is widened, producing the “*confluens*” pattern.

Oreohelix strigosa fragilis (Hemphill)

Fig. 289.

Patula strigosa var. *fragilis* Hemphill, 1890, Nautilus, 4 :17.

Oreohelix strigosa fragilis (Hemph.), Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 336, pl. 16, fig. 1.—Pilsbry, *l.c.*, p. 346, pl. 19, fig. 5 (genitalia).

“Shell umbilicated, elevated or globosely depressed, translucent, thin, fragile, somewhat shining, of a dark horn color, surface covered by fine oblique striae; whorls 5, convex, the last descending in front, and striped by two dark chestnut bands, one above and the other below the periphery; suture well impressed; aperture oblique; lip simple, thickened, umbilicus moderate, deep, partially covered by the reflected lip at the columella. Height of the largest specimen $\frac{9}{16}$ inch, greatest diameter $\frac{3}{8}$ inch, lesser $\frac{3}{4}$ inch.” (Hemphill.)



Fig. 289. *Oreohelix strigosa fragilis*. a, near Franklin, collected by Hemphill; b, mountain west of Franklin.

IDAHO: Near Franklin, among red sandstone (Henry Hemphill), Lectotype 5227 C.A.S. A small, isolated, barren-looking mountain about a mile west of Franklin, in the edges of Paleozoic limestone slides surrounded by sage brush (Henderson & Daniels, station 38).

UTAH: Prater Gulch, south of High Creek Canyon, about six miles southeast of Franklin, Idaho, nearly east of the railroad station of Webster, Utah, in quartzite talus (Henderson & Daniels).

In specimens received from Hemphill the shell is a peculiar dull brown, fawn color or wood brown of Ridgway, somewhat translucent, usually paler at the base, with two darker bands, which are sometimes faint or broken. They vary in size from 10.8 x 17.8 mm. to 14.4 x 21.2 mm. They are rather high, the h/d index 67.92 and 64.20 in two measured, rarely more depressed, index 60.67. Umbilicus variable, contained 6 to 7 times in diameter.

Henderson and Daniels' shells from their Idaho locality are small, 17 to 19 mm. diameter, strongly depressed, the h/d index often as low as 53.70; lighter colored, usually with contrasting bands. They differ from small

depressa by the somewhat translucent shell. At the Henderson and Daniels' Utah locality the shells average about 20 to 22 mm. in diameter and are sometimes higher, with the periphery often angular in front of the mouth.

Genitalia as in *O. s. depressa*, the distal portion of the penis collapsing into a trefoil shape in the individual dissected, from about a mile west of Franklin, Idaho. Length of penis 18 mm.; of internally costate part 5 mm.; epiphallus 4; penial retractor 6 mm.; diameter of the shell about 19 mm.

It should be mentioned that G. D. Hanna and Allyn G. Smith have expressed the opinion that "the brown color and the nature of the bands indicate a strong possibility that these shells are a small race of *Anguispira*. Except for the small size, the thinness of the shell and the absence of bands in some cases we would hesitate to separate them more than subspecifically from *A. kochi*."

Oreohelix strigosa buttoni (Hemphill)

Fig. 290.

Patula strigosa var. *buttoni* Hemphill, 1890, in Binney, 3rd. Suppl., Bull. Mus. Comp. Zoöl., 19: 220.

Patula strigosa Gould var. *buttoni* Hemph., Binney, 1892, 4th. Suppl., Bull. Mus. Comp. Zoöl., 22: 171, pl. 1, figs. 2, 10.

Oreohelix strigosa buttoni (Hemph.), Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 346, pl. 21, fig. 6 (genitalia).—Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 327, pl. 16, fig. 2.

"Shell umbilicated, elevated, or moderately depressed, nearly white, sometimes stained with light chocolate; whorls five, convex, with numerous oblique striae; suture impressed, aperture circular; peristome thickened, not reflected, darker than the body of the shell; extremities nearly approached



Fig. 290. *Oreohelix strigosa buttoni*, from the original lot.

and joined by a callus; with or without a basal tooth; tooth when present very variable, generally consisting of a single tubercle; in some specimens it is nearly or quite square, as high as long; in other specimens it is long and bifid. Diameter of the largest specimen, $\frac{3}{8}$ inch; height, $\frac{1}{2}$ inch. Diameter of the smallest specimen, $\frac{1}{2}$ inch; height, $\frac{3}{8}$ inch." (Hemphill.)

UTAH: Boxelder County (Henry Hemphill), Lectotype 5678 C.A.S. Taylor Canyon, near Ogden, south of Ogden Canyon, about limestone ledges; half hour's walk below Gateway in Weber Canyon, southeast of Ogden, in gneiss slide rock; and about half a mile above mouth of Weber Canyon, (Henderson and Daniels).

Hemphill's shells are matt, dirty white with more or less brown suffusion above, mainly in streaks, usually bandless or with weak traces of bands,

rarely with two distinct but uneven bands. In a series of 30, four have a distinct columellar tooth, several others a mere trace. The diameter runs from 11.9 to 23 mm., the toothed shells from 15 to 19.8 mm. Hemphill's printed labels give the locality "Sandstone ledges, altitude 4500 feet" and "Red sandstone ledges, alt. 5000 feet.;" I can see no difference in the shells. Just where in Boxelder County he found *buttoni* remains uncertain, but he collected "in the gulches near Ogden" (in Weber County) and northward.



Fig. 291. *Oreohelix strigosa buttoni*, Taylor Canyon. (After Henderson & Daniels.)

The shells from Henderson and Daniels' localities, on limestone and gneiss, though matt are brighter colored than Hemphill's; diameter about 16 to 22 mm. "Many examples have strong spiral color bands." "The tooth on the columellar margin is very often absent." (Fig. 291.)

Genitalia as in form *tooelensis*, *O. s. depressa* from Provo, and others, the penis collapsing flat. The lower part has 5 ribs within. Length of penis 25 mm., of internally costate portion 10, of epiphallus 7 mm., penial retractor 15 mm.; vagina 6.7 mm. The specimens dissected came from Taylor Canyon, near Ogden, Utah.

(Hemphill dedicated this form to "Mr. O. Button of Oakland." This was doubtless an error for Fred L. Button.)

***Oreohelix strigosa meridionalis* Pilsbry & Ferriss**

Fig. 319 h.

Oreohelix strigosa meridionalis Pilsbry & Ferriss, 1919, Proc. Acad. Nat. Sci. Phila., for 1918, p. 324, fig. 15 (genitalia), pl. 7, fig. 9.—Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 390, fig. 12.

The shell is depressed and very openly umbilicate, the last whorl sub-angular above the aperture; otherwise resembling *O. s. apache*. Striation weak, subobsolete spiral lines only very faintly developed. It differs from *O. s. depressa* by the distinctly smoother shell.

Height 14.4 mm., diameter 24.7 mm.; umbilicus 6 mm. wide; 5½ whorls.

ARIZONA: Y Salt House branch of Eagle Creek, Greenlee County (Ferriss), Type 109186 A.N.S.P. Also taken on the Black River near the horseshoe bend and opposite the mouth of Fish Creek, Apache County.

By the shells alone we would hardly separate this form from *O. subrudis apache*; yet the genitalia (Fig. 292) agree with those of *O. s. depressa* and various allied forms except that the organs are longer in shells of similar diameter; yet in Colorado *depressa* this is a rather variable character, and it is somewhat affected by the conditions of preservation. The penis is very long, its internally costate portion hardly one-third of the entire length, having about 4 principal ribs within; the internally papillose portion

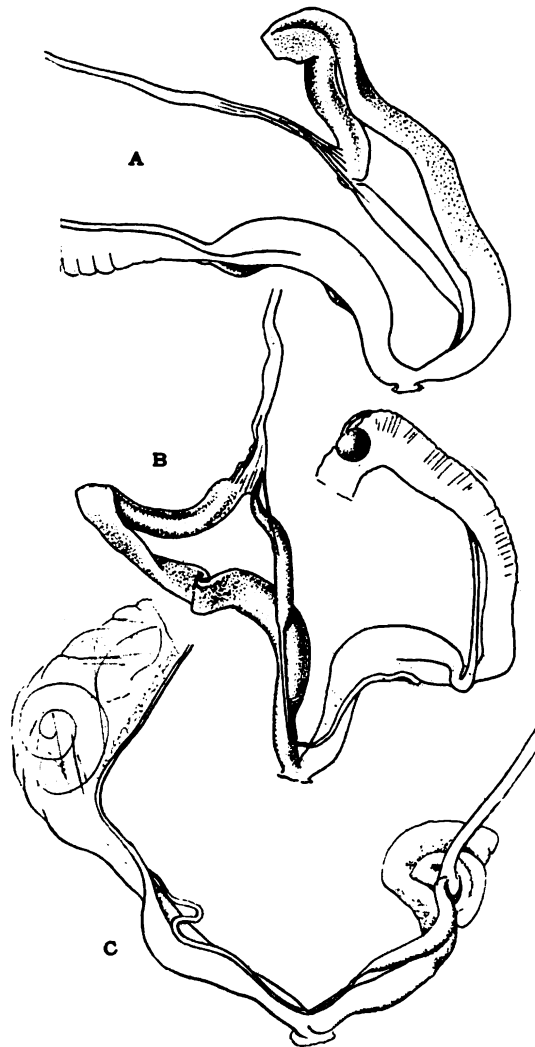


Fig. 292. *Oreohelix strigosa meridionalis* terminal ducts of genitalia; b, the type.

flattened, weakly ribbed within, sometimes having a trilobed section distally. Measurements of the organs of 5 specimens follow:

Length of penis	33	31	19.5	28	27 mm.
Length of ribbed part	9	10	6	7.5	6 mm.
Epiphallus	10	8	5	6	.. mm.
Vagina	9	10	6.5	8	.. mm.
Diameter of shell	24	..	22	21.5	22.2 mm.

An unusual feature of the race is the large size of the young at birth; one from the specimen figured has a diameter of 5.3 mm.

(*Meridionalis*, of mid-day, hence southern.)

Oreohelix strigosa nogalensis new subspecies

Fig. 293.

The shell is shaped like *O. strigosa cooperi*, rather narrowly umbilicate (umbilicus contained $5\frac{3}{4}$ times in diameter in the type). Cartridge buff streaked with grayish and with the inner whorls cinnamon-buff; on the base some faint (or sometimes distinct) purplish-brown clouding; other shells in the same lots have two narrow dark bands. Sculpture of fine, irregular striae cut by spiral lines (from distinct to faint). The embryonic shell is smoothish, with weak spirals on the latter part of the second whorl. The last whorl is obscurely subangular at first, becoming well rounded. Aperture shortly oval. The columellar margin of the peristome is thickened within, often with a rudimentary tooth.

Height 13.3 mm., diameter 17.1 mm., $5\frac{1}{2}$ whorls. Type.
 Height 12.7 mm., diameter 18.6 mm.; $5\frac{1}{3}$ whorls.
 Height 13.7 mm., diameter 20.5 mm.; $5\frac{1}{2}$ whorls.



Fig. 293. *Oreohelix strigosa nogalensis*.

NEW MEXICO: Sierra Blanca, Lincoln County, on the flanks of Nogal Peak (Pilsbry and Ferriss, October, 1922), Type 165940 A.N.S.P., from Water Canyon, west slope of the peak. Picacho (Wharton Huber).

It lives on steep, leafy slopes with very little rock, near the canyon bed, the trees mostly maple; higher, close under the peak, it was taken among aspens. On account of the high spire and narrow umbilicus these snails were taken for *O. subrudis* until dissected, when the relationship was at once obvious. The locality is so remote from the range of *O. strigosa cooperi* that an independent origin from the *O. strigosa depressa* stock seems probable.

The internally ribbed part of the penis forms about one-third of its entire length. In one of the type lot the length of penis is 14 mm., of ribbed part 5 mm., and in another 15 and 5 mm.

In one lot from Nogal Peak, 7500 feet, some are larger, as in the last measurement above, and the umbilicus is sometimes wider, $4\frac{3}{4}$ times in diameter. In a set of five dead shells from Picacho, in the foothills about 40 miles southeast of the type locality, the diameter is 16 to 19 mm.

By having a callus or weak tooth within the columellar margin this race resembles *O. strigosa buttoni* of Utah. As in that snail, the tooth is only occasionally developed, in any lot. The locality is farthest south for any member of the *strigosa* group.

Oreohelix strigosa cooperi (W. G. Binney) Fig. 279: 32-38.

Helix cooperi W. G. Binney, 1858, Proc. Acad. Nat. Sci. Phila., p. 115; 1859, Terr. Moll., 4: 97, pl. 77, fig. 11; 1869, L. & Fr. W. Sh. N. A., 1:78, figs. 133, 134.

Oreohelix strigosa cooperi (W. G. Binn.), Pilsbry, 1934, Proc. Acad. Nat. Sci. Phila. for 1933, 85: 390, pl. 14, figs. 32-38, text-figs. 9-9b.

Patula strigosa cooperi W. G. B., Shimek, 1890, Bull. Lab. Nat. Hist. State Univ. Iowa, 1: 203 (loess of Johnson and Polk counties, Iowa).

Pyramidula strigosa iowensis Pilsbry, 1898, Nautilus, 11: 141 (loess at Iowa City, Iowa; extinct).

[*Oreohelix cooperi*] form *iowensis* Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 353, 357 (first description).

Oreohelix strigosa stantoni Dall, 1905, Harriman Alaska Exped., L. & Fr. W. Moll., 13: 52.

"Shell umbilicated, elevated, globose; solid, with oblique incremental striae intersected with delicate spiral lines; color white, variously marked with a single narrow band, or broader longitudinal and spiral patches of reddish-brown; suture impressed; spire elevated; whorls five, convex, the last rounded, very decidedly deflected at the aperture; umbilicus moderate, pervious, $\frac{1}{4}$ th the greater diameter of the shell; aperture very oblique, circular; peristome simple, thickened, reflected at the umbilicus, with its extremities very nearly approached and joined by a heavy white callus. Greater diameter 15, lesser 13, height 9 millimeters." (W. G. Binney.)

SOUTH DAKOTA: Black Hills (F. V. Hayden). Lawrence County, along Spearfish Creek above Spearfish, 3700 to 4300 feet; near Savoy, 4900 to 5300 feet, in forest, on limestone; Deadwood (H. Burrington Baker).

IOWA: Loess of Johnson and Polk counties (Pilsbry, Shimek).

ALBERTA: Cypress Hills (for *stantoni* Dall).

The striation is moderately strong and irregular; spiral striation varies from distinct to practically obsolete. The periphery is well rounded, never angular in front. The umbilicus does not vary much from one-fifth of the diameter, being contained 4.9 to 5.2 times in diameter in the extremes measured. The two principal bands of *Oreohelix* are generally present, but the upper or more rarely both may be wanting. The base usually has few or many bands, or rarely none. There is more or less fleshy mottling in both banded and bandless shells.

By the shell alone I cannot distinguish topotypic *cooperi* from some lots of *O. subrudis*. Fortunately it is very easy to open the penis and note the diagnostic difference, the internally ribbed part occupying decidedly less

than half the length in *cooperi*, half or more than half in *O. subrudis*. No tangible anatomic distinction has been found between the subspecies and local races of *O. strigosa* known as *cooperi*, *depressa*, *carnea*, *tooelensis*, *fragilis* and *buttoni*, all based on shell characters.

Dissection of many individuals collected by Dr. H. B. Baker shows that the Black Hills *cooperi* is specifically distinct from the common snail of the Rocky Mountains long passing under that name, and now known as *O. subrudis* (Pfr.).

Black Hills specimens from lower Spearfish Creek within 3 miles of Spearfish, Lawrence Co., S. D., on limestone in forest (Figs. 315: 9, 9a, 9b) and from near Savoy, Lawrence Co., have genitalia with all the essential characters of *O. s. depressa*. The anterior third of the penis has about six unequal ribs in the cavity, the remainder being papillose within, as usual. The system is otherwise as in *O. strigosa* and other members of the *strigosa* group. Measurements of the penes of five large and small individuals from Spearfish Creek follow:

Length of penis	22 mm.	15 mm.	11.7 mm.	14.5 mm.	17 mm.
Length ribbed part	7 mm.	6.3 mm.	3.7 mm.	5 mm.	7 mm.
Diameter of shell	21 mm.	15 mm.	11.7 mm.	17 mm.	18 mm.

None of the many specimens dissected from the Black Hills shows any approach to the proportions found in *O. subrudis* (= "*cooperi*" as formerly defined anatomically).

Binney figured a high, "gerontic" specimen in which the last whorl descends very deeply; but he mentioned that some of the lot have a more flattened spire, and gave measurements of a flatter specimen. His later figures were probably from Colorado shells of *O. subrudis*.

In the series taken by Dr. Baker similar high forms occur abundantly near Savoy, on limestone in forest at 4900 to 5300 feet, always associated with shells having lower spires. Several figured measure as follows:

12 × 18 mm.; whorls 5½.	10.3 × 12.1 mm.; whorls 5.
12.7 × 17 mm.; whorls 5½.	8 × 10 mm.; whorls 4½.
13 × 16.5 mm.; whorls 5½.	5.5 × 9 mm.; whorls 4½.
11.2 × 14 mm.; whorls 5½.	

Small adults of this lot are among the smallest *Oreohelices* known. The variation in elevation is also extreme.

On Spearfish Creek 1-3 miles above Spearfish, in forest on limestone, 3700 to 4300 feet, a larger size is reached and the variation in height is somewhat less.

Height 16.6 mm., diameter 21.8 mm.; whorls 5½.
Height 15 mm., diameter 19.5 mm.; whorls 5½.
Height 8 mm., diameter 11 mm.; whorls 4½.

Oreohelix strigosa stantoni Dall agrees with small examples of *cooperi*. It has not been dissected. The description follows:

"The variety *stantoni* is dwarfed, measuring in maximum diameter 10.0, minimum 8.5, and height 8.0 mm., with about five whorls, a peripheral brown band with a narrower one above and sometimes others on the base, the remainder ashy, rudely incrementally striate, with rounded periphery and deep, narrow (1 mm.) umbilicus. It is very similar to some varieties of the European *H. virgata* Da Costa." (Dall.)

ALBERTA: "33 miles southeast of Medicine Hat, Assiniboia near top of Cypress Hills, altitude 4,700 feet; latitude about 49° 30', west longitude 110° 10'." Type in U.S.N.M.; eight specimens collected by Dr. T. W. Stanton in 1903.

Oreohelix cooperi form *iowensis* Pilsbry (Fig. 294), is quite small, height 7.7, diameter 11.4, umbilicus 2.6 mm., with 4½ whorls. There is a reddish band just under the periphery, and the initial whorl is very convex and smooth. It is from the loess, type 10922 A.N.S.P., from Iowa City, Iowa. It does not appear to differ from small specimens of *cooperi*, and is notable only as the eastern outpost of *Oreohelix*.



Fig. 294. *Oreohelix cooperi iowensis*.

The geographic range of *O. s. cooperi* as understood now, comprises several small, widely separated areas lying east and northeast of the *strigosa depressa* country, in a region where little collecting has been done. These areas apparently are remnants of a wide distribution acquired in or prior to the Pleistocene. See map on page 447, which, however, does not show Pleistocene range in eastern Iowa.

(Named in honor of Dr. J. G. Cooper, surgeon and naturalist of the Pacific Railroad Survey.)

***Oreohelix strigosa berryi* Pilsbry**

Fig. 295.

Oreohelix cooperi berryi Pilsbry, 1915, Nautilus, 29: 48.—Berry, 1916, Nautilus, 29: 127.

Oreohelix strigosa berryi Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 393, fig. 10.

Oreohelix (subrudis?) berryi Pils., Henderson, 1936, Univ. Colo. Stud., 23: 93.

The shell has the shape characteristic of *O. cooperi* except that the last whorl is distinctly angular in front, the angle disappearing on the last half or third, leaving the periphery rounded. Color cinnamon to snuff brown,

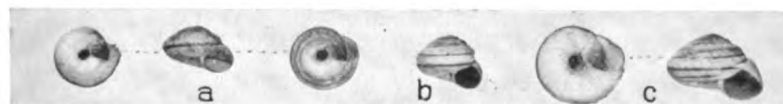


Fig. 295. *Oreohelix strigosa berryi*. a, type and paratypes; b, Half Moon Pass; c, Dry Pole Canyon.

from the third whorl on profusely marked with white patches and narrow streaks; last whorl having a chocolate band below the periphery (frequently also a narrower or paler band in the middle of the upper surface, and several dilute brownish bands on the base, interrupting the white streaks). The surface is irregularly striate and shows traces of spiral striation in places.

Whorls $4\frac{1}{2}$, all convex. Embryonic shell of nearly two whorls, which are finely striate and covered with very fine spirals, the last half of the second whorl having more distinct spiral striae. Umbilicus narrow, contained $5\frac{1}{2}$ times in the diameter of shell.

Height 6.3 mm., diameter 9.4 mm. Type.

Height 6.1 mm., diameter 9.3 mm. Paratype.

MONTANA: East wall of Swimming Woman Creek Canyon, Big Snowy Mountains Musselshell County at over 5000 feet (S. S. Berry), Type 112489 A.N.S.P. Dry Pole Canyon, Timber Creek Canyon, west of head Middle Cottonwood Canyon at about 8000 feet, and Half Moon Pass, Big Snowy Mountains, Fergus County (S. S. Berry).

WYOMING: Clematis Gulch, west of Mammoth Hot Springs, Yellowstone National Park (J. and B. Henderson).

A characteristic snail of the Big Snowy Range, but apparently the same race has been taken about 150 miles southward in Yellowstone Park. It is less strongly sculptured than *O. pygmaea* from west of the Big Horn range. The diameter varies from about 13 mm. (largest from Dry Pole Creek) to 7 mm. (smallest from Middle Cottonwood Creek). Some lots are deficient in spiral lines, and this is the case also in the Yellowstone Park specimens, where the largest have a diameter of 10 mm.

At one time I thought that this pygmy race "is perhaps not a subspecies in the proper use of that term, but a dwarf form traceable to some unfavorable factor of the particular stations where it occurs". As it has been found in two places associated with normal *O. subrudis* this idea seems untenable. Henderson writes: "In Yellowstone Park west of Mammoth it is found in abundance, which surely does not indicate unfavorable conditions, and it intermingles with the form we are calling *subrudis*, which is not there dwarfed as should be the case if conditions were unfavorable. It is a north exposure, shady, with good cover, plenty of lime in the soil, not especially dry nor wet. There is no intergrading between the two forms at that colony. My own inclination is to call it a perfectly good species, or a well-marked subspecies of *cooperi* or *subrudis*."

Similar in genitalia (Fig. 315: 10) to *O. s. depressa*, and to *O. s. cooperi* from the Black Hills except that the hermaphrodite duct has a very short convoluted portion. The vas deferens is inserted sublaterally on the epiphallus. Length of penis 8 mm., of internally plicate part 3 mm.; diameter of shell 9.3 mm. The specimen figured is one of the type lot.

The shell is more strongly angular at the periphery, but otherwise does not differ materially from small individuals of *cooperi* from the Black Hills. The specimens opened differ from *cooperi* by the very short convoluted portion of the hermaphrodite duct. For comparison I have drawn that of a Spearfish Creek, Black Hills, example of *cooperi* with a shell of 9.5 mm. diameter (Fig. 315: 9c), which will be seen to have the hermaphrodite duct

about as in large *cooperi*. *O. s. berryi* appears to be a small race on the northeastern margin of *depressa* territory, and probably not really distinguishable from *O. strigosa cooperi*, of which the anatomy was unknown to me at the time I defined *berryi*. What we called *cooperi* then was what is now known as *subrudis*; from that *berryi* is surely distinct.

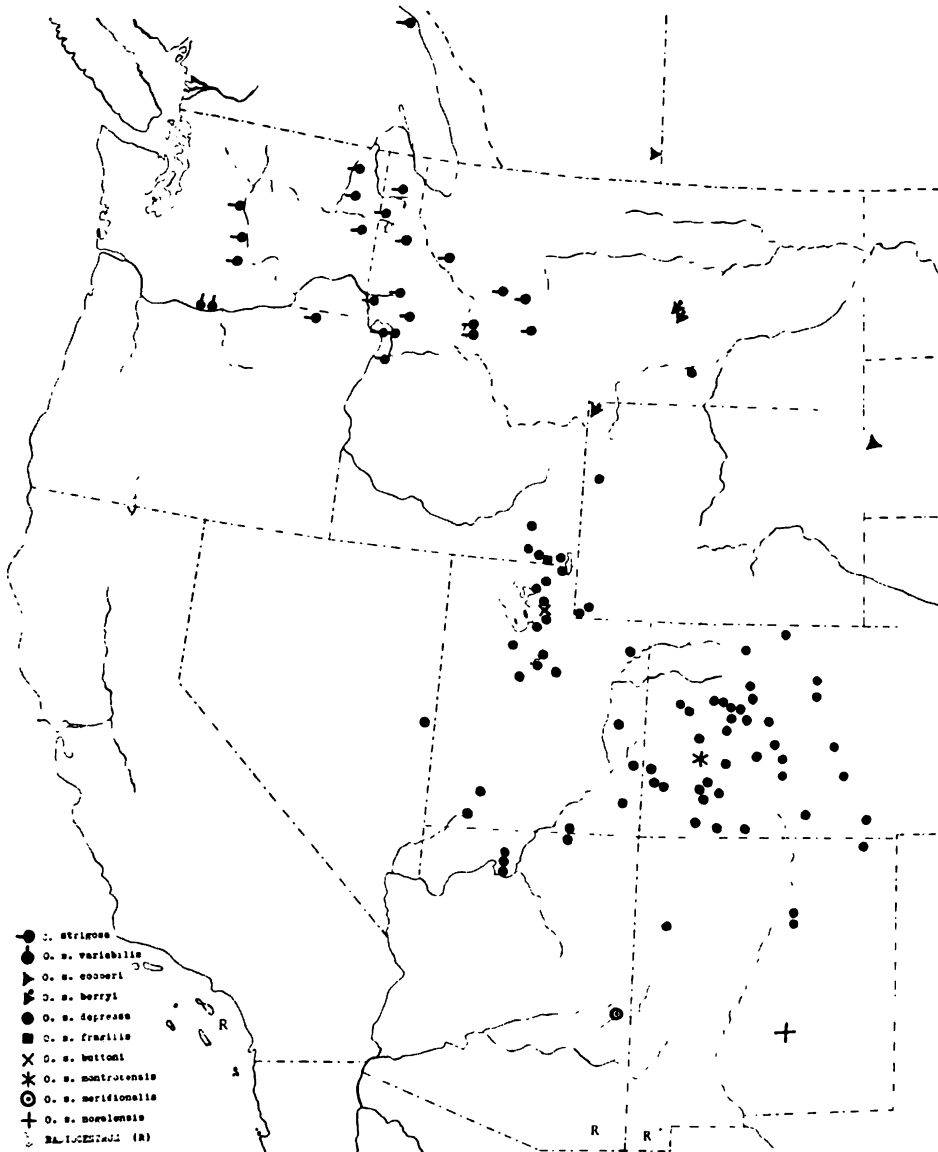


Fig. 296. Distribution of *Oreohelix strigosa* and subspecies, and of the subgenus *Radiocentrum* (R), localities in Mexico not represented.

Oreohelix pygmaea Pilsbry

Fig. 297 a, b.

Oreohelix pygmaea Pilsbry, 1913, *Nautilus*, 27: 52, pl. 3, figs. 10, 11, 12.—Henderson, 1924, *Univ. Colo. Stud.*, 13: 117, pl. 3, fig. 9.

“The shell is related to *O. cooperi*, from which it differs in being smaller, with a narrower umbilicus, much more convex whorls, and rougher sculpture. The spire is convexly conic. Embryonic two whorls moderately convex, finely and weakly striate, with a few distinct spirals on the latter part near the periphery. Post-embryonic whorls increase very slowly and are very convex, the convexity greater above the middle of each, with sculpture of

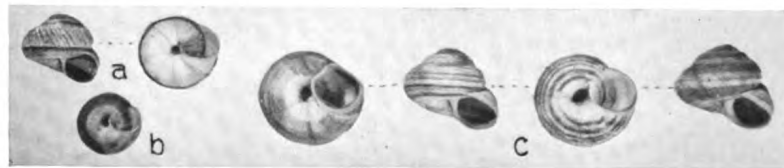


Fig. 297. a. *Oreohelix pygmaea*, type and paratype; b, above Squaw Creek, west side Big Horn Mts. c. *O. p. maculata*, cotype and paratypes, White Creek.

strong, irregular wrinkles along growth-lines and moderate or very weak spiral impressed lines. On the last whorl, which is very convex throughout, the sculpture is strongest above, but continues upon the base. Suture deeply impressed. Umbilicus small, its width contained $6\frac{1}{3}$ to $8\frac{1}{2}$ times in that of the shell. Peristome thin, forming $\frac{3}{4}$ to $\frac{1}{2}$ of a circle. The spire is flesh-colored when worn, fleshy-brown with whitish streaks in young shells; the last 1 or $1\frac{1}{2}$ whorls are impure white with fleshy streaks; marked with a deep brown band below the periphery, and usually several narrower and lighter bands above it and on the base.”

Height 8.7 mm., diameter 11 mm.; 5 whorls.

Topotypes measure 9 x 10.8 mm., 5 whorls; 7 x 9.7 mm., $4\frac{3}{4}$ whorls.

WYOMING: Shell Creek Canyon, 10 miles northeast of Shell (Don W. Walker), Type and paratypes 106977 A.N.S.P. White Creek Canyon, 8 miles east of Shell, in very damp pine forest (Don W. Walker). Raymond, Big Horn County (F. W. Kelsey). Route 16 just above Squaw Creek, west side of Big Horn Mountains (A. A. Olsson).

MONTANA: Shiveley Ranch, southeast of Billings (F. W. Rohwer, University of Colorado Museum).

This snail is intermediate between *O. cooperi* (W. G. B.) and *O. peripherica* (Ancey). The irregular costulae or wrinkles are stronger than in the first, but less regular than in *O. peripherica*. It is readily distinguishable from young or small *cooperi* by the far greater convexity of the whorls of the spire, as well as by the sculpture.

“Mr. Walker, who collected the Wyoming material, says the Shell Creek *pygmaea* and *cooperi* [*subrudis*] were found together on a steep slope on the south side of the canyon, where they occurred in great numbers, more of the small ones below and more of the *cooperi* above” (Henderson). It was found with *O. subrudis* also in White Creek Canyon.

Genitalia of a paratype are figured (Fig. 277 E). The epiphallus tapers to the vas deferens as in *O. subrudis*. The internally ribbed anterior part of the penis is slightly less than half the total length, and has five rather strong ribs. The larger talon, Fig. 277 e, is brown. Length of penis 7 mm., of its costate part 3 mm.; epiphallus 2.5 mm.

The radula has 22.1.22 rather short teeth. Central and laterals have small ectoconal cutting edges. The marginals have distinct ectocones, as usual; exceptionally the ectocone is twinned, but on most teeth it is simple (Fig. 277 D).

Specimens of "*H. alternata* var. *kelseyi*" Hemphill MS., from Raymond, a place near the northern boundary of Big Horn County, Wyoming, received from Hemphill through Ferriss, are *O. pygmaea* as I stated in 1934 (Proc. Acad. Nat. Sci. Phila., 85: 408); but others given me by F. W. Kelsey are small *O. subrudis*. It has not been described. The combination *Oreohelix kelseyi* (Hemphill) was used by Henderson (1936, Univ. Colo. Stud., 23: 90).

***Oreohelix pygmaea maculata* Henderson**

Fig. 277 c.

Oreohelix pygmaea Henderson, 1918, Nautilus, 32: 45-47, not of Pilsbry.

Oreohelix maculata Henderson, 1921, Nautilus, 35: 15.

"Shell below medium size for the genus, spire elevated, whorls 5½, with convex periphery, somewhat flattened above near the suture, resulting in a deeply impressed suture, convex below. Embryonic whorls dark brown in most examples, at first nearly smooth, with very fine growth-lines crossed by microscopic spiral lines, which, at about the beginning of the third whorl, develop into beaded ribs easily detected with a low-power lens. The last two whorls of the shell bear numerous rather strong, rude, blunt, irregular ribs, parallel with the growth-lines, crossed by about equally numerous rude spiral ribs, this sculpture being especially well developed on the base of the last whorl. This sort of sculpture is typical of the *depressa-cooperi* group, as distinguished from the sharp-ribbed *haydeni* group, but the sculpture is very much stronger in *maculata* than is usual in either *depressa* or *cooperi*, and the two latter are smoother below than at the periphery and above, while in *maculata* the opposite is true. Aperture rounded, outer and inner lips approaching. Umbilicus deep and narrow. Color exceedingly variable, a large number seen collectively appearing quite dark because of a preponderance of brown. The great majority of examples have irregular, poorly defined light brown patches on a white ground color, particularly noticeable under a lens, with usually one spiral band or more of the same color above the periphery and stronger bands of darker brown, varying in width and number, just below the periphery and on the base. A few albinos were found, without intergradation to the typical color, as is also true of *O. cooperi obscura* at the same locality. A considerable number of examples are almost entirely dark brown, but, except in a very few specimens, there is a wide, conspicuous lighter band at or just above the periphery of the melanistic shells, which shows just above the suture on the spires." (Henderson.)

Height 11.5 mm., diameter 14 mm. Type.
10.8 x 13.5 mm., 11 x 14 mm., 10.6 x 12.8 mm.,
12 x 13.5 mm., 10.8 x 14 mm., Cotypes.

WYOMING: Shell Creek Canyon and White Creek Canyon, several miles down the canyon from the localities of *O. pygmaea* (Junius Henderson), Type in University of Colorado Museum, cotype 128530 A.N.S.P.

This snail is larger than *O. pygmaea*, more or less angular at the periphery, with more strongly developed spiral sculpture, but the relationship seems very close. It has not been dissected.

(*Maculata*, spotted.)

Oreohelix peripherica (Ancey)

Fig. 298.

Patula cooperi, strongly ribbed variety, Bland in Ingersoll, 1876, 8th Ann. Rep. Hayden Surv., for 1874, p. 397, Bear River, Utah.

Helix idahoensis var. *peripherica* Ancey, 1881, Le Naturaliste, 1: 403 (3me année).

[*Patula strigosa*] var. *binneyi* Hemphill, Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zoöl., 13: 27, 29, 31, pl. 2, fig. 13.

[*Patula strigosa*] var. *multicostata* Hemphill, Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zoöl., 13: 32, pl. 2, fig. 6.

[*Patula strigosa*] var. *gouldi* Hemphill, Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zoöl., 13: 32, pl. 2, figs. 5, 16.

[*Patula strigosa*] var. *albofasciata* Hemphill, Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zoöl., 13: 32, pl. 2, figs. 3, 4.—Hemphill in Binney, 1892, 4th Suppl., Bull. Mus. Comp. Zoöl., 22: 171, pl. 4, fig. 9.

[*Patula strigosa*] var. *castaneus* Hemphill, Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zoöl., 13: 32, pl. 2, figs. 11, 14 (exclusive of record from Celilo, Ore.).

Oreohelix peripherica color-form *castanea* (Hemph.), Henderson, 1929, Proc. Cal. Acad. Sci., (4), 18: 221, pl. 24, fig. 1 (lectotype, 2986 C.A.S.).

[*Patula*] *peripherica* (*multicostata* Hemph.), Ancey, 1887, Conch. Exch., 2: 64.

Oreohelix peripherica (Anc.) and local races *binneyi*, *newcombi*, *multicostata*, *gouldi*, *albofasciata* and *castaneus* Hemph., Pilsbry, 1913, Nautilus, 27: 53; 1916, Proc. Acad. Nat. Sci. Phila., pp. 343, 349, pl. 20, figs. 1-6, genitalia; 1917, Proc. Acad. Nat. Sci. Phila., p. 43, 45, fig. 3b.—Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., pp. 317, 327, 330, 335, pl. 15, figs. 1-4 (variation and distribution); 1917, pp. 62, 69, 70.—Henderson, 1924, Univ. Colo. Stud., 13: 116 (synonymy and references); 1936, Univ. Colo. Stud., 23: 90.

"I owe to the kindness of Dr. Newcomb a second variety of this species [*H. idahoensis*], of the same shape as the preceding¹ but the umbilicus more open, ornamented at the periphery with two narrow brown bands, of which the lower is the more strongly marked, and provided with close, irregular ribs in low relief. In shape it so nearly resembles *Helix* (*Anguispira*) *cooperi* W. G. Binn. that I think it may well be a hybrid displaying the characteristics of *H. idahoensis* and *cooperi*. It is 9 mm. high, 14 in diameter, and comes from Utah. By the shape and color it looks much like *H. cooperi* figured in Binney and Bland's work 'Land and F. W. Shells of North Amer.', p. 78, fig. 136, but it possesses ribs which the latter does not have. I propose to name this interesting variety *Helix idahoensis* Newc. var. *peripherica*." (Ancey.)

UTAH: Bear River valley in Boxelder and Cache Counties; Wasatch Mountains, in upper Weber Canyon. Banks of Bear River north of Brigham (Hemphill, Henderson and Daniels); North Ogden Canyon; various places in Cache Junction and Wheelon district, and south of Tren-

¹ This refers to a variety described but not named by Ancey, later said by him (*in litt.*) to be a form of *peripherica*.

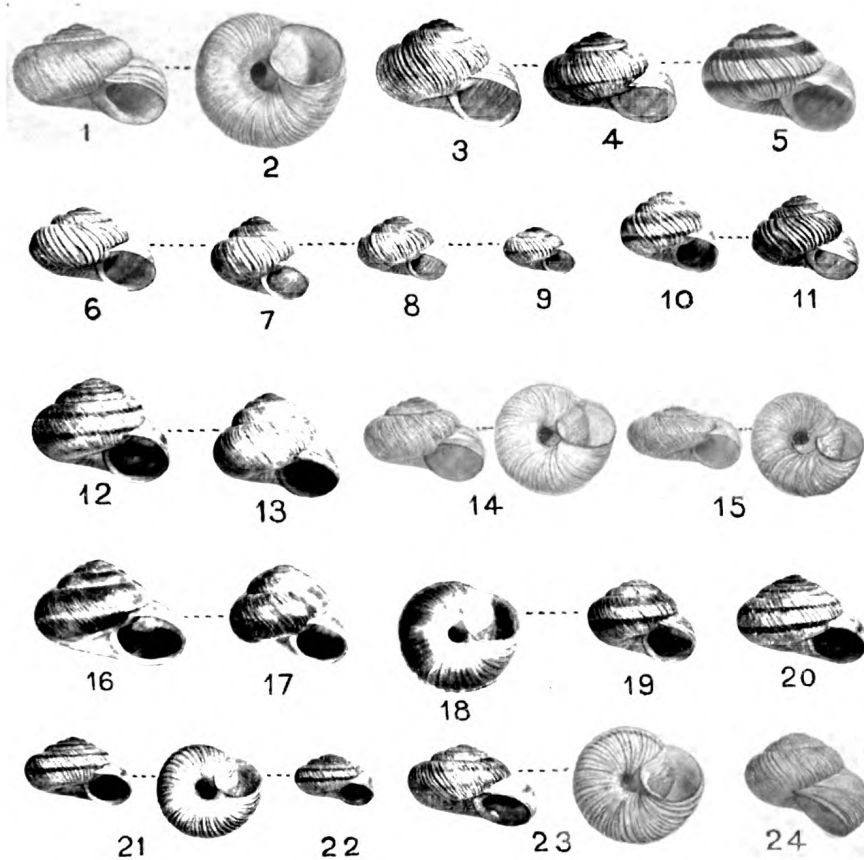


Fig. 298. *Oreohelix peripherica*. 1, 2, mountain north of Newton. 3-5, below Cache Junction. 6-11, 18, 19, below Cache Junction. 12, 13, Ogden Canyon. 14-15, Morgan. 16, 17, 20-22, 24, Boxelder County. 23, Brigham.

ton; Newton, Smithfield and Morgan (Henderson and Daniels). South Tremonton (Chamberlin and Jones).

This polymorphic species was well characterized by Ancy as similar to *O. cooperi* but ribbed. It varies widely in size, degree of elevation, development of ribs and in being either plain or banded. It is a case where several factors for banding and sculpture exist in usually mixed colonies, which are rendered still more heterogeneous by local conditions determining size. The several varietal names proposed for these mutations by Hemphill and Binney do not denote subspecies, but have the same value as the color-combinations in mixed colonies of *Liguus*. The conditions could not be fully understood from Hemphill's assorted lots, but the field work of Henderson and Daniels (1916, pp. 317, 328-334) brought out the facts of association. "A careful study of Hemphill's material in the Clapp

Collection, taken in connection with a study of our own material, both in the field and in the laboratory, convinces us that the forms mentioned in the foregoing synonymy should not be separated as subspecies. Some of the names may be useful as descriptive terms, provided they are used in such a way as to indicate their rank." "At every station we found them intermingled, enormously variable in size, shape, color and sculpture, so completely grading together that we were compelled to believe them to belong to one protean species, and the same as Ancey's previously described *peripherica*, a conclusion reached also by Dr. Pilsbry some time ago." (Henderson and Daniels.)

Ancey's type was a small specimen of the form Hemphill called var. *multicostata*, similar to Figure 298: 21.¹ It is slightly larger than "var. *gouldi*", which was from a colony of small shells of the same color-form, (Fig. 298: 22, diameter 10.6 mm.). In large series of this color-form sent out by Hemphill assorted according to size, the diameter runs from 10.2 mm., with 4½ whorls, to 20 mm. with 5½ whorls (Figs. 298: 4, 9, 10, 20-22). Hemphill's var. *albofasciata* is similar to typical *peripherica* except that the bands are wider, the upper one reaching to the suture, the lower spreading more or less on the base, a white band at periphery, as in Figures 298: 5, 19. It passes by imperceptible degrees into "var. *castanea*," in which there are wider bands and a general suffusion of brown (Figs. 298: 16-18). Several of Hemphill's lots show the decadence of bands to faint lines or vanishing, the latter condition being "var. *binneyi*", which is merely a bandless form of *multicostata* (Figs. 298: 1-3, 6-8, 11, 13, 24). The shell is light buff to nearly white with dull pinkish spire and sometimes a faintly traced subperipheral line. Hemphill assorted his lots by size, shape and color, and labelled all "Box Elder Co., Utah." Figures 16, 17, 20-22, 24 are from his collections, also Figure 23, labelled Brigham City, Utah. The association, intergradation of forms and the distribution have been worked out by Henderson and Daniels, whose papers of 1916-7 should be consulted for details. Specimens from colonies below Cache Junction are illustrated in Figure 298 as follows:

Figures 298: 3-5, Henderson and Daniels Station 29, steep east banks of Bear River just above entrance to gorge. Connecting unbanded forms with form *albofasciata*; diameter 15 to 20.6 mm.

Figures 298: 6-11, Henderson and Daniels Stations 30-32, parts of one large colony at different elevations, opposite power plant dam; diameter 8 to 16 mm.

Other localities from their collections are represented in Figures 18, 19, from the gorge above Wheelon, where the colors of Figures 3 to 5 also occur. Figures 1, 2, west slope of mountain east of Newton, a pure colony of

¹ Our fig. 298: 21 agrees with Ancey's measurements and is here selected as neotype of the species, 10869 A.N.S.P.

binneyi. Figures 12, 13, north Ogden Canyon; two reversed individuals were found. Farther southeast, in the Weber River valley, *peripherica* occurred in a gulch about half a mile north of Morgan depot, Figures 14, 15, white, or very few with one or two lines of color, 14 to 16 mm. in diameter, moderately to strongly depressed, the h/d index from 54.3 to 66.0, the more depressed shells being distinctly angular at periphery. In another colony about 2 miles east of Morgan, Henderson and Daniels found shells "showing complete intergradation between Hemphill's *binneyi* and *albofasciata* forms."

In some shells there is a callus or a low tooth within the baso-columellar margin, as in Figure 298: 23. It varies individually in degree of development, and toothed examples occur in colonies of toothless but otherwise similar shells. An exactly similar tooth is found in some specimens of *O. strigosa buttoni* and *O. strigosa nogalensis*.

The sculpture of *peripherica* varies from quite coarse to fine, and it appears to be less variable in any colony than the color. Henderson and Daniels remark that "wherever the form *albofasciata* was found, it was associated with the *binneyi* form". In a few colonies *binneyi* was found without *albofasciata*, but usually there are some narrowly one- or two-banded examples with them.

In genitalia this species does not differ materially from *O. strigosa depressa* and *O. haydeni*. The internally costate part of the penis is less than half of the total length, usually slightly over a third. The internally papillose distal portion usually collapses flat, but in a few specimens from Cache Junction there are weak indications of a third ridge. The cylindrical lower part of the penis has 5 or 6 longitudinal ribs within. Lengths of male organs in mm. follow:

Locality	Penis	Ribbed part	Epiphallus	Diam. shell
Below Wheelon	18	6.5	4.5	20
Below Cache Junction	14	6.5	4	13
Mt. near Newton	21	7.5	5	20
Near Morgan	13	5	4.5	15

I have also dissected specimens from a gulch tributary to Ogden Canyon. In all, the proportions agree, though the absolute size varies with that of the shell. The specimens opened from various localities include relatively smooth, fine-ribbed and coarse-ribbed, white and banded individuals.

The central and inner lateral teeth have no side cusps. There are about 12 lateral teeth on each side in a small specimen from below Cache Junction. In an individual from near Newton there are 17, 13, 1, 13, 17 teeth. The transition from lateral to marginal teeth is very gradual in this species, so that the exact number of laterals is somewhat uncertain.

Binney's descriptions of the named mutations and forms follow.¹ All

¹ "Hemphill camped on the 'banks of the Bear River,' north of Brigham, where the valley 'was considerably broken by mountain spurs, through one of which the river had

were collected by Hemphill; according to his labels at an elevation of about 4500 feet.

Color-var. *binneyi* Hemphill. (Figs. 298: 1-3, 6-8, 11, 13-15, 24.) "This variety has strong, rough wrinkles rather than decided ribs, about 50 on the first [last] whorl of one individual. Some individuals have a decided, erect tubercle within the peristome near its junction with the parietal wall of the aperture. There are no revolving bands of color." (W. G. Binney.)

Color-var. *multicostata* Hemphill. (Figs. 298: 4, 10, 12, 20-23.) "On one specimen I counted over 70 coarse rib-like striae to the first whorl. There are two revolving bands of chestnut on all the individuals received from Mr. Hemphill. Two have the denticle on the peristome." (W. G. Binney.) [The name *multicostata* is superfluous, as this pattern is identical with typical *peripherica*].

Size-var. *gouldi* Hemphill. (Fig. 298: 22.) "One individual has 62 rough wrinkles on the first whorl. There are two revolving bands of color. The specimen figured [by Binney; diameter 12.5 mm.] is the largest sent me by Mr. Hemphill, others being smaller by one-half, and some being very much depressed. Among the thousand specimens collected, none were large." (W. G. Binney.) [This form was found in a patch of wild rye about 50 feet square, about 3 miles above the localities of the preceding and following forms. It is merely the small form of *multicostata*].

Color-var. *albofasciata* Hemphill. (Figs. 298: 5, 18, 19.) "The body of the whorl is clouded, with a broad white band at the periphery, and white around the umbilicus. Some individuals are white with two revolving bands of color. On one there are about 70 rough wrinkles to the first whorl. Some have a toothlike process on the peristome. The variety differs, as usual in the group, in the elevation of the spire and in size." (W. G. Binney.)

Color-var. *castanea* Hemphill. (Figs. 298: 16, 17.) "This variety differs somewhat in the sculpturing; the wrinkles are usually less developed than in the previously mentioned varieties, but on a few individuals are coarser. Those from eastern Oregon are almost smooth. The principal characteristic of the variety is its color, which is uniform chestnut excepting around the umbilicus. A few, like the one figured, have a double revolving white band." (W. G. Binney.) [The eastern Oregon form mentioned is *O. strigosa variabilis* Hend. The history and characters of "*castaneus*" have been fully discussed by Henderson, 1929.]

(Περιφέρια. periphery, circumference.)

***Oreohelix peripherica weberiana* new subspecies**

Fig. 299.

The shell is depressed, moderately umbilicate (about $6\frac{1}{2}$ times in diameter), with very coarse, unequal and irregular ribs, and fine spiral

cut its way, leaving high, rocky cliffs on either side, with scattered clumps of bushes along the river and on the edges of the bluffs.' Wheelon is located just where the river leaves the gorge, . . . while Cache Junction itself is in the valley perhaps a couple of miles up the river from the gorge. A careful consideration of the topography and biological conditions, in connection with Hemphill's notes, convinced us that his camp was just below Wheelon, for in his search for *Oreohelix* he would surely have camped close to the mountains, the valley here being quite unfavorable to land snails." (Henderson and Daniels.)

striae locally developed. There are two wide, interrupted dark bands, the upper one reaching the suture (*albofasciata* pattern).

Height 10.8 mm., diameter 17.5 mm., h/d index 61.7; $4\frac{3}{4}$ whorls.

UTAH: West side of Weber River four miles west of Coalville (T. W. Stanton), Type 113572 A.N.S.P., paratypes also in U.S.N.M.

This is the roughest form of *peripherica* except *O. p. wasatchensis*. The largest of the lot in United States National Museum has a diameter of 20.5 mm.



Fig. 299. *Oreohelix peripherica weberiana*, type, natural size and enlarged.

Oreohelix peripherica newcombi ("Hemphill" W. G. Binney) Fig. 300 a.

[*Patula strigosa*] curious form, Binney, 1878, Terr. Moll., 5: 159, fig. 68 (as "*H. cooperi* var."); pl. 16, fig. A, teeth.

[*Patula strigosa*] var. *newcombi* in part, Binney, 1885, Man. Amer. L. Sh., p. 481, no description.

[*Patula strigosa*] var. *newcombi* Hemph., Binney, 1886, 2d Suppl., Bull. Mus. Comp. Zool., 13: 32, pl. 2, fig. 8.

Oreohelix peripherica newcombi (Hemph.). Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 330. — Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., pp. 343, 357. — Henderson, 1924, Univ. Colo. Stud., 13: 117, pl. 3, fig. 2.

"This variety has numerous separated, rough, heavy transverse ribs (44 on the first whorl of one individual), and two widely separated revolving bands of color. It varies, as usual in the group, in size and globoseness. Some want the revolving band." (W. G. Binney.)

UTAH: Mountains north of Ogden, among bushes on steep sides of a gulch facing north, in continual shade (Hemphill).

A coarsely ribbed form having a faintly sketched peripheral carina or angle in many examples, not perceptible in some others. Intercostal intervals are distinctly to obsoletely striate spirally. In the same lot the bands may be either distinct, faint or wanting. The umbilicus is usually small but is variable, contained $5\frac{1}{2}$ to nearly 9 times in diameter. Two measure: 14.6 x 17.3 mm., and 15.3 x 19.5 mm. The locality is said to be farther north than where *wasatchensis* was found, the exact place unknown. Figured from shells received from Hemphill.

(Named for Dr. Wesley Newcomb.)

Oreohelix peripherica wasatchensis ("Hemphill" W. G. Binney) Fig. 300 b, c, d.

[*Patula strigosa*] var. *wasatchensis* Hemphill, Binney, 1886, 2d Suppl., Bull. Mus. Comp. Zool., 13: 34, pl. 2, fig. 7.

Oreohelix peripherica wasatchensis (Hemph.), Henderson & Daniels, 1917, Proc. Acad. Nat. Sci. Phila., p. 67.—Pilsbry, 1917, Proc. Acad. Nat. Sci. Phila., p. 43, genitalia.—Henderson, 1924, Univ. Colo. Stud., 13: 117, pl. 2, fig. 9.

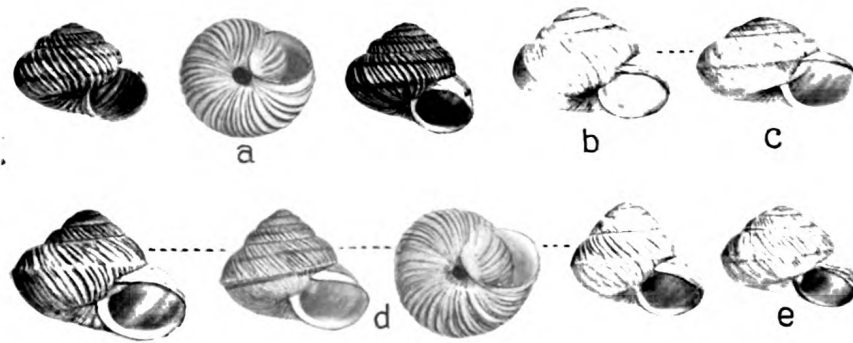


Fig. 300. a, *Oreohelix peripherica newcombi*. b-e, *O. p. wasatchensis*: b, c, from Henderson & Daniels' lower station; d, topotypes from Hemphill; e, Henderson & Daniels' upper station.

The shell is pyramidal, narrowly umbilicate; buff with dull fleshy upper whorls and some streaks, with two narrow dull brown bands or bandless. The last whorl is convex above and below a strong peripheral keel. Sculpture of very coarse, irregular wrinkles of growth and minute spiral striae in places. Topotypes from Hemphill measure:

Height 17 mm., diameter 23.3 mm.

Height 18 mm., diameter 21.6 mm.

Height 15.4 mm., diameter 18 mm.

UTAH: Wasatch Mountains near Ogden, among quartzite boulders, only found in a plot of about an acre (Hemphill). South side of valley about a mile below the mouth of Ogden Canyon on base of river terrace in a thicket of scrub oak and mountain maple; also farther up the mountain and into a quartzite slide (Henderson and Daniels).

This race is one of Hemphill's most spectacular finds, typically very distinct by its high spire, keeled periphery and coarse, irregularly developed sculpture. Henderson and Daniels' specimens are not typical, being lower, much less roughly sculptured and with the keel usually less prominent. At their lower station (Fig. 300 b, c) the keel is weak or reduced to an angle in front only, and sometimes inconspicuous. At their higher station (Fig. 300 e) the keel is often well expressed and the sculpture coarser, but the form is somewhat less elevated than in Hemphill's shells, illustrated in Figure 300 d. Specimens from their first station measure 16.5 x 21 mm. and 13 x 21 mm.; from the higher station, 15 x 20 mm. and 12.2 x 19.6 mm.

The genitalia of two specimens received from Henderson show the proportions of *peripherica*, though the size is greater. Length of penis 20 mm., of its internally ribbed part 8 mm., epiphallus 7 mm.

Oreohelix idahoensis (Newcomb)

Fig. 301 a.

Helix idahoensis Newcomb, 1866, Am. Journ. Conch., 2: 1, pl. 1, figs. 1-3.—Binney & Bland, 1869, L. & Fr. W. Sh. N. A., 1: 79, fig. 138.

Patula idahoensis Newc., Binney, 1878, Terr. Moll., 5: 160, fig. 70, pl. 4, fig. 1 (teeth). [*Patula strigosa*] var. *idahoensis* Newc., Binney, 1886, 2d Suppl., Bull. Mus. Comp. Zool., 13: 29, pl. 2, figs. 1, 2.

Oreohelix idahoensis Newc., Pilsbry, 1913, Nautilus, 27: 54.—Henderson, 1924, Univ. Colo. Stud., 13: 110, pl. 3, fig. 3; 1936, 23: 89, 90.

The shell is turbinate-conic with an obtuse apex and an umbilicus contained about 6 ($5\frac{1}{3}$ to 9) times in the diameter; buff-pink or paler with a darker apical area and pure white ribs. Embryonic whorls nearly 2, convex,

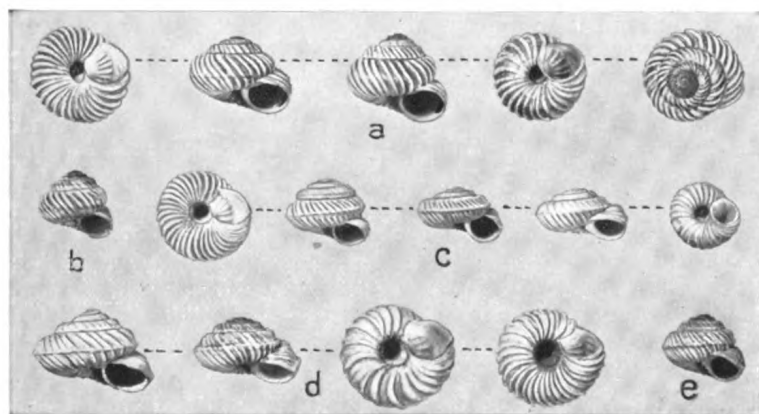


Fig. 301. a, *Oreohelix idahoensis*, cave near Lucile; b, east of Lucile. c, *O. idahoensis baileyi*, Sheep Gulch; d, Cottonwood Tree Creek, south of Lewiston; e, Lime Point, Asotin County.

with fine radial striae and near the end of the second some minute spiral striae; on the next whorl are retractive riblets, becoming strong, subregular ribs on the later whorls, nearly equal to their intervals; usually without spiral striae or lines, but sometimes fine spirals are weakly developed on the upper surface. The whorls are strongly convex, swollen below the deep suture, the last slowly but rather deeply descending in front, rounded peripherally (rarely with weak trace of a peripheral keel). Aperture sub-circular; peristome is blunt and yellowish in old shells; parietal callus short, thick in old shells.

Height 11.2 mm., diameter 13.2 mm.; $5\frac{1}{2}$ whorls. Type.

Height 11 mm., diameter 13.7 mm.; $5\frac{1}{2}$ whorls. Lucile.

Height 11.3 mm., diameter 12 mm.; $5\frac{1}{2}$ whorls. Lucile.

Height 10.5 mm., diameter 13.7 mm.; 5 whorls. Lucile.

IDAHO: "Between Idaho City and the Coeur d'Alene mining district"¹ (Henry Hemphill), Type 10857 A.N.S.P. Below cave about 1½ miles south of Lucile, east bank of Salmon River, and in soft limestone about a mile up Sheep Gulch, east of the town (H. Burrington Baker). Salmon River Mountains (Hemphill). Banks of Salmon River 11 miles south of Slate Creek (Allyn G. Smith). (Varieties west to the Snake River Canyon.)

This is one of our prettiest land shells. The lot of several hundred taken at Lucile cave is quite uniform in general appearance, but the height of spire and width of umbilicus vary, as well as the count of ribs, 23 to 32 on the last whorl. Immature shells of 9 or 10 mm. in diameter have the periphery angular and in the intercostal intervals somewhat keeled.

Shells from the soft limestone east of Lucile average smaller than those from the cave, down to 7 x 10 mm.; the spire is often lower, but both form and size intergrade. In a few individuals there is a vestigial keel at the otherwise well rounded periphery. By these characters they are transitional to *O. i. baileyi*. Spiral striation may be quite absent, but usually some faint traces are visible under the lens.

The Utah records for *O. idahoensis* were based upon specimens of *O. peripherica*, a species in which the ribs are weaker and the whorls less convex.

Genitalia (Fig. 277 c, Lucile cave) of the *strigosa* type. The internally four-ribbed anterior part of the penis forms less than half of the total length; the granulose part is slightly flattened but less than usual. Vas deferens is inserted on the side of the apex of epiphallus. The black talon is minutely speckled with white. Length of penis 12 mm., ribbed part 5 mm., epiphallus 4 mm., shell 10 x 14 mm.

There are 21.1.21 teeth (Fig. 306 A). Centrals and laterals have strongly developed outer cutting points, on the outer laterals and marginals becoming well developed ectocones. There are about 8 laterals, but the transition to marginals is very gradual. This agrees with Binney's account except that he found 33.1.33 teeth with 14 laterals, half again as many teeth. So great a divergence makes the examination of further specimens desirable.

***Oreohelix idahoensis baileyi* Bartsch**

Fig. 301 c.

Oreohelix idahoensis baileyi Bartsch, 1916, Proc. U. S. Nat. Mus., 51: 333, pl. 31, figs. 4-6.—Winslow, 1920, Occ. Pap. Mus. Zool. Univ. Mich., no. 79, p. 1, pl. 1.—Henderson, 1924, Univ. Colo. Stud., 13: 111, fig. 26; 1936, 23: 90.—Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 394, fig. 11, anatomy.

The shell is ribbed as in *O. idahoensis* but is more depressed, the last whorl with a keel at periphery; intercostal intervals finely but often rather weakly striate spirally.

IDAHO: Seven Devils Mountains on a limestone ridge beside a rapid creek, alt. 3700 feet (Vernon Bailey), Type 133221 U.S.N.M. Snake River

¹ Newcomb's locality is vague, since the places mentioned are more than 200 miles apart. Lucile is on the road between them. As the type specimens from Newcomb agree exactly with those collected by Dr. Baker at Lucile, that place has been selected as type locality. It is known from other labels that Hemphill collected there.

Canyon 8 miles below the mouth of Salmon River, in the same mountains (I. C. Russell). Cottonwood Tree Creek along the Snake River, 50 miles south of Lewiston (John Lorang). On blue marble about 3 miles up Sheep Gulch, east of Lucile (H. Burrington Baker).

WASHINGTON: Lime Point, T. 7 N., R. 47 E., Asotin County, below a limestone cliff (Harold St. John).

This carinate form seems to be abundant along the Snake River, but quite typical specimens of it were taken by Dr. Baker in Sheep Gulch, near Lucile on the Salmon River, only a mile or two from colonies of *O. idahoensis*.

It varies widely in form, and the last whorl occasionally descends very deeply.

A lot of 32 measured by Mina Winslow gave the following proportions:

Height 8.16 mm., diameter 12.1 mm., h/d index 67.35. Average for 32 shells.

Height 9.6 mm., diameter 14.2 mm., h/d index 67.6. Largest in diameter.

Height 7.7 mm., diameter 11 mm., h/d index 70. Smallest in diameter.

Height 9.7 mm., diameter 11.5 mm., h/d index 84.34. Most elevated.

Height 7 mm., diameter 12.3 mm., h/d index 56.91. Most depressed.

High and low shells in a lot from near Lucile measure: 7.1 x 12 mm., h/d index 59.16; 8.7 x 11.1 mm., h/d index 78.87.

The ribs vary from 19 to 30 on the last whorl in a lot from Cottonwood Tree Canyon. According to Bartsch the type has 23 ribs.

The largest seen are from Cottonwood Tree Creek, the largest and smallest of a lot of 9 measuring: 11.1 x 15.7 mm., and 9 x 14 mm. Specimens of this lot were alive after confinement for 8 months 17 days in a dry box. In a lot of 13 from Asotin County, Washington, the shell is rather small and compact, two measuring: 7 x 10.8 mm., h/d index 64.81, and 8.5 x 11.2 mm., h/d index 75.90.

Junius Henderson found "such minute graduation from the typical form described and figured by Newcomb to that of Bartsch, that I doubt whether *baileyi* is entitled to a name as a subspecies or even a variety"; but while I have seen intergrading shells from around Lucile, the strongly carinate form alone seems to occur in the Snake River region. Having seen all of the material in Ann Arbor, Washington and Philadelphia I think that *baileyi* may conveniently be recognized as a subspecies, pending further information. The carinate form is doubtless the older, the rounded *idahoensis* being a more evolved and later race which passes through the carinate phase in youth.

In a specimen from Cottonwood Tree Creek the central and lateral teeth have well developed side cutting points as in *O. idahoensis*. Genitalia (Fig. 315: 11) as in that species. Length of penis 10 mm., of internally ribbed part 4 mm.; epiphallus 3.5 mm.; penial retractor 6.5 mm.; talon 1.5 mm.; diameter shell 15 mm.

Oreohelix elrodi (Pilsbry)

Fig. 302.

Pyramidula elrodi Pilsbry, 1900, Nautilus, 14: 40; 1902, Nautilus, 16: 62.—Stearns, 1902, Nautilus, 16: 61, 83.—Elrod, 1901, Rocky Mountain Magazine, 2: 695, figs.; 1902, Nautilus, 15: 88, 130; 16: 109, text-fig.; Bull. Univ. Montana, no. 10, Biol. Ser., no. 3, p. 115, 116, pl. 32 (locality, station and habits).

Oreohelix elrodi Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 270, footnote, pl. 19, fig. 2 (genitalia).—Henderson, 1918, Proc. Malac. Soc. Lond., 13: 24; 1924, Univ. Colo. Stud., 13: 128, pl. 3, fig. 1.

The shell is strongly depressed, biconvex, acutely carinate, with open umbilicus contained about 4 times in the diameter; pale vinaceous fawn color to nearly white (under a fugacious light brownish cuticle which is lost in all adult shells seen). Spire low conoidal, often much depressed. Embryonic shell of $2\frac{1}{3}$ to $2\frac{2}{3}$ whorls, the first smooth, the rest varying from

Fig. 302. *Oreohelix elrodi*.

unevenly striate to finely costellate. Later whorls are coarsely sculptured with rude, unequal, retractive ribs, usually narrower than their intervals, which are densely and finely striate spirally. On the second whorl an impression appears above the suture, continuing to the last, the suture being filled by the peripheral keel. The last whorl descends shortly in front. Aperture angular at termination of the keel. Peristome blunt, the parietal callus thick in old shells.

Height 10 mm., diameter 21 mm.; 5 whorls. Type.

Height 8.8 mm., diameter 21.2 mm.

Height 13.3 mm., diameter 28 mm.; $5\frac{1}{2}$ whorls.

MONTANA: Shores of McDonald Lake, abundant on northern shore, Mission Mountains, at from 3000 feet up the mountain to 7500 feet (Morton J. Elrod), Type 78740 A.N.S.P.

Elrod's mountain snail is strikingly unlike other landshells of the region, but it has a deceptive resemblance to the Californian *Monadenia circumcarinata* (Stearns). It may have been derived from such a snail as the carinate form of *O. idahoensis*, but the dentition is quite different. It is found in rock crevices and on exposed talus, not among bushes.

Some shells show a narrow and ill-defined band of pale brown below the keel and another revolving above at the outer third of the last whorl.

The penis is like that of *O. strigosa* the lower third having thick walls, densely plicate within; above that the walls are thinner, densely lined with long papillae, and in the upper third there are several low fleshy ridges, also papillose. There is an extremely short, conic papilla in the apex. The vas deferens enters the epiphallus centrally. The vagina is much dilated and muscular above (Fig. 284: 2).

There are 27.1.27 teeth, the central and laterals with no side cusps or cutting points; an ectocone appearing about the 10th tooth. It is well developed and simple on the marginals.

Oreohelix hendersoni Pilsbry

Fig. 303 b.

Oreohelix hendersoni Pilsbry, 1912, Nautilus, 26: 29; 1916, Proc. Acad. Nat. Sci. Phila., pp. 344, fig. 1b (teeth); 346, pl. 20, fig. 7 (genitalia).—Henderson, 1912, Nautilus, 26: 11; 1924, Univ. Colo. Stud., 13: 122, pl. 3, fig. 4.

The shell is depressed, with about the shape of *O. strigosa depressa*, the last whorl angular in front, becoming rounded in the last half turn, shortly descending in front, the umbilicus contained about $4\frac{1}{2}$ times in the diameter. First $2\frac{1}{2}$ whorls rusty brown; the ground color then becomes very pale brown,

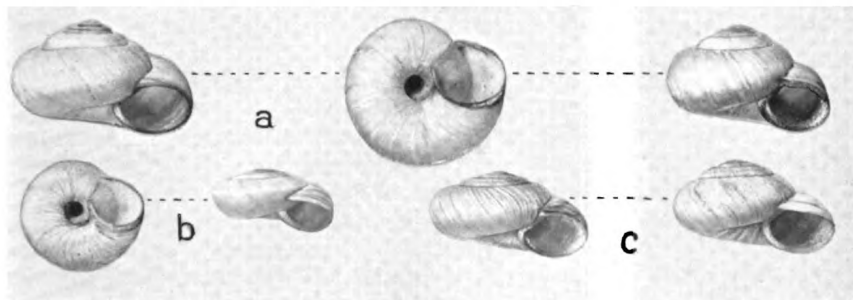


Fig. 303. a, *Oreohelix hendersoni dakani*. b, *O. hendersoni*, type. c, intermediate form from near Rifle Gap.

and a narrow darker band midway between sutures appears on the third whorl, usually not continuing upon the last whorl, which is cream tinted (or opaque white by loss of cuticle in old shells), with indistinct streaks of faint brown or gray. Embryonic whorls about $2\frac{1}{3}$, the first half turn smooth, the rest having close, fine thread-like radial striae, which on the second whorl are crimped by coarser spirals; this sculpture stopping abruptly at the end of the embryonic stage. Later whorls have weak, irregular wrinkles of growth, which are indistinctly cut by very weakly impressed spiral lines (often almost or wholly obsolete). The strongly oblique aperture is rounded; parietal callus light.

Height 8.7 mm., diameter 16.4 mm.; $4\frac{3}{4}$ whorls.

COLORADO: North bank of Little Thompson Creek, 10 miles northwest of Longmont, Boulder County, on a talus slope of Niobrara limestone (Albert Dakan), Type and paratypes 104732 A.N.S.P.

The embryonic sculpture is like that of Glenwood Springs forms of *O. haydeni*, and in genitalia it does not differ from them; but *O. h. mixta*, which alone approaches *hendersoni* in shell form, is less depressed and has decidedly rougher surface. As in most of the *haydeni* series, color bands have almost disappeared.

The length of the penis is three-fourths of the diameter of the shell. Its internally costate segment is one-third the total length, and the distal papillose portion is somewhat flattened. Length of the epiphallus is con-

tained $2\frac{3}{4}$ times in that of the penis. The lower third of the spermatheca duct is large, then abruptly contracting. Length of penis 12 mm., of its costate lower portion 4; epiphallus 4.5; penial retractor 4; vagina 4; spermatheca and duct 10.5; diameter of shell 16 mm.

The three areas of the radula appear distinct, in a slightly enlarged view, the rows of marginal teeth being oblique. In most *Oreohelices* the areas are not well marked. The central tooth and laterals have rudimentary side cusps. Formula 16.12.1.12.16. By the forms of the individual teeth and the more distinct differentiation of areas in the radula, this species differs from the *strigosa* series.

(Named for Professor Junius Henderson, ardent investigator of mountain snails.)

***Oreohelix hendersoni dakani* Henderson**

Fig. 303 a.

Oreohelix hendersoni dakani J. Henderson, 1913, *Nautilus*, 27: 38.—Pilsbry, 1917, *Proc. Acad. Nat. Sci. Phila.*, p. 44, fig. 2 (genitalia).—Henderson & Daniels, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 334; 1917, p. 65.

Oreohelix hendersoni form *dakani* Henderson, 1924, *Univ. Colo. Stud.*, 13: 123, pl. 3, fig. 5.

“Distinguished from typical *hendersoni* by the following shell characters: spire much more elevated; peripheral angulation of the earlier whorls disappearing on the penultimate whorl, so that scarcely a trace of it is observable in front of the aperture on the last whorl of the adult shell; shell larger, whorls higher in proportion to width, producing a corresponding difference in shape of aperture. Alt. 14, diameter 22, whorls $5\frac{1}{2}$.” (Henderson.)

Height 14.4 mm., diameter 21.2 mm. Topotype.

Height 15 mm., diameter 23.4 mm. Topotype.

COLORADO: Northwest corner of Peebles ranch, two miles up Elk Creek from Newcastle; found in great abundance (Albert Dakan), Type in Univ. of Colo. Mus., cotypes 112872 A.N.S.P. 9 miles east of Meeker, Rio Blanco County, and East Rifle Creek, Garfield County (Junius Henderson).

The shell is nearly pure white with a small light brown apical area and a nearly vanishing band on the third whorl; very rarely a narrow, interrupted band revolves below the periphery. The edge of the peristome is dusky and the parietal callus is rather thick. Umbilicus contained $4\frac{1}{4}$ to $4\frac{3}{4}$ times in the diameter.

Henderson found that a mile or two east of Rifle Gap, only a few miles from the type locality of *dakani*, there is a fine colony with depressed shells shaped like *hendersoni* but equal to *dakani* in diameter. Specimens measure from 11.2 x 21 mm. to 13.4 x 24.2 mm. The periphery is subangular in front in some, rounded in other examples (Fig. 303 c). Between this and the *dakani* locality is a colony in which intergrades are found. Henderson thinks that “In view of the variation in the altitude of spire in the various species of this genus the subspecific rank of *dakani* is exceedingly doubtful.”

In a lot from a hill west of the Fish Hatchery on the north side of Grand River, near Glenwood Springs, the shell has a buff to pale brownish wash,

with brownish streaks and sometimes some translucent brown to gray mottling. The sculpture is more pronounced than in typical *dakani*.

Specimens from the type locality were dissected, Figure 305 b. The genitalia are similar to *hendersoni* but with a longer penis. It is unlike *O. rugosa*, which resembles *O. cooperi* closely in soft anatomy. The distal part of the penis of *dakani* has a trilobed transverse section. Length of penis 21 mm.; of ribbed lower part 7.3 mm.; epiphallus 6.3 mm.; vagina 6 mm.

***Oreohelix haydeni* (Gabb)**

Fig. 304 a.

Helix haydeni Gabb, 1869, Amer. Journ. Conch., 5: 24, pl. 8, fig. 1.

Oreohelix haydeni (Gabb), Henderson, 1924, Univ. Colo. Stud., 13: 123, pl. 2, fig. 7.—
E. G. Berry, 1932, Nautilus, 46: 56, pl. 3.

The depressed shell has a low-conoidal spire and an umbilicus contained 5 times in the diameter; rather solid; white (bleached). The whorls are convex, the first very finely striate, the next with 2 or 3 spiral threads; the later whorls have coarse, irregular striae of growth and strong, raised spiral cords on both upper surface and base, one at the periphery a trifle more prominent; in the type there are 3 cords above and 6 below the periphery; between some of them weak spiral lines appear. The last whorl descends moderately in front. The aperture is slightly wider than high; peristome blunt, crenulated by the spirals, the margins joined by a thick parietal callus.

Height 12.2 mm., diameter 20.7 mm.; 5½ whorls. Type.

UTAH: Weber Canyon, Wasatch Mountains (F. V. Hayden), Type and 5 paratypes 28048 A.N.S.P. Dry Creek Canyon, the first tributary to Weber Canyon south of the cement plant at Devil's Slide (Elmer G. Berry, 1930).

The typical form of *haydeni* is characterized by having the spiral ribs strongly developed both above and below, the peripheral rib but little more prominent than the rest. In the type lot of 6, 5 have 10 and one has 11 spiral ribs on the last whorl. Elmer G. Berry, who collected several hundred shells at apparently the type locality, found the number of ribs to vary from 8 to 13, but those with fewer than 10 have some threads in place of ribs. The shape was found to vary from rather high-spined to very flat, depressed forms. "The color of living specimens is a dull ashy gray." He gives measurements varying from 11.6 x 17.7 mm., 5 whorls, to 16.5 x 22.3 mm., 6 whorls. He found the species very narrowly localized in this one tributary canyon, where they were found "under the dead leaves of *Amelanchier alnifolia* Nutt., near the base of the shrub."

For more than sixty years the typical form of *O. haydeni* was known only by the original lot of "dead" shells. The first living specimens were taken by Mr. E. G. Berry, to whom we owe knowledge of the exact locality. It seems to be surrounded by colonies of less strongly sculptured races (*hybrida*, *gabbiana*?).

There seems some ground for the hypothesis that the weakly sculptured forms, such as *gabbiana*, *utahensis*, *hybrida* and *mixta*, which still exist in

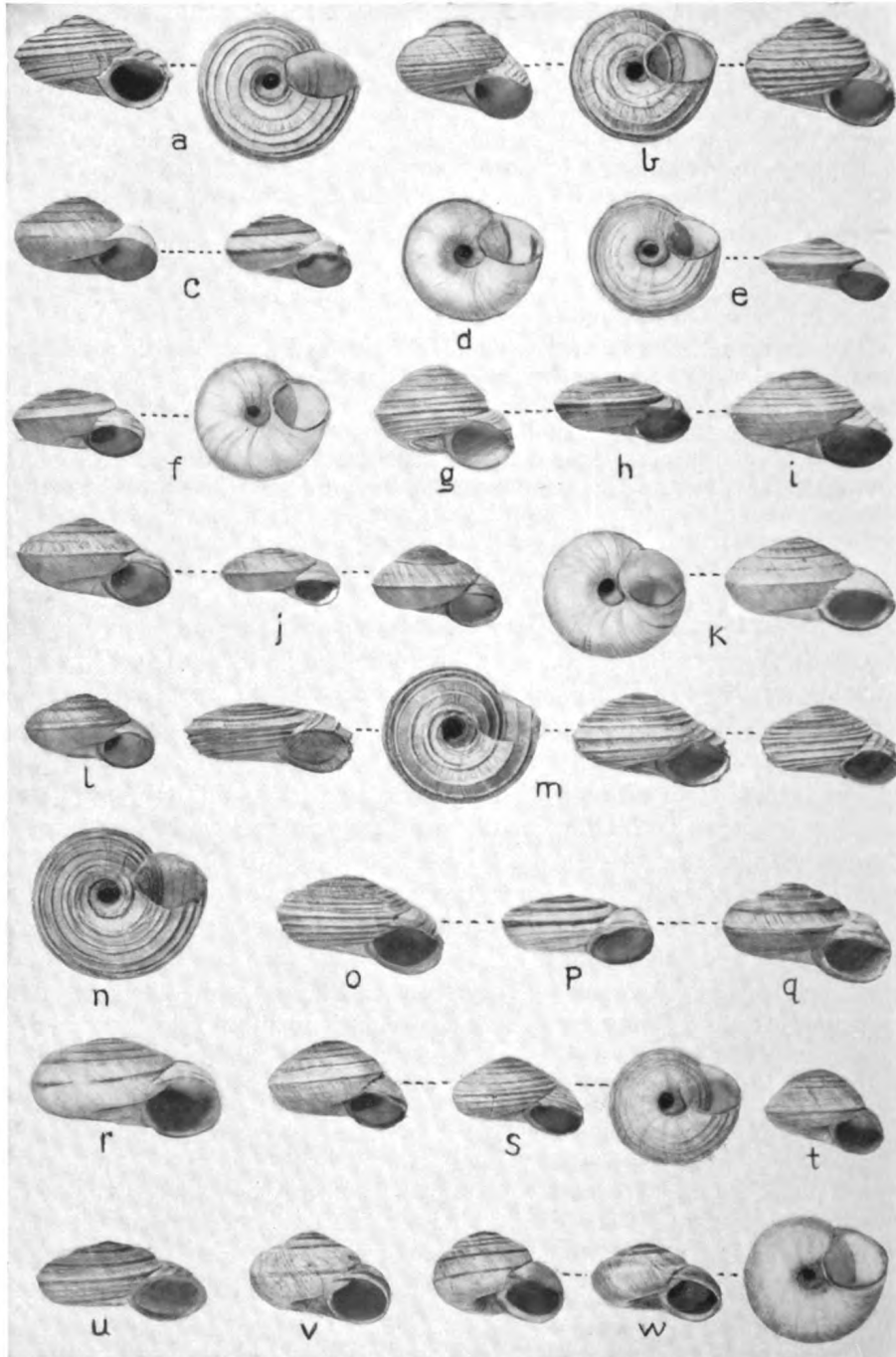


Fig. 304. See legend at bottom of p. 465.

the Colorado, Utah and Montana areas, are similar to the primitive form of the species, which attained a wide distribution; then in several parts of its range strongly lirate forms arose independently—typical *haydeni*, *oquirrhensis*, *corrugata*, *betheli* and *hesperia*.

We owe our knowledge of the Utah races, after Hemphill's early discoveries, mainly to the papers and collections of Henderson and Daniels. The Idaho forms have been collected by H. Burrington Baker.

Explorations in Colorado, Utah, Montana and Idaho brought to light numerous local forms of *O. haydeni* which have been named as subspecies. Most of them are highly variable. Their territory has been carefully worked only in widely separated places. It is to be anticipated that some subspecific distinctions now drawn with difficulty may in the future prove subject to change; yet the distribution of the *haydeni* group of forms will probably remain conspicuously discontinuous, and our present knowledge of the subject seems most easily expressed by recognition of the numerous named races.

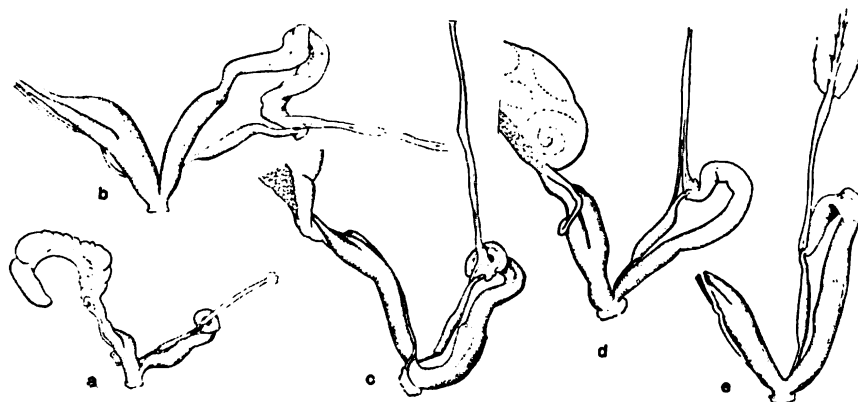


Fig. 305. a, *Oreohelix tenuistrata*. b, *O. hendersoni dakani*. c, *O. haydeni mixta*. d, *O. haydeni gabbiana*. e, *O. haydeni betheli*.

I have examined and figured the genitalia of seven of the subordinate races, which agree closely, and do not differ materially from those of *O. strigosa*. The internally ribbed anterior part of the penis is less than half of the total length, usually one-fourth to one-third. The internally granular distal part collapses flat or somewhat trefoil in section. Lengths in mm. of the male end organs follow:

Fig. 304. a, *O. haydeni*, type. b, *O. h. corrugata*. c, *O. h. hybrida*, near Logan?. d, second gulch south of Logan Canyon. e, f, Devil's Slide. g, h, i, *O. h. oquirrhensis*, Oquirrh Mts., Hemphill. j, *O. h. oquirrhensis* f. *gabbiana*, Oquirrh Mts., Hemphill. k, Oquirrh Mts., southeast of Garfield. l, *O. h. oquirrhensis* f. *utahensis*, type. m, n, o, p, q, *O. h. betheli*. r, hybrid with *O. s. depressa*?. s, t, *O. h. alta*. u, *O. h. oquirrhensis*, Byrne Resort, Montana. v, *O. h. mixta*, type. w, *O. h. mixta*.

	<i>betheli</i>	<i>mixta</i>		<i>gabbiana</i>	<i>corrugata</i>	<i>hybrida</i>	
Penis	19	18	15.5	16	16.5	16	12
Ribbed part	6	6.8	5	6	5	4	5.3
Epiphallus	7.5	6.3	5.3	5.5	5	4	4.7
P. retractor	18	18	10	11	7	5	...
Diam. shell	22.5	18.3	15	20	18	19	13
Figure 305	e	c		d			

The radula of typical *O. haydeni* has not been examined. *O. h. oqu-irrhensis* f. *gabbiana* from Devil's Slide, Utah, (Fig. 306 d) has 30.130 teeth, the central and laterals with well developed but short ectoconal cutting edges. Those of *O. h. betheli* are similar. *O. h. corrugata* (Fig. 306 f) has conspicuously longer cutting edges and small mesocone on the centrals; 9 laterals. In the form from John Day Creek, Idaho, (Fig. 306 e), with

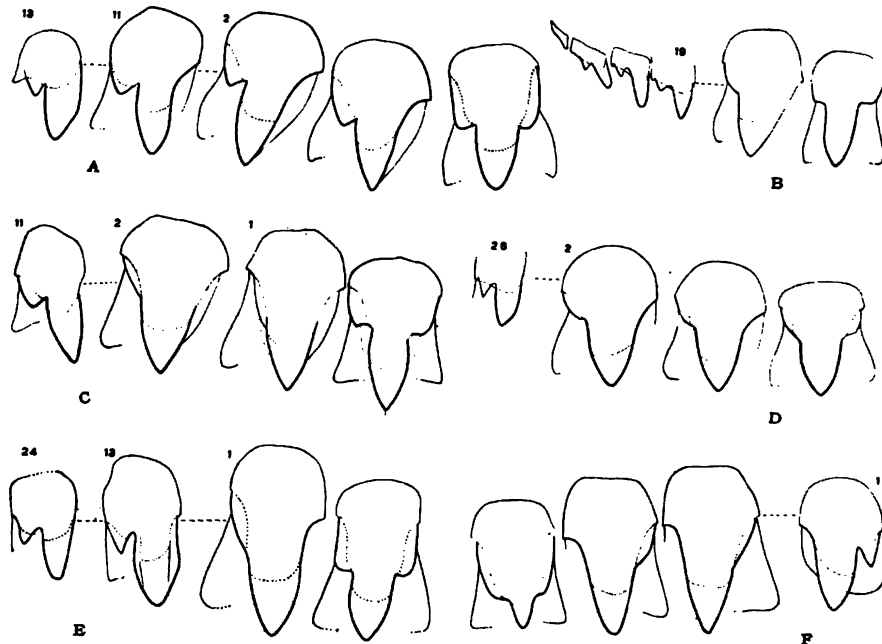


Fig. 306. Teeth of: A, *Oreohelix idahoensis*. B, *O. haydeni hesperia*, Wet Creek. C, *O. haydeni perplexa*. D, *O. haydeni* form *gabbiana*, Devil's Slide. E, *O. haydeni hesperia*, John Day Creek. F, *O. haydeni corrugata*.

29.1.29 teeth, the cutting edges are strongly developed, wider, approaching the form of cusps. They are quite low on some laterals, larger on others. The outer laterals and transition teeth have overhanging lateral cutting edges. The transition to the bicuspid marginals is very gradual. The smaller form from Wet Creek, Idaho (Fig. 306 b) has 27.1.27 teeth, similar to the preceding but the wide ectoconal cutting edges are shorter. Except by having more numerous teeth, these Idaho *haydeni* resemble *O. idahoensis* closely.

***Oreohelix haydeni corrugata* Henderson & Daniels**

Fig. 304 b.

Oreohelix haydeni corrugata Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 337, pl. 17, fig. 1.—Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 347, pl. 21, fig. 4 (genitalia).

"Shell rather globose; spire elevated, one or two examples tabulate; whorls 5 to 5½, ample, convex, last one scarcely carinated at the periphery on elevated specimens; spiral sculpture strong, closely resembling that of typical *haydeni* and the subspecies *betheli*, consisting of an average of about 13 strong, sharp ridges (in a few examples scarcely stronger than the riblets), the interspaces much broader and occupied by from 3 to 6 spiral riblets or threads; numerous crowded, irregular, transverse riblets and growth lines roughen the shell and give to the spiral ridges and riblets a knobbed appearance under a lens; color pinkish-white to white, first 2 or 3 whorls dark horn-color. Umbilicus deep and very narrow, almost cylindrical, exhibiting whorls to the apex [and contained fully 7 times in the diameter]." (Henderson & Daniels.)

Height 14 mm., diameter 18 mm. Type, Univ. Colo. Mus.

Height 14 mm., diameter 19.7 mm. Cotype, A.N.S.P.

UTAH: Cache County, near the Idaho line, on a small mountain of Paleozoic limestone, nearly isolated from the main chain, southeast of Webster Station, under the shrub *Kunzia tridentata* and coarse-leaved herbaceous plants, and in a rock slide (Henderson and Daniels), Type in Univ. of Colo. Mus., cotype and paratypes 112854 A.N.S.P. ?Fillmore Canyon (Chamberlin and Jones, 1929, Bull. Univ. Utah, 19: 69, fig. 22).

"The shell is more globose, the whorls of greater caliber and the umbilicus much narrower than in typical *haydeni*, and typical *betheli* is even more depressed and widely umbilicated" (Henderson & Daniels). This seems to be a rather distinct race, both by the shell and the teeth.

(*Corrugata*, wrinkled up.)

Oreohelix haydeni hybrida (Hemphill)

Fig. 304 c-f.

Patula strigosa var. *hybrida* Hemphill, 1890, Nautilus, 4: 17.

Oreohelix haydeni hybrida (Hemph.), Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 335, pl. 15, fig. 4; 1917, pp. 57-72.—Pilsbry, 1917, Proc. Acad. Nat. Sci. Phila., p. 42, fig. 1, a, c (anatomy).—Henderson, 1924, Univ. Colo. Stud., 13: 125, pl. 2, fig. 6.

[*Patula strigosa*?] var. *albida* Hemphill on labels, Henderson & Daniels, 1917, Proc. Acad. Nat. Sci. Phila., p. 66, as synonym of *hybrida*.

"Shell umbilicated, depressed, white, spire horn-color, surface of the shell covered with fine oblique striae, and widely separated revolving raised lines; whorls 5, flattened above, rounded beneath, the last falling in front, and striped with two faint chestnut bands, suture well impressed; umbilicus large, showing nearly all the volutions; aperture nearly circular; lip simple, thickened, its terminations approaching and joined by a thin callus. Height ¾ inch, diameter ¾ inch, lesser ⅝ inch." (Hemphill.)

Height 11.2 mm., diameter 18.7 mm.; 5 whorls. Paratype.

Height 9.7 mm., diameter 14.4 mm.; 4½ whorls.

IDAHO: St. Charles Canyon west of St. Charles, Bear County (Henderson and Daniels).

UTAH: Near Logan, Cache County (Hemphill), type locality. Just within mouth of Logan Canyon on the west slope of the mountain, and in

short ravines south of the canyon; gulches northeast and southeast of Deweyville, Boxelder County; mouth of Garden Canyon west of Garden City; around Devil's Slide in numerous places, Morgan County, in the Weber River valley (Henderson & Daniels).

Typical *hybrida* has the last whorl full and well rounded with a very weakly sketched peripheral angle, but in the typical lot this angle varies from hardly noticeable to moderately distinct. The sculpture is of fine close unequal growth wrinkles crossed by widely spaced but very low spiral cords, crenulated by the striae, and, chiefly on the base, with finer spirals in the intervals, marked by crimping of the striae. The nearly white shell with pale brown spire may have two distinct but narrow dark bands or none. Umbilicus contained $5\frac{1}{2}$ to 6 times in the diameter. In a lot from the second gulch south of Logan Canyon the diameter runs from 17 to 20 mm.

Specimens from Deweyville have fine, nearly effaced spirals but are deficient in the larger spaced cords. Those from Garden City have the sculpture well developed, periphery strongly angular. At St. Charles Canyon, Idaho, the size is small, 13-14 mm., sculpture typical or subobsolete.

At Devil's Slide, farther south in the Wasatch range, "the stations are not far apart and in the same canyon, so that it may almost be considered one large colony." Shells from the extremes of the colony seem referable to *hybrida*. At Henderson and Daniels' station 48, on both sides of and above the slide, south side of the canyon, under *Balsamorhiza* on steep limestone slopes, practically typical *hybrida*, the spiral sculpture distinct. At their station 54, about a mile down the canyon from the railroad tunnel, were found glossy shells, white with gray radial streaks and weak bands or none; peripheral angle moderate; spirals very weak or absent, and the umbilicus often wider, $4\frac{1}{2}$ to $6\frac{1}{2}$ times in the diameter. At Henderson and Daniels station 49, west slope of the gulch entering canyon from the north below the Devil's Slide depot, the shells are intermediate between *hybrida* and the following lots, having a weak to strong angle and distinct spiral sculpture. At stations 51, 52, 53, north and west of the railroad tunnel, the form is lenticular, strongly keeled, flattened or concave on both sides of the keel, with spirals varying from quite strong (Fig. 304 e) to very weakly sketched (Fig. 304 f); bands rarely well marked, more often absent. These lenticular shells appear indistinguishable from the Oquirrh form *gabbiana*, to which Henderson referred them with some hesitation (1917, p. 72); but there are also transitions to *hybrida*, and it seems likely that this whole Devil's Slide series is genetically related, and parallel to the *oquirrhensis-gabbiana* series in the Oquirrh range. The true *haydeni* occurs in the same neighborhood. Chamberlin and Jones (1929, p. 70) report *gabbiana* from Ogden Canyon below power dam, half a mile below Pine View Lodge, and

from Big Cottonwood Canyon. It is evident that the whole Weber Canyon and the Wasatch northward should be overhauled—a work of some weeks—as definite conclusions cannot be drawn from the small area which has been worked.

Specimens from Collinston, Utah (about five miles north of Deweyville) and Logan, Utah, were labelled “var. *albida*” by Hemphill in his collection, according to Henderson and Daniels, who state that it is a smooth form of *hybrida*, grading so completely into typical *hybrida* that they cannot consider it entitled to a separate name, even as a “form”. They collected the same form at the mouth of the first gulch northeast of Deweyville.

***Oreohelix haydeni oquirrhensis* (Hemphill)**

Fig. 304 g, h, i.

Patula strigosa [var.] *haydeni* W. G. Binney, 1878, Terr. Moll., 5: 159, pl. 16, fig. B (teeth), C (jaw).¹

[*Patula strigosa*] var. *oquirrhensis* Hemphill in Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zool., 13: 30; 34, pl. 2, fig. 12.

Oreohelix haydeni oquirrhensis Hemph., Pilsbry, 1916, Nautilus, 29: 141.—Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., pp. 318-337; 1917, Proc. Acad. Nat. Sci. Phila., p. 77.—Henderson, 1924, Univ. Colo. Stud., 13: 124, pl. 2, figs. 1, 5.—Chamberlin & Jones, 1929, Bull. Univ. Utah, 19: 69.

[*Patula strigosa*] var. *gabbiana* Hemphill, in Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zool., 13: 30; Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zool., 13: 34, pl. 2, fig. 9.

Oreohelix haydeni gabbiana Hemph., Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 347, pl. 21, fig. 1 (genitalia).—Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 323, pl. 16, fig. 3.

[*Patula strigosa*] var. *utahensis* Hemphill, in Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zool., 13: 30; Binney, 1886, 2nd Suppl., Bull. Mus. Comp. Zool., 13: 33 (locality only; not the description or figure cited).

Oreohelix haydeni utahensis Hemph., Pilsbry, 1916, Nautilus, 29: 139.

The shell is faint cream-buff with brownish spire and sometimes two rather indistinct dark bands; it is similar to *O. haydeni* but with the periphery more conspicuously carinate, the spiral cords not so strong and generally irregular in size and spacing, and the umbilicus often narrower, contained about $5\frac{1}{2}$ ($4\frac{3}{4}$ to 6) times in the diameter. Paratypes measure:

13 x 21.7 mm., 5 whorls.	10 x 15.7 mm., 5 whorls.
13.5 x 20.7 mm., $5\frac{1}{2}$ whorls.	9 x 18.3 mm., 5 whorls.

UTAH: Oquirrh Mountains (Hemphill). West side of Oquirrh Mts. southwest of Garfield, under bushes, on limestone, and on south side of a gulch south of preceding, nearly east of Morris Station, under shrubbery (Henderson and Daniels). Skull Valley, Tooele County (Chamberlin and Jones).

MONTANA: Byrne Resort, Hell Gate River 34 miles above Missoula (Henderson and Rodeck).

Binney's figure 12 may be accepted as representing the type. It is a rather small, high specimen of about 17.7 mm. diameter. Our Figures 304 g,

¹ Binney confused the Wasatch and the Oquirrh ranges in his account of “*haydeni*” and of his fig. 63 (*newcombi*). They were not “found by Mr. Hemphill in the same locality”.

h, i, represent large and small paratypes. Typically the spirals are rather strong, but they vary to as weak as in *O. hemphilli*. Mr. Hemphill gave names to the several stages of sculpture development, but it seems impossible to make any definite division of the series of about 100 before me, though selected examples are more unlike than many accepted species. Junius Henderson who collected in the Oquirrh range, writes: "Hemphill recorded *hemphilli* and *haydeni*, and described *oquirrhensis*, *utahensis* and *gabbiana*, all from the west side of the Oquirrh mountains, but his material from there all represents one protean subspecies of *haydeni*. It may be by some considered convenient to retain the names *utahensis* and *gabbiana*, but if so they should not be given subspecific rank."

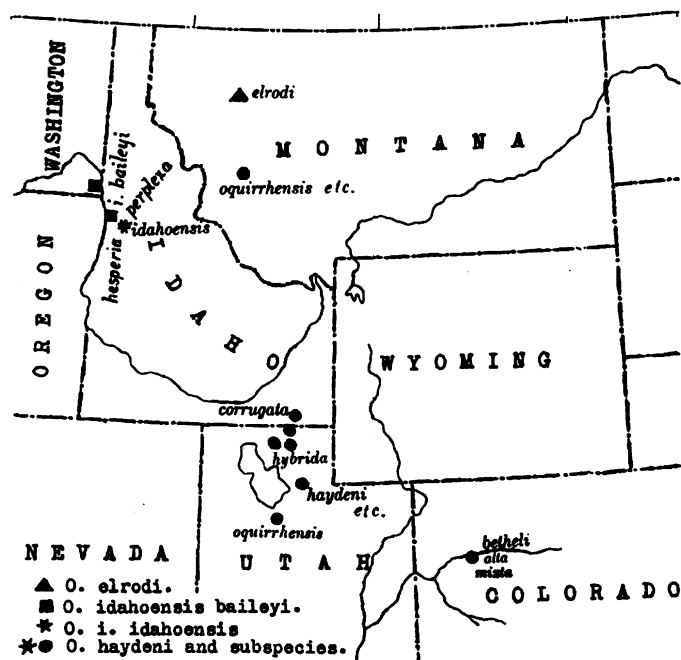


Fig. 307. Distribution of *Oreohelix elrodi*, *O. idahoensis* and *O. haydeni* with its subspecies.

Form *gabbiana* Hemphill (Figs. 304 j, k), "is a coarse, rough *haydeni* with the revolving ribs nearly or quite obsolete" (Hemphill). "The ends of the peristome are nearly approached and often continuous" (Binney). The spirals resemble those of *O. hemphilli*; in some examples they are stronger, in others they practically disappear. The keel may become merely an angle on the last whorl, as in Fig. 304 k, from east of Morris Station, occurring with normally carinate shells.

Shells not distinguishable from *gabbiana* are found in the Wasatch range also. See under *O. h. hybrida*.

Form *utahensis* Hemphill. (Fig. 304 l.) "This has the form of *hemphilli* but is destitute of the revolving ridges of *haydeni*" (Hemphill); but it is not separable from some specimens of *gabbiana*. This form and the preceding were fully discussed by Henderson and Daniels, 1917, pp. 77-81.

H. B. Baker took subfossil specimens referable to *utahensis* near Clinton's Cave, Lake Point, Tooele County, Utah, at 5000 feet, diameter 15 to 21 mm.; the peripheral angle distinct on the smaller shells, faint on the larger.

The radula of a specimen of the form referred to *gabbiana* from Devil's Slide is figured (Fig. 306 d). It has 30.1.30 teeth. Ectocones are represented by rather low cutting edges on the central and inner lateral teeth.

Montana shells collected at Byrne Resort, on Hell Gate River 34 miles above Missoula (Fig. 304 u) have been referred to *oquirrhensis* by Henderson. They have the umbilicus more ample within than Utah shells, being similar to the Idaho race; but the finely crenulated ribs are not so strong as in the latter, being about as in many *oquirrhensis*. They are well keeled, and more depressed than typical *oquirrhensis*. There are two weak brown bands. Two measure: 11 x 22 mm., and 8.6 x 19.4 mm. Genitalia as in Utah specimens.

As in the Oquirrh range the strongly sculptured race *oquirrhensis* is accompanied by colonies of more lenticular, nearly smooth shells (forms *gabbiana* and *utahensis*, Figs. 304 j, k, l, so also above the Byrne Resort about a mile above the *oquirrhensis* locality, Henderson & Rodeck found carinate shells of the *gabbiana* form, the surface smooth to the eye, but under the lens showing spaced spiral granulose lines, almost obsolete in some individuals. The embryonic whorls appear somewhat more convex than in *gabbiana*, and in one shell two spiral bands are conspicuous. Two measure: 9.1 x 18.5 mm., and 13.2 x 20.4 mm.; 5 whorls.

A single worn specimen of a peculiar snail from Gold Creek, between Drummond and Garrison, Montana, is contained in the University of Colorado Museum. It has weak spirals and a carinate periphery, and does not seem referable to any of the known races of *haydeni* or *hemphilli*. Found under shrubbery on a dry slope.

Vanatta (1921, *Nautilus*, 34: 141) recorded *O. h. oquirrhensis* from "The Narrows," Zion Canyon, in southern Utah, collected by Louis H. Bregy. In 1925, I explored that locality for it, and subsequently the canyon has been searched for three summers by A. M. Woodbury (1930, *Nautilus*, 43: 56) without success. An error in Mr. Bregy's label seems indicated.

***Oreohelix haydeni bruneri* (Ancy)**

Helix bruneri Ancy, 1881, *Le Naturaliste*, 1: 468 (3me année).

Patula strigosa Gould var. *bruneri* Ancy, 1887, *The Conchologist's Exchange*, 2: 64.

"Shell dirty white, deeply and widely umbilicate, convex above and below, strongly depressed. Spire very obtuse, very broadly subconic.

Whorls 5, strongly convex, coarsely sculptured with growth striae which are not very regular and are crenulated by spiral ribs, sometimes subinterrupted, and above, especially on the first whorl, are scarcely distinct. Suture margined, impressed, subplanulate. The last whorl has a projecting but not acute keel at the periphery and about 8 spiral ribs on the lower surface. Aperture submarginate-circular, oblique; peristome simple, acute, the margins joined by a thin callus. Shell of a dirty white color with two brown bands at the periphery. Diameter maj. 15.5, min. 14, alt. 7 mm." (Ancey.)

MONTANA: (L. Bruner).

"This species, of the group of *Helix* (*Anguispira*) *cooperi* W. G. B., seems to me really distinct by the very evident but not at all acute carina of the last whorl, the spiral ribs with which it is provided, especially beneath, and by the much more depressed shape, equally convex above and below. The umbilicus appears wider in proportion. *Helix haydeni* Gabb differs by the more strongly marked spiral ribs, quite distinct on both sides, its more acute carina and smaller umbilicus. *H. bruneri* has nearly the same differences from *H. hemphilli* as from *H. cooperi*. Except for the spiral ribs, this shell shows the greatest similarity of form with *H. (Xerophila) filimargo* of the Crimea, the umbilicus and the carina are also nearly identical.

"This shell [*bruneri*] does not seem to me identical with the form *oquirrhensis* Hemphill, as suggested by Mr. Binney himself. It is much more flattened and the umbilicus is wider. The spiral ribs are also more obsolete and interrupted." (Ancey.)

W. G. Binney (1885, Man. Amer. Land Sh., p. 165) placed it in the synonymy of "*Patula*" *strigosa*. On a later page (168) he remarked of "*Patula*" *hemphilli* that "It certainly gradually runs into *strigosa*, forms with revolving striae being identical with varieties of *haydeni* and called *H. bruneri*, as proved to me by the type of that species kindly loaned me by Mr. Ancey." In his 2nd Supplement (1886, Bull. Mus. Comp. Zoöl., 13: 34) he stated that "*H. bruneri* Ancey is a synonym of *oquirrhensis*".

From this information, all that is available, it appears that *bruneri* is a Montana snail which, with a shell shaped like *O. hemphilli*, has weak sculpture of the *haydeni* type, and thus must be quite similar to some examples of *O. haydeni oquirrhensis* form *gabbiana*. It is tentatively allowed to stand separately, since a re-arrangement of the subspecific names will be necessary if *bruneri* is found to be identical with *gabbiana* or *oquirrhensis*. Junius Henderson states (1924, Univ. Colo. Stud., 13: 125) that Professor Bruner informed him that he had only a vague recollection of sending the shells to Ancey, and did not remember where they were collected. Positive identification does not seem possible until Ancey's type specimen can be found.

Oreohelix haydeni betheli Pilsbry & Cockerell

Fig. 304 m-g.

Oreohelix haydeni betheli Pilsbry & Cockerell, 1913, *Nautilus*, 26: 144.—Henderson, 1913, *Nautilus* 27: 39 (record from Lyons, Colo., is an error).—Henderson & Daniels, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 337, pl. 18, fig. 1.—Pilsbry, 1916, *Proc. Acad. Nat. Sci. Phila.*, pp. 343, 347, pl. 21, fig. 2 (anat.).—Henderson, 1924, *Univ. Colo. Stud.*, 13: 126, pl. 2, fig. 2.

Oreohelix haydeni gabbiana Henderson, 1912, *Nautilus*, 25: 134, station and habits.

The shell is typically much depressed with rather wide umbilicus, contained $4\frac{2}{3}$ times in diameter in the type (4 to 5 times in other examples). Cartridge-buff to nearly white, with the spire or early whorls dilute brown; with two faint and narrow bands in the type (from distinct to wanting in topotypes). Embryonic whorls delicately striate radially, the first convex, the second concave or grooved near the outer suture, and usually with several spiral lines. Last whorl carinate, typically with rude, irregular wrinkles of growth, and numerous strong spiral cords above and below; shortly, abruptly descending in front. Peristome thin, the parietal callus rather thick.

Height 10.2 mm., diameter 21.5 mm.; $4\frac{1}{2}$ whorls. Type.

Height 9 mm., diameter 22.8 mm.; $4\frac{1}{2}$ whorls.

Height 13 mm., diameter 22 mm.; 5 whorls.

Height 9.2 mm., diameter 20 mm.; $4\frac{3}{4}$ whorls.

COLORADO: Glenwood Springs, on steep bluffs north of the Grand River, under stones on the talus (E. Bethel, T. D. A. Cockerell, J. Henderson and others), Type and paratypes 94059 A.N.S.P.

This race differs from typical *haydeni* by being more depressed, more strongly carinate, with generally smaller and more numerous spiral cords, and by the shape of the second whorl, which is concave or grooved above the outer suture, while in *haydeni* it is convex throughout.

Specimens taken in the same place show great variation in the degree of depression, size of umbilicus and in sculpture. In the type locality, above the north end of the pipe-line bridge across the river, typically sculptured shells (Fig. 304 o) occur with others having typical embryonic whorls, but the spiral cords reduced to mere traces on the later whorls and the bands often distinct (Fig. 304 p, q). There are also transition series from typical *betheli* to a wholly *depressa*-like form in which the periphery is rounded and the surface smooth (Fig. 304 r), found by S. L. Schumo subfossil in the hillside above the pipe-line bridge.

On the north side of Grand River a mile or two above Glenwood Springs, Henderson collected a series varying in sculpture from *betheli* to *depressa*, the spiral ribs well developed in some, weak in other shells, or reduced to granulose threads at wide intervals; also many with only the even spiral lines usual in *depressa*, continuous or interrupted. These shells have the appearance of blends in a hybrid colony.

Oreohelix haydeni alta Pilsbry & Cockerell

Fig. 304 s, t.

[*Oreohelix haydeni*] *alta* Pilsbry, Pilsbry & Cockerell, 1913, *Nautilus*, 26: 144.

Oreohelix haydeni alta Pils., Henderson & Daniels, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 337, pl. 18, fig. 2.—Henderson, 1924, *Univ. Colo. Stud.*, 13: 126, pl. 2, fig. 4.

A race differing from *O. h. betheli* by the smaller shell, with weaker spiral ribs and higher spire; umbilicus contained about 5 (4 to 6) times in the diameter. Two narrow brown bands are present in some examples, but more frequently one or both are absent. Type measures 11.2 x 17.1 mm., 5½ whorls. Topotypes, 11.8 x 18 mm., and 11 x 17.4 mm., both with 5½ whorls.

COLORADO: Bluff facing the Grand River on the south side, east of Glenwood Springs, under bushes (E. Bethel), Type and paratypes 115082 A.N.S.P. Also collected by J. Henderson, Maxwell Smith and others.

"I have examined about 2000 specimens and found none with as coarse spiral sculpture as the average *betheli*, and none as depressed as many *betheli*, though the spiral sculpture and altitude of the spire vary, as usual in *Oreohelix*." "It is not a case of a few individuals in a colony differing from the typical form, but of a whole colony differing in three characters, though separated only by a narrow river. Typical *betheli* was found mostly about rock slides, while *alta* was under bushes not near any coarse rock slides." (Henderson.)

(*Altus*, tall.)

***Oreohelix haydeni mixta* Pilsbry**

Fig. 304 v, w.

Oreohelix haydeni gabbiana (in part), Henderson, 1912, *Nautilus*, 25: 134; *Univ. Colo. Stud.*, 9: 56.

Oreohelix haydeni mixta Pilsbry, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 348, 349, pl. 21, fig. 3; pl. 22, fig. 5 (genitalia); 1917, *Proc. Acad. Nat. Sci. Phila.*, p. 42, fig. 1b.—Henderson, 1924, *Univ. Colo. Stud.*, 13: 126.

The shell is whitish with the early whorls clay color (the last whorl sometimes having two narrow brown bands, the upper one ascending the spire). Sculpture of unequal, deeply cut growth-wrinkles, cut by spiral engraved lines, unequally developed, and on the base often grouped so as to leave spiral bands of long granules at intervals. Periphery angular or subangular or even rounded in front, becoming rounded on the rest of the last whorl. Embryonic shell having wavy radial ripples and very fine spiral striation (often obsolete); on the second whorl some coarse spirals, and with the peripheral carina strongly pinched out.

Height 12.3 mm., diameter 18.2 mm.; 5½ whorls.

Height 10.8 mm., diameter 21.2 mm.; 5½ whorls.

COLORADO: Glenwood Springs, south of the Grand River, very abundant on a mountain directly above the *alta* station, well up towards the top and in a ravine a few hundred yards to the south; thence in less abundance southward along the edge of town (Junius Henderson), Type and paratypes 94058 A.N.S.P. (E. Bethel.)

This race resembles *O. haydeni hybrida* in shape. It varies in degree of depression, two from one lot measuring 10.2 x 17 mm., and 12.3 x 17.3 mm. The periphery is sometimes keeled in front and angular to the aperture, or sometimes the angle scarcely reaches to the last whorl, which is rounded. The umbilicus is contained about 6 times in the diameter in

the type, but it may be either wider or narrower. Two bands are sometimes present.

Junius Henderson has shown that the locality given in the original description (from information supplied by Prof. Bethel) is erroneous; he could find no such shell in the place assigned, or anywhere on the north side of the river. Seven lots seen, collected by Professor Henderson and by Maxwell Smith, are from south of the river east of the town.

(*Mixtus*, confused, mixed.)

Oreohelix haydeni hesperia new subspecies

Fig. 308.

The shell invariably has the spiral ribs and the peripheral keel very strongly developed, with numerous interstitial spiral striae and weak wrinkles of growth; umbilicus wide, contained about 4 ($3\frac{2}{3}$ to $4\frac{1}{3}$) times in the diameter and large within, as in *O. h. betheli*.

Height 12.2 mm., diameter 25 mm.; h/d index 48.80.

Height 13 mm., diameter 20.6 mm.; h/d index 63.10.

Height 11 mm., diameter 22.2 mm.; h/d index 49.54.

Height 11.7 mm., diameter 18.8 mm.

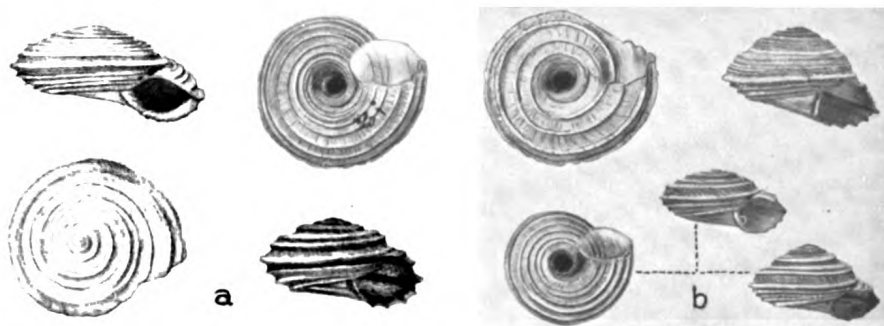


Fig. 308. *Oreohelix haydeni hesperia*: a, John Day Creek; b, Wet Creek.

IDAHO: North-facing slide of blue limestone $2\frac{1}{2}$ miles up John Day Creek, Type 174022 A.N.S.P.; $\frac{1}{2}$ mile up the middle fork of same creek in humid, north-facing slide of white marble. Small form from south-facing slide of soft limestone about 2 miles up Wet Creek (H. Burrington Baker).

The localities are east of the Salmon River a few miles north of Lucile. Many specimens of this race do not appear distinguishable from the most strongly sculptured shells of *O. h. betheli*. In both the umbilicus is more capacious within than it is in *haydeni* or *oquirrhensis*. The shells from John Day Creek are all large. Those from the lower locality are from light buff to nearly white with dull pinkish-cinnamon inner whorls; two of about 150 have a dark band below the periphery. Those from the middle fork are very boldly sculptured and have two bands.

In a long series from Wet Creek the diameter is smaller, 8.2 x 15.8 mm. to 9 x 18.1 mm., the color fawn, vinaceous fawn or lighter, paler on the base, the ribs whitish. There are usually 5 (4 to 8) ribs on the base, 2 (1 to 3) on the upper surface of the last whorl.

Genitalia like other forms of *haydeni*, and not materially unlike *O. strigosa*. The anterior, internally ribbed part of the penis is one-third the total length and has four ribs within. Length penis 15 mm., ribbed part 5 mm., epiphallus 3 mm., vagina 5.5 mm. A preparation of the Wet Creek form differs only by smaller size, ribs in the penis low, more unequal. Length of penis 9.5 mm., ribbed part 3.7 mm. diameter of shell 17 mm.

The radula of an individual from John Day Creek (Fig. 306 E) has 29.1.29 teeth. Centrals and laterals with ectocones which may be rather well developed or reduced to wide cutting edges. A radula of the smaller form from Wet Creek (Fig. 306 B) has 27.1.27 teeth.

(*Εσπέρια, of the evening, hence western.)

Oreohelix haydeni perplexa new subspecies

Fig. 309.

The shell is low conic with terraced spire and obtuse summit, the umbilicus contained 5 (4 to 5½) times in the diameter; pale pinkish cinnamon,



Fig. 309. *Oreohelix haydeni perplexa*.

becoming darker on the inner whorls, lighter on the base, the ribs whitish, or sometimes buff throughout. A brown subperipheral band and one above are present in some examples, but the upper one or both are often lacking. There are about 2 convex embryonic whorls, the first nearly smooth, the next finely striate radially; later whorls convex, usually somewhat angular in the middle, roughly sculptured with coarse, irregular retractive riblets and spiral cords, a median one stronger; last whorl with lattice sculpture of many (usually 8 to 10) spiral cords and fine interstitial spiral striae, a carinate (or angular) periphery and oblique riblets; it descends a little in front. The aperture is nearly circular, the parietal callus short.

Height 11.4 mm., diameter 15.7 mm.; h/d index 72.61; 5½ whorls. Type.

Height 10.2 mm., diameter 15.8 mm.; h/d index 64.55.

Height 12.1 mm., diameter 14.4 mm.; h/d index 84.00.

Height 10 mm., diameter 12.8 mm.

IDAHO: Twilegar Gulch, below bluish limestone ledges, Sect. 35, T. 26 N., R. 1 E., northeast of and near Lucile, Idaho County (H. Burrington Baker), Type 174024 A.N.S.P.

This remarkable snail unites the "transversely ribbed" series of Binney and Hemphill with the "longitudinally ribbed", combining the sculptural

features of *O. haydeni* and *O. idahoensis*. Its locality lies between the areas of those species, all being found where creeks and washes draining into the Salmon River cross limestone belts.

The series of over 200 is rather homogeneous as *Oreohelices* go, the type being an average example. Those with higher and lower h/d indices measured above are exceptional specimens. A few dwarf ones down to about 11 mm. diameter, 5 whorls, were found.

Genitalia about as in *O. haydeni hesperia*. The anterior part of penis has 3 or 4 very low ribs within, the granulose part flattened as usual. The example figured contained 15 embryos. Length penis 13 mm., internally ribbed part 5 mm., epiphallus 4 mm.; diameter of shell 16 mm. (Fig. 277 b).

The radula has 27.1.26 teeth (Fig. 306 c) in a row counted, about 8 being laterals. The central has strongly developed ectoconal cutting points in some rows, far weaker in others. The laterals have quite narrowly overhanging cutting edges, a distinct ectocone appearing on the 9th tooth and well developed on the marginals.

(*Perplexus*, confused, perplexed.)

Oreohelix tenuistriata Henderson & Daniels

Fig. 310.

Oreohelix tenuistriata Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 338, pl. 15, figs. 5, 6; 1917, Proc. Acad. Nat. Sci. Phila., p. 53.—Pilsbry, 1917, Proc. Acad. Nat. Sci. Phila., p. 45, fig. 3a (genitalia).

The shell is thin, varying from rather depressed to moderately elevated, rather narrowly umbilicate, the umbilicus contained 5 to 6 times in the diameter. Buff, the spire brownish; often streaked; with two dilute brown bands, one well above, the other barely below the periphery, often scarcely discernible. The whorls are strongly convex, carinate in immature stages, angular in adult shells. The first whorl is nearly smooth but may show microscopic spiral striae; delicate retractive striae appear on the second whorl. Later whorls have many crowded, sharp, wavy striae which when perfectly preserved have cuticular edges, especially where they cross a number of low spirals. On the base there are about 7 such spirals, distinct in immature, often weak in mature individuals. Peristome thin.

Height 9 mm., diameter 12.8 mm.; $5\frac{1}{3}$ whorls.

Height 6.8 mm., diameter 10.6 mm.; $4\frac{3}{4}$ whorls.

IDAHO: A canyon between McCammon and Hot Lava Springs, about 2 miles southwest of the latter place, under shrubs and mats of the radical leaves of *Balsamorhiza sagittata* (Nutt.), overhanging small piles of limestone in open spaces among the mountain mahoganies (J. Henderson & L. E. Daniels), Type University of Illinois Collection, paratype 112801 A.N.S.P.



Fig. 310. *Oreohelix tenuistriata*, topotype.

Topotypes dissected show that this is a species having genitalia like *O. haydeni* and *O. strigosa depressa*. The length of penis is equal to the diameter of the shell; the length of its internally ribbed lower portion is contained $2\frac{1}{2}$ times in the total length. Length of penis 10 mm.; of its internally costate portion 4 mm.; of penial retractor 6.5 mm.; epiphallus 2 mm.; vagina 3 mm. (Fig. 305 a).

The central and lateral teeth have sharp side cutting points, the marginals with distinct cusps. There are about 6 lateral teeth; but the transition to marginals is very gradual. Jaw is striate, light yellow.

The original description and figures were based upon three imperfect and immature specimens. In 1916 Henderson and Daniels revisited the type locality and obtained living examples, a few mature; the above description and the figures being from one of these.

The structure of the penis shows it to be related to *O. haydeni*. The crowded striae, waved where they cross the very low spirals, are characteristic. The contour varies; one topotype has about the shape of *O. s. cooperi*, height 8.5 mm., diameter 12 mm., umbilicus small, about 8 times in the diameter.

Since the preceding account was written and the figures prepared I have been able to examine a long series, no. 18603, University of Illinois, collected by L. E. Daniels, June 17, 1916, "one mile above McCammon, south side of Port Neuf River, 3 miles southwest of Lava Hot Springs." These specimens show that the well rounded form shown in Figure 310 is exceptional. The shell is usually angular or carinate, and the spiral cords are often rather strongly developed, there being from none to four above the periphery, usually six on the base, but sometimes only two or three there. In part of the shells there are fine spirals between the cords. The largest of this lot measure: height 7.9 mm., diameter 12.8 mm., and 8.2 x 12.2 mm.

It is a small and delicate form of the *haydeni* series, which now seems separable, though possibly further collecting may show the subspecific status more appropriate.

(*Tenuistriatus*, with thin striae.)

Oreohelix nevadensis Berry

Fig. 311.

Oreohelix nevadensis Berry, 1932, Journ. Ent. & Zool. Pomona Coll., 24: 60, figs. 5-8.

"Shell of medium size, in embryo with a pinched keel, which is softened in adolescent shells to a simple carina, and becomes fully rounded and obsolete on the last half or all of the body-whorl in large mature shells; some shells evidently maturing at small size, however, remaining more or less carinate to the aperture. Embryonic shell coarsely radially wrinkled and finely spirally striate, a secondary coarser and sparser spiral sculpturing appearing both on the upper and lower surfaces of the last quarter-whorl. Subsequent whorls show this coarser sculpturing as a system of peculiar interrupted spirals having the appearance of beaded welts, often obscure and eventually becoming reduced to mere traces or even entire obsolescence

on the body-whorl of the larger shells; on the base of the shell the spirals are more distant from one another, but often more persistent and their peculiar characters thus more easily to be made out. Color of periostracum on spire, variably clouded with brownish or brownish-buff below, and with two conspicuous dark brown spiral bands about 1.0 mm. wide, one subperi-

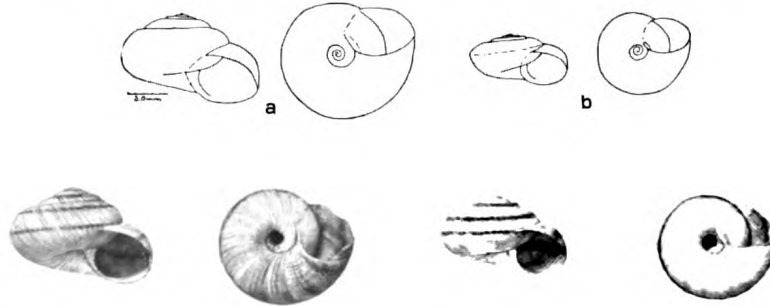


Fig. 311. *Oreohelix nevadensis*. Above, a, type; b, paratype (after Berry). Below, paratypes 152605 A.N.S.P.

pheral in position, the other about midway between this and the suture above; area above upper band in many shells dark brown, of a shade nearly as dark as the band; occasional shells show traces of one or two indistinct spiral bands on base." (Berry.)

Height 10.8 mm., diameter 18 mm., diameter umbilicus 3.5 mm.; $5\frac{1}{2}$ whorls. Type.

Paratypes measure from 12.3 x 19.3 mm., umbilicus 3.5 mm., $5\frac{1}{4}$ whorls, to 7.6 x 12.6 mm., umbilicus 2.4 mm., 5 whorls.

NEVADA: Cleve Creek, Shell Creek Mountains, White Pine County, at 8100 feet (Robert D. Moore), Type 7178, paratypes 7179, 7180 Berry Collection, other paratypes 152605 A.N.S.P.

"This snail seems superficially nearest among described forms to *O. haydeni hybrida* (Hemphill), but the spiral striae are weak to obsolete on most adult shells, the color banding is conspicuous, the surface is less rugose, and the young shells are flatter, more narrowly umbilicate and have a less commodious aperture. Although I have but a single embryo of *hybrida* (H. & D. Sta. 103, southeast of Deweyville, Utah) available for comparison, this too appears to show differences, being a deeper shell, planulate above, and simply carinate, whereas embryos of *nevadensis* exhibit a low but distinct spire in profile and the carina is quite distinctly pinched out into a keel. Eleven mature snails cleaned proved to contain no embryos, whereas the remainder yielded from 3 to 12 each." (Berry.)

Carinate specimens measure from 12.6 to 14.4 mm. diam., two containing embryos.

OREOHELIX SUBRUDIS GROUP

Oreohelix subrudis ("Pfeiffer," Reeve)

Fig. 313.

Helix subrudis Pfeiffer, Reeve, Dec., 1854, *Conchologia Iconica*, 7, pl. 198, figs. 1390a, b.—Pfeiffer, May 8, 1855, *Proc. Zool. Soc. Lond.*, for 1854, p. 287; 1859, *Mon. Hel. Viv.*, 4: 97.

Oreohelix subrudis ("Pfr." Rve.), Pilsbry, 1934, *Proc. Acad. Nat. Sci. Phila.* for 1933, 85: 395, text-fig. 13 (penis), pl. 15, fig. 15 (by error "*subrugosa*" on p. 397).

Oreohelix subrudis subrudis (Pfr. in Rve.), Henderson, 1936, *Univ. Colo. Stud.*, 23: 92.

Helix cooperi W. G. Binney, in part, 1869, *L. & Fr. W. Sh. N. A.*, 1: 78, figs. 133, 134.

Patula strigosa Gld., in part, Binney, 1878, *Terr. Moll.*, 5: 158, fig. 64 (upper), 65 (lower).

Patula strigosa var. *cooperi* W. G. B. Cockerell, 1890, *Nautilus*, 3: 101.

?*Patula strigosa sinistrorsa* Cockerell, 1893, *Brit. Nat.*, p. 80.

Patula strigosa form *globosula* Cockerell, 1890, *Nautilus*, 3: 101.

P. strigosa form *globulosa* Ckll., Pilsbry, 1893, *Man. Conch.*, 8: 118 (error for *globosula*).

Patula cooperi Cockerell, 1889, *Nautilus*, 3: 8, with varieties *typica*, *elevata*, *minor*, *confluens*, and (p. 9) *trifasciata*. Cf. Ckll., *Nautilus*, 3: 102, and *Proc. Acad. Nat. Sci. Phila.*, 1916, p. 356.

Pyramidula strigosa var. *cooperi* Elrod, 1902, *Univ. Mont. Bull.* 10, pp. 103-172; *Nautilus*, 17: 3.

Oreohelix cooperi W. G. B., Henderson, 1907, *Univ. Colo. Stud.*, 4: 168, 1924, 13: 111, fig. 27 (references in full); 1929, 17: 90 (occurrence in Ore. and Wash.).—Pilsbry, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 350, pl. 22, figs. 1-4; 1917, p. 44 (anatomy); 1919, *Proc. Acad. Nat. Sci. Phila.* for 1918, p. 320, fig. 14 (anatomy).

Oreohelix cooperi obscura Henderson, 1918, *Nautilus*, 32: 46.

Oreohelix cooperi form *obscura* Henderson, 1924, *Univ. Colo. Stud.*, 13: 116.

Oreohelix cooperi form *apache* Pilsbry & Ferriss, 1919, *Proc. Acad. Nat. Sci. Phila.* for 1918, p. 323, fig. 14c (genitalia), pl. 7, figs. 7-8a.

Oreohelix cooperi form *maxima* Pilsbry, 1916, *Proc. Acad. Nat. Sci. Phila.*, p. 357, pl. 22, fig. 1 (genitalia).

"Shell umbilicate, depressed, somewhat solid; obliquely, rather roughly striate and under the lens decussate with close spiral striae; opaque, whitish, encircled with a wide violaceous-brown band at the suture and some other obsolete ones. Spire depressed-conoid, the apex a little obtuse, corneous, of five somewhat convex, slowly increasing whorls, the last tubular, not descending. Umbilicus of medium size, nearly one-third of the diameter. Aperture a little oblique, lunate rotund; the peristome simple, straight, its margins converging, the columellar narrowly spreading. Major diameter 17.5, min. 15, height 9 mm."¹ (Pfeiffer.)

Height barely 11 mm., major diameter 16.75 mm., min. 14.5 mm.; width of umbilicus 3 mm. (Type, measured by J. R. le B. Tomlin.)

Distribution.—Rocky Mountain and Great Basin regions from about 32° 22' N. Lat. to about 50°. Southeastern British Columbia, southwestern Alberta, Idaho, Montana, Wyoming, Utah, Colorado, Arizona and New Mexico; southward at high elevations only.

¹ The low h/d index indicated by Pfeiffer's measurements is owing to his method of measuring the height, "ad basin axis, nec ad basin aperturæ". Also, he apparently measured the umbilicus to the edge of the cavity rather than across the coil of the umbilical suture.

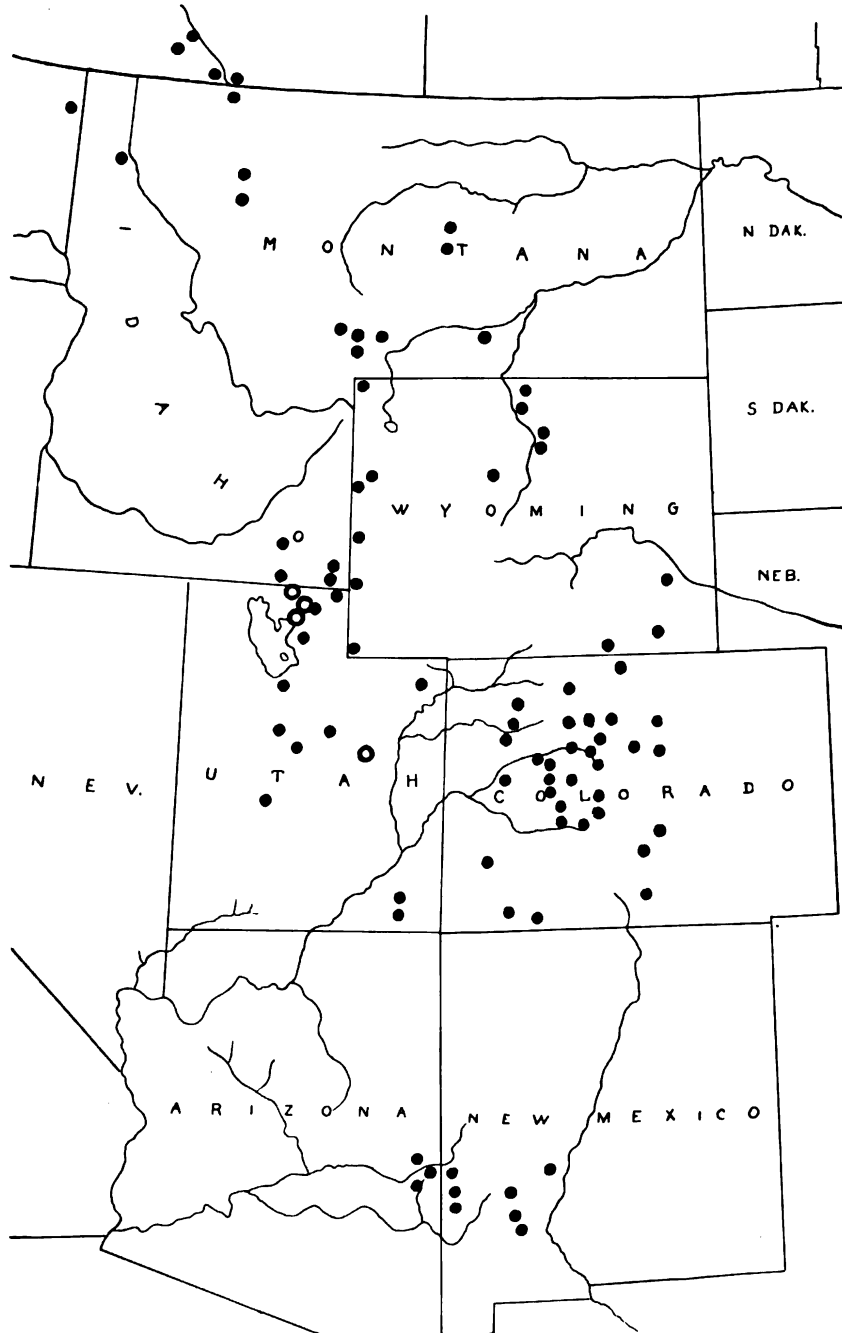


Fig. 312. Distribution of *Orcohelix subrudis* and its subspecies; rings represent the subspecies *O. subrudis rugosa*.

The distribution of the species is roughly represented on the map (Fig. 312). Usually not more than one record for a county is plotted.

The type of this species is in the British Museum. I am indebted to Mr. J. R. le Brocton Tomlin for notes and a comparison with specimens sent, and to Lieut.-Col. A. J. Peile for careful drawings, reproduced in Figure 313 p. A photograph of Reeve's figure of the same specimen is reproduced (Fig. 338: 15).

The type specimen (Fig. 313 p) is banded about as in Figure 313 d, left, from Colorado, but the subperipheral band is narrower and there are traces of one band below it. Lieut.-Col. Peile states that the wide upper band is blotchy, with occasional whitish radial streaks. The shell is a rather low example of the species. It has irregular striation, stronger and puckered below the suture, and weaker on the base.

O. subrudis differs from *O. strigosa depressa* by the greater height of the shell, the more rounded last whorl and smaller umbilicus, the rather sharp, fine striation with close spiral lines cutting the striae (but varying from distinct to weak). The color is often as in *O. s. depressa*, two bands on a buff or paler ground, but some specimens in most lots have additional narrow or wide bands on the base, which are very rarely seen in *depressa*. These qualities are all variable, and diagnosis is somewhat difficult or uncertain, especially if the shells are in bad condition, or only few are available. Often the two species occur together. When living or preserved animals are at hand an examination of the penis gives reliable data. This examination will be found a very simple matter.

Many specimens from Idaho, Wyoming, Utah, Colorado, Arizona and New Mexico have been dissected (Fig. 314). All agree in having the internally costate part of the penis longer than the papillose part, which at once differentiates the species from *O. strigosa* and *O. peripherica*, in which the costate part is much shorter than the papillose part. The penial retractor is short, less than half the length of the penis in the smaller specimens, but about two-thirds the length of penis in the large forms from Yellowstone Park and New Mexico. The median part of the penis is often somewhat swollen, but in other examples this is not noticeable. The penis has usually four main fleshy ridges in the anterior part, as in specimens from McCammon, Idaho (Fig. 314 f), and the Black Range of New Mexico, or there may be about 6 unequal ridges (Fig. 314 a, Yellowstone Park, no. 96973), one of them continuing upwards further than the others. Measurements in mm. follow; Many more, with figures, have been published in my papers of 1916 and 1919.

	Yellowstone, <i>maxima</i>	McCammon, Idaho	Black Range, New Mexico	Black Range, New Mexico	Blue Mts., Arizona	Glensyre, Colorado	Apache Co., <i>apache</i>
Length penis	14.3	12	21	15.5	17	8.6	18
Ribbed part	8.7	7.5	11	9	10	4.6	9.5
Epiphallus	5	5.5	4.5	5	7	4.3	....
Diam. shell	26	22	22	....	21	17	23

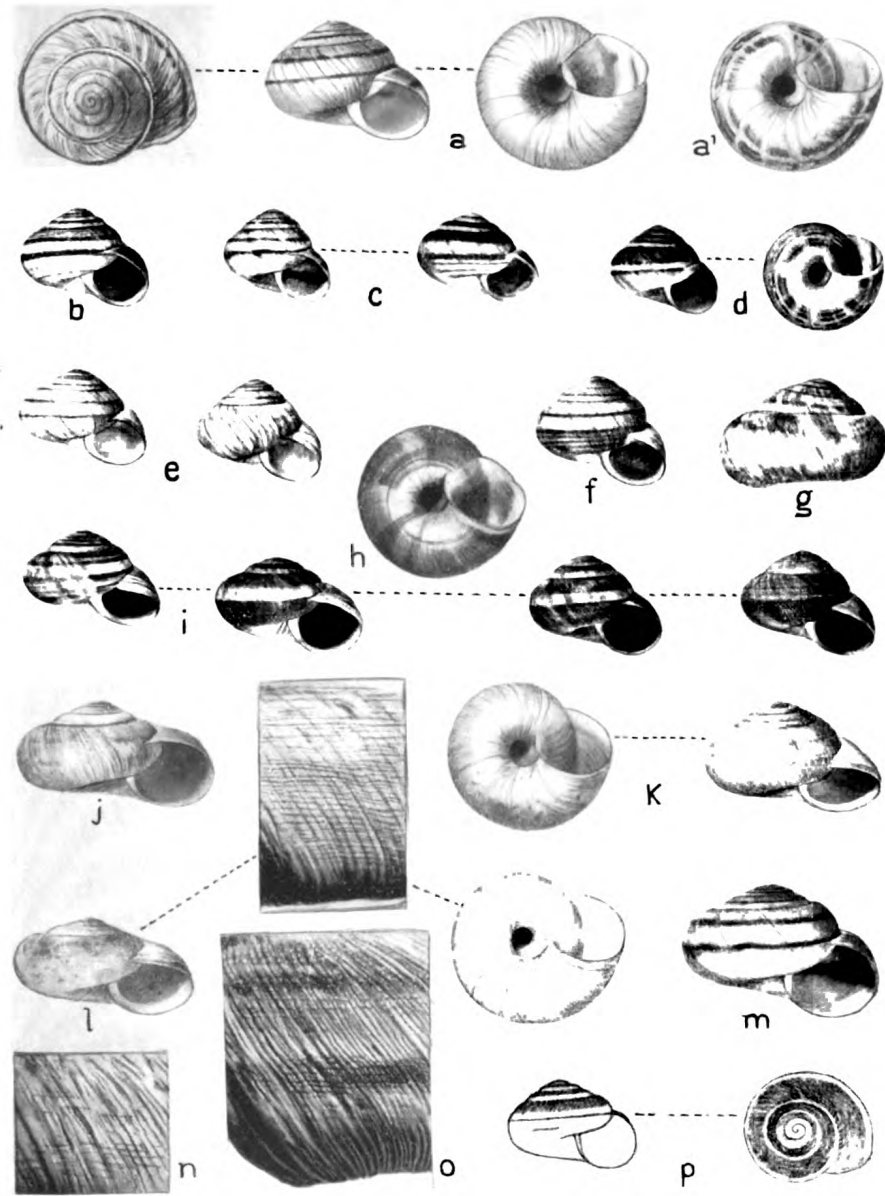


Fig. 313. *Oreohelix subrudis* and varieties. a, 6 miles below Minturn, Colo.; b, 3 m. above Minturn; c, d, Gleneyre, Larimer Co., Colo.; e, Garden City, Utah; f, Yellowstone Park; g, 1 m. north of McCammon, Ida.; h, above Glenwood Springs, Colo.; i, form *obscura*, White Creek, Wyo.; j, *O. s. rugosa*, west of Clarkston, Utah; k, Boxelder Co., Utah; l, *O. s. albida*, Logan, Utah; m, *O. subrudis* form *maxima*, type; n, *O. s. rugosa* $\times 3$; o, *O. subrudis*, Bennington Canyon, Ida.; p, *O. subrudis*, type, drawn by Lieut.-Col. A. J. Peile.

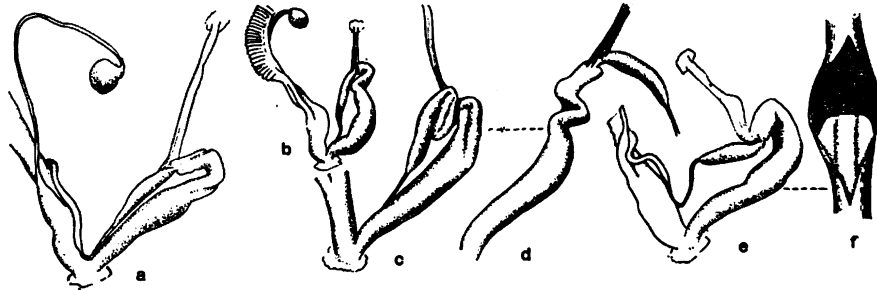


Fig. 314. a, *Oreohelix subrudis* form *maxima*, Yellowstone Park. b, *O. subrudis*, Gleneyre. c, d, *O. subrudis rugosa*, Clarkston, Utah. e, f, *O. subrudis*, Holden's Spring, Black Range, N. M.

O. subrudis is extremely variable in size, shape, width of umbilicus and color, even in the same colony, though naturally the variation is frequently greater in different colonies compared. Generally the size and often the color are moderately uniform in single colonies, yet there are many exceptions.

The following varietal names, published by Professor Cockerell nearly fifty years ago, were not intended as subspecies but as varieties in the XIX Century European sense (cf. Moquin-Tandon), being a terminology for such variations of shape and color as may occur among individuals of polymorphic colonies. Cockerell's definitions (1889) and later remarks (1916) are quoted.

"*Patula cooperi* var. *typica*, the ordinary form in Colorado, with two distinct bands, diameter 19 to 25 mm. Canyon City (T. Morgan), Cave of the Winds, Manitou (E. W. Roper),¹ and many other localities.

"Var. *elevata*, spire elevated, Utah (Hemphill). Merely an extreme of the ordinary variation of the species.

"Var. *minor*,² very small, Utah (Hemphill). The original intention was to call all of the shells below a certain size *minor*, not regarding the variety as a race or subspecies in any sense.

"Var. *confluens*, bands confluent, shell therefore brown with a broad white band above the periphery and a white umbilical region; Grand River in Garfield Co. and by Plateau Creek in Mesa Co. Also West Mountain Valley, Custer Co. Type in U.S.N.M.

"Var. *trifasciata*, with three bands, one above the periphery and two below, all distinct, the area between the first band and the suture marbled with brown; Mam Mountains, Mesa Co., Colorado.

"*Patula strigosa* form *globosula*. Small, globose, dark above periphery with two bands, transverse grooved striae rather well marked. Diameter $11\frac{1}{2}$, alt. $8\frac{1}{2}$ mill. Black Lake Creek, Summit Co., [Colorado]. The speci-

¹ The locality Manitou was for the form later called *depressa*, which had not been segregated from two-banded "*cooperi*" (= *subrudis*) at that time.

² Var. *minor* Ckll. was not preoccupied by var. *minor* Yarrow, as the latter was a nude name; but neither is recognizably defined.

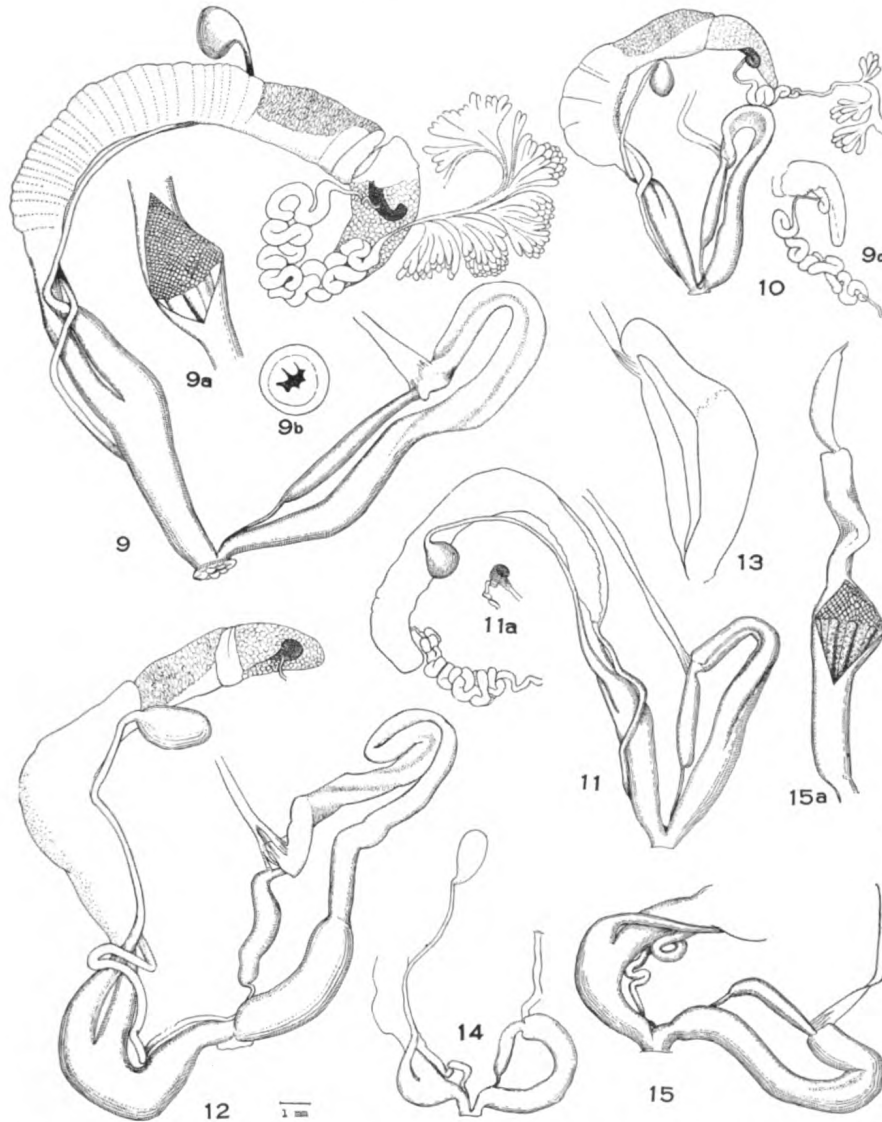


Fig. 315. 9, *Oreohelix strigosa cooperi* (W. G. B.), Spearfish Creek, 1 to 3 miles above Spearfish, Black Hills, S. D. a, section of the penis opened. b, transverse section below place opened; 9c, same; albumen gland, talon and hermaphrodite duct of small specimen, the shell 9.5 mm. diam. 10, *Oreohelix strigosa berryi* Pils. Topotype. Snowy Mts., Montana. 11, *O. idahoensis baileyi* Beh.; 11a, talon. 12, *O. strigosa meridionalis* P. & F. Black River opposite mouth of Fish Creek, Apache Co., Ariz. 13, *Oreohelix subrudis* (Pfr.). Outline of penis and epiphallus of a specimen from west of Bear River above Steamboat Springs, N.W. Colorado. 14, *Oreohelix junii*. Park Lake, Grand Coulee, Washington. 15, the same. Upper end of Blue Lake, Grand Coulee; 15a, penis opened.

men seems immature, but is remarkable as being the only form I have seen in Colorado that is nearer to *strigosa* than *cooperi*. It is doubtless allied to var. *gouldi* Hemphill." (Cockerell, 1890.)

"*Patula strigosa cooperi* form *major*. Shell with diameter 25 mill. Near head of North Mam Creek, Mesa Co." (Cockerell, 1890.)

NEW MEXICO AND ARIZONA: *O. subrudis* probably occurs in the Rocky Mountains in the northern part of New Mexico, but if so, records are lacking. Far to the south large forms are abundant in the Black, Mogollon and neighboring ranges, and the adjacent part of Arizona, the area of this herd lying more than 200 miles from the nearest known Colorado and Utah localities. It is a common snail in the Black Range, along the boundary

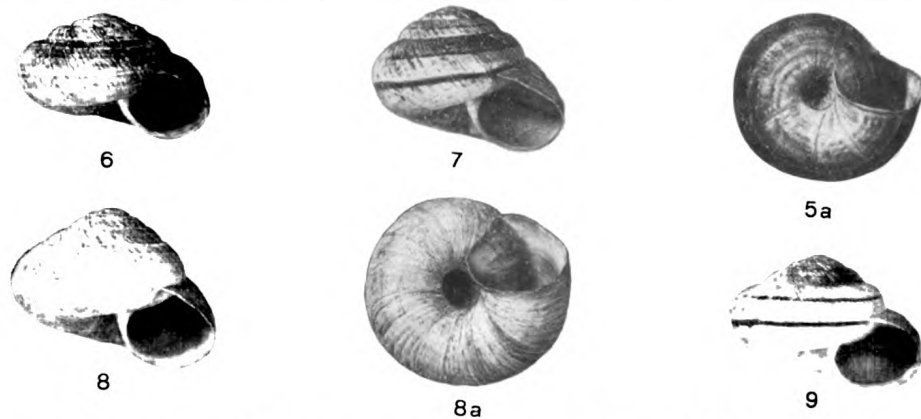


Fig. 316. *Oreohelix subrudis*, Black Range, New Mexico. 5a-7, Silver Creek, about 8000 ft. 8, 8a, same, 7500 ft. 9, Holden's Spring, about 9000 ft. All $\times 1\frac{1}{4}$.

of Grant and Sierra Counties, New Mexico. This forms the southern border of the vast area of *O. subrudis*, which is represented by a capacious form of the species. Many examples are typical in coloring (Fig. 316: 7, 9), but pale shells with faint bands or none are abundant, especially on Silver Creek (Fig. 316: 6, 8, 8a). Occasionally throughout the range, specimens were found with very broad, almost black bands (Figs. 316: 5a and 317). These color forms are found together, throughout the forest zone of the range. The extremes of elevation of the spire (Fig. 316: 6, 7), also occur in single colonies. The shape- and color-forms are spread throughout the range, though particular color-forms are often prevalent at one or another station. The specimens figured measure as follows: Fig. 316: 5a, alt. 14, diameter 20 mm.; Fig. 316: 6, 13 x 20 mm.; Fig. 316: 7, 15.6 x 20.6 mm.; Fig. 316: 8, 8a, 16.7 x 22 mm.; Fig. 316: 9, 14.3 x 20.5 mm.



Fig. 317. *Oreohelix subrudis*.

In the Black Range and environs *O. subrudis* is not confined to limestone exposures, but it also sparsely scattered on shaded

hillsides throughout the forested zone of the range from Sawyer Peak northward, at elevations between 7500 and 9500 feet.

Northeast of the Black Range, in Socorro County, it was taken at Sam's Canyon, about 6 miles south of Chloride, dead only, and in the San Mateo Mountains, everywhere on the south side, abundant.

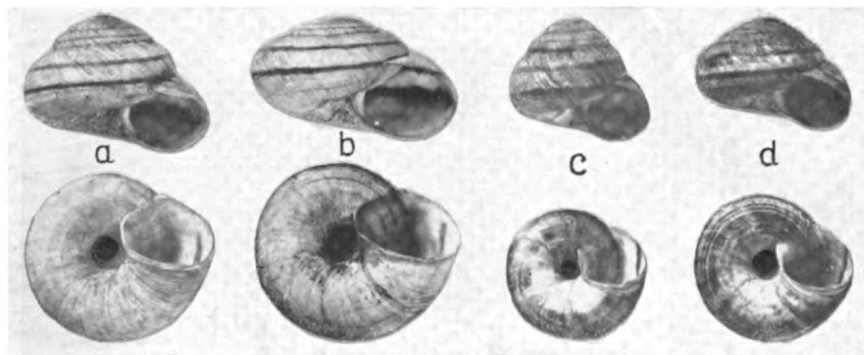


Fig. 318. *Oreohelix subrudis*. a, b, east side of Blue River, Arizona; c, d, west side.

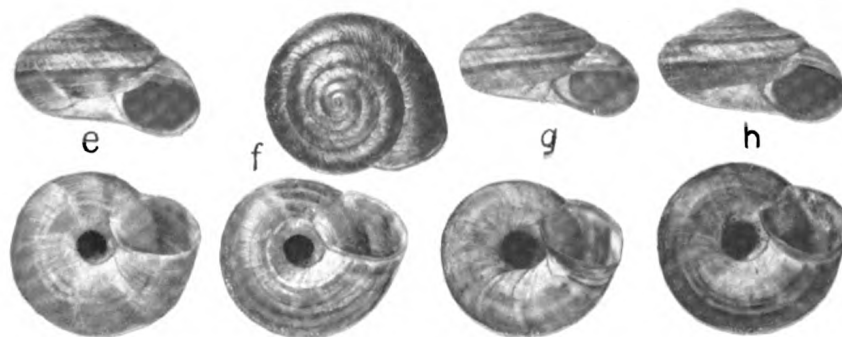


Fig. 319. e, f, g, *Oreohelix subrudis* form *apache*, Black River, Arizona. h, *Oreohelix strigosa meridionalis*, Eagle Creek.

The lower part of the penis contains two or three fleshy ridges, the upper ends of which project a little into the cavity of the thin-walled portion (Fig. 314 e, f).

Shells from the Mogollon Mountains, Catron County, New Mexico, resemble those from the Black Range closely, but they are somewhat more variable in contour, two from a lot from near the crest of the range measuring 13 x 21 mm., and 16.5 x 20 mm. (Fig. 316: 9) representing the commonest color form.

In Arizona similar forms were found at high elevations under logs and leaves in heavy timber in the southern Blue Mountains and north to Mt.

Thomas in Apache County. Also lower, along the Blue River, Greenlee County, among rocks (Fig. 318 a-d). The extremes of contour illustrated are well connected by intermediate shapes partly figured in Proc. Acad. Nat. Sci. Phila., 1918, pl. 7. Some albino shells occurred among the banded and clouded patterns. Height 15.6, diameter 18 mm., to 16 x 26.5 mm., umbilicus 4.7 mm. The Blue River series shows all gradations of shape between very high shells, those of the typical *cooperi* contour, and an openly umbilicate shell with whorls of small caliber. The sculpture varies from that of Black Range *cooperi* to more effaced, the striation and spirals weak.

O. subrudis form *apache* Pilsbry & Ferriss. (Fig. 319 e, f, g.) Rather large size, dark or very dark coloring and subobsolete sculpture (the spirals being especially weak) characterize the shells taken along the Black River and Fish Creek, in Apache County, Arizona. The shell is generally quite depressed and as openly umbilicate as the forms of *O. strigosa*. The diameter is usually from 22 to 26 mm. Few have the spire very high, and none are as high as many of the Blue River shells. Height 15 mm., diameter 24 mm.; umbilicus 4.5 mm. Type no. 109184, from Station 76 (1913), Black River 2 miles above Fish Creek.

On account of the form and sculpture of this large series, so unlike the usual forms of *subrudis*, it appears best to name it. The Blue River series varies from the *apache* type to the normal *subrudis* form. Indeed, specimens could be selected from the Mogollon series agreeing with *apache*, though they are quite exceptional there. The genitalia are either practically typical *subrudis* or the costate part of the penis may be relatively a trifle longer.

COLORADO: "Generally speaking, *cooperi* [that is, *subrudis*] does not extend so freely to the lower elevations as does *depressa*, though the upper range of both reaches nearly or quite to timber line. East of the Front Range in Colorado (along the eastern fringe of the range of the genus), *cooperi* [*subrudis*] is not common, possibly because of the rarity of favorable conditions at the higher elevations, where the rocks are mostly granitic and gneissic; but along the base of the foothills, where limestone is common, *depressa* is locally abundant, though rare in the granitic area. In western Colorado limestones extend to great elevations, and *cooperi* is the more common form. Usually we have found only one form in each locality, but at nearly all our stations in the Roaring Fork and Crystal River drainage (Marble, Aspen, and Carbondale districts) we have found *depressa* and [*subrudis*] mingling freely." (Henderson.)

The locality of the type specimen of *O. subrudis* in the Cuming Collection, British Museum, is unknown, but those most like it are from Colorado. Shells from the North Park, Larimer County, at about 7000 feet, among aspens, agree well with Reeve's figure in size and color, but the spire is usually higher. There may be a broad band below the suture, with a narrower one below the periphery and several weak lines on the base, as in the type, or two narrow bands in the usual positions, with or without

basal lines. Three measure: height 13.4 mm., diameter 17.8 mm., 11.2 x 16.4 mm., 11.9 x 14.5 mm. (Fig. 313 c, d). Similar shells are found in many places in Colorado and Wyoming.

A coloring occurring sporadically is the *confluens* pattern, deep brown with light peripheral zone and umbilical area (Fig. 313 h, near Glenwood Springs at bridge over Roaring Fork, where it is associated with two-banded shells).

The prevalent color pattern of the species is illustrated by shells from near Minturn, Eagle County, Colorado (Fig. 313 a, b). There are two somewhat uneven chestnut-brown bands, with more or less brown suffusion or maculation between the upper band and the suture, the base either plain whitish or having irregular bands. At stations about 6 miles below Minturn the shells are large, up to 23 mm. in diameter; stations above Minturn have smaller shells, down to 15 mm. (Fig. 313 b, a lateral canyon 3 miles above Minturn).

"The *cooperi* [*subrudis*] material from several places in the vicinity of Boulder is all fossil, in the superficial deposits. This is the extreme eastern edge of the range of the genus in Colorado." (Henderson.)

UTAH: The two-banded pattern predominates, but bandless shells often occur with them, as at Garden City (Fig. 313 e), and Eureka. In extreme southeastern Utah it is a common snail in the Blue Mountains, around Monticello, San Juan County, diameter 12.5 to 18 mm. I have not verified these anatomically. The largest specimens seen from the State are from near the summit of Nelson Peak, Oquirrh Mountains, the diameter up to 25 mm., umbilicus 5 mm.

IDAHO: In the Bear Lake region of southeastern Idaho the shells are in some places similar to those figured from Garden City, Utah, small, about 15 mm. in diameter, sharply striate, with weak bands or none. Other places, 4 to 5 miles up Paris Canyon and near mouth of Bennington Canyon, have larger shells, up to 25 or 26 mm., similar to those from below Minturn, Colorado; the size being rather uniform in each colony. A peculiar color-form having much resemblance to *O. strigosa montrosensis*, but with typical *subrudis* genitalia, was taken by Henderson and Daniels one mile north of McCammon, Bannock County (Fig. 313 g).

WASHINGTON: Henderson has reported "*cooperi*" (= *subrudis*) from near Locke, Pend Oreille County, farthest west for the species. Records of *cooperi* from east of Milton, Oregon, belong to *O. strigosa* f. *delicata*. Those from mountains east of Walla Walla are also a form of *strigosa*.

WYOMING: A prevalent form is the common two-banded pattern, with or without additional spiral lines on the base, diameter about 17 to 21 mm. (Fig. 313 f, Mammoth Hot Springs, Yellowstone Park).

Form *maxima* Pilsbry (Fig. 313 m), is a shell with about the typical shape of *subrudis*, but of large size, the type measuring, height 17 mm.,

diameter 26 mm., umbilicus 5 mm., whorls $5\frac{1}{2}$, more rounded than in *O. strigosa depressa*. There is a band at, another above the periphery, and below the suture a wider, paler one interrupted into maculae. This is the prevalent *subrudis* pattern. Genitalia (Fig. 314 a) normal for *subrudis*. The type is from Yellowstone National Park, 10 miles southwest of Jardine, Montana, 96973 A.N.S.P., collected by E. M. Kindle. Other specimens are from Grade Canyon near Cokeville, Uinta County in southwestern Wyoming, collected by J. A. G. Rehn. Two of these measure height 17.2 mm., diameter 26 mm., and 16.6 x 22.5 mm. In addition to the markings described above, they have several narrow brown encircling lines on the base.

All gradations of size exist between *maxima* and the smallest *subrudis*, though in different colonies; so that *formae* such as *minor* and *maxima*, based on size alone, have little taxonomic value and are scarcely susceptible of definition.

Form *obscura* Henderson (Fig. 313 i), is a seal-brown or warm blackish-brown color, with whitish peripheral zone, wanting in some shells. Striation fine and sharp, the spiral lines well developed. Diameter 17 to 18 mm. Distinguished only by color, which is an intensified *confluens* pattern, but this is nearly uniform throughout the colony; in a few shells, however, buff predominates. The locality is White Creek Canyon, east of Shell, Wyoming. Paratypes are figured.

MONTANA: Two-banded shells similar to those of Colorado and Wyoming are widely spread, the size varying from 7.8 x 11 to 10 x 15 (Warm Spring Canyon, Deer Lodge County), and 18.5 mm., Bozeman Mt., Gallatin Range. In the Mission Range and northward a high form, *limitaris* + *apiarium*, occurs. In the Tobacco Root Mountains, Madison County, at 9000 feet, the shells are rather small.

BRITISH COLUMBIA: In the Coal Creek valley, near Fernie, the ordinary two-banded form was taken, one measuring 16.1 x 22.7 mm. Higher, at Crow's Nest Pass, the *apiarium* form was found, together with normally proportioned *subrudis*.

(*Subrudis*, somewhat rough.)

Oreohelix subrudis limitaris (Dawson)

Fig. 320.

Helix limitaris Dawson, 1875, Rep. Geol. Brit. N. Am. Boundary Comm., p. 347.—

Description reprinted by W. G. Binney, 1885, Man. Amer. Land Sh., p. 261.

(?) "*H. militaris*" Binney, 1886, 2d Suppl., Bull. Mus. Comp. Zoöl., 13: 27.

Oreohelix cooperi limitaris (Dawson), S. S. Berry, 1922, Canad. Dept. Mines, Bull. 36, p. 4, pl. 1, figs. 1-5.



Fig. 320. *Oreohelix subrudis limitaris*, neotype, enlarged and natural size. (After Berry.)

"The shell is of only moderate size, fairly elevated, with an obtuse apex. The spiral sculpture is obsolete below, and on the upper surface of the whorls is only moderately developed, being much broken and interrupted by the very coarse and irregular lines of growth. The periphery is obtusely angular in front, becoming rounded or but faintly subangular on the forward part of the last whorl. The umbilicus is deep and narrow, contained in the diameter seven to eight times, its circular outline but little interfered with by the slightly reflexed inner lip. The color of the somewhat dehiscent periostracum is a deep rusty brown, irregularly clouded with brownish cream and slaty tones, and with two conspicuous, encircling, seal brown bands, one on the shoulder, the other just below the periphery, with sometimes a lighter and less distinct band interpolated between them, or one or more similar secondary bands on the basal part of the shell, and there is sometimes one just below the suture. The embryonic shell seems essentially similar to that of *O. c. apiarium* as described (cf. Berry, 1919, p. 200, fig. 1), but is smaller, the spiral sculpture is weaker, and the axial riblets stronger and more regular." (Berry.)

"Height 11 mm., diameter 17 mm.; 5½ whorls." (Dawson.)

"Height 14.1 mm., diameter 17.2 mm.; 5¾ whorls." (Berry.)

"Height 11.7 mm., diameter 16.3 mm.; 5¾ whorls." (Berry.)

ALBERTA: Waterton Lake (G. W. Dawson, J. B. Tyrrell), Neotype 2881 Geol. Surv. Canada.

The original material seems to be lost, but specimens collected by the same expedition in the same general locality and most probably from the identical swamp where Dawson collected the originals, were examined by Dr. S. S. Berry. His description is copied, with figures from his plate. *O. c. apiarium* Berry, from only a few miles south, is said by Berry to be "very close, and it is entirely possible that material from a wider range of localities may show that it is impracticable to draw any arbitrary line between them."

(*Limitaris*, of the boundary.)

***Oreohelix subrudis apiarium* Berry**

Fig. 321.

Oreohelix cooperi apiarium Berry, 1919, Proc. Acad. Nat. Sci. Phila., p. 199, fig. 1; pl. 10, figs. 1-9b.

Pyramidula strigosa var. *cooperi* Elrod, 1902, in part.

"The shell is large for this group of *Oreohelices*, strongly elevated, with an obtuse apex. The spiral sculpture is obsolete below, but strong on the upper half of the whorls where it consists of numerous fine striations, quite visible to the naked eye, which are interrupted by the coarse and very irregular lines of growth. The periphery is obtusely angular in front, becoming rounded or with just the faintest suggestion of angulation on the remainder of the last whorl. The umbilicus is narrow and deep, contained in the diameter about six times, its circular outline partially interfered with by the slightly reflexed inner lip. The color is extremely variable, the ground color of the shell ranging from a very light brownish cream, almost white, through shades of yellowish brown to dark chestnut, and tones of gray to a livid brownish slate. The adult shell usually shows two narrow darker bands, one on the shoulder, the other just below the periphery, with

sometimes a broader light band between, and several weaker and narrower bands below extending upon the base of the shell. Entirely bandless specimens seem to occur but rarely.

"The embryonic shell is lenticular in outline and strongly carinate as usual in the genus. It is sculptured with numerous very fine, crowded, wavy, spiral striae, crossed on the neanic portion by coarser, but still narrow, rather irregularly spaced, wrinkle-like, incremental ridges, some of them eventually becoming almost rib-like above, but practically obsolete below the periphery, where, however, the fine spiral striation is in these young specimens beautifully developed." (Berry.)

Height 19.6 mm., diameter 22 mm., diameter umbilicus 3.5 mm.; $6\frac{1}{2}$ whorls. Type.

Height 15.4 mm., diameter 15.6 mm., umbilicus 2.5 mm.; 6 whorls.

Height 15.5 mm., diameter 20 mm. Topotype.

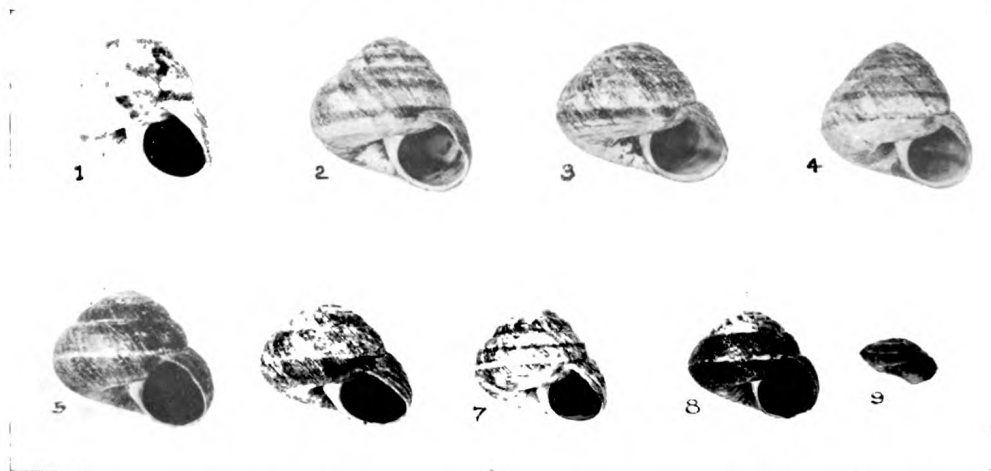


Fig. 321. *Oreohelix subrudis apiarium*; 2, the type; 9, juvenile. (After Berry.)

MONTANA: Glacier National Park, McDonald Creek Canyon opposite Glacier Wall, Granite Park Trail, altitude 3550 feet (Berry), Type 4130 S. S. Berry Collection; paratypes 114485 A.N.S.P. Red Eagle Lake, on trail to Lower St. Mary's Lake (Helen A. Fox, 1909). Mission Range near McDonald Lake, 3200 feet, and Flathead Lake (M. J. Elrod).

BRITISH COLUMBIA: Crowsnest Pass (M. M. Green).

"Despite its great size, *O. c. apiarium* is nearer, I think, to *O. c. limitaris* (Dawson) than to any of the other described races of the *cooperi* complex. The latter differs in its very much smaller size, less elevation, rather greater carination of the front part of the last whorl, and very much weaker spiral striation on the upper portion of the whorls. Relative to the size of the shell the lines of growth are coarser in *limitaris*, and the adult shell has from $\frac{1}{2}$ to $\frac{3}{4}$ of a whorl less." (Berry.)

Equally high shells occur sporadically in many colonies of *subrudis* elsewhere, but the high shape appears to be prevalent in Glacier National

Park. In the Mission Mountains, around McDonald Lake, the shells are somewhat intermediate between *apiarium* and normal *subrudis*, the height/diameter index 78 to 85. Three measure: 16.6 x 19.5 mm., 15 x 19.2 mm., 18.2 x 22.7 mm. Equally large shells come from Flathead Lake, 18 x 23.2 mm. At Crowsnest Pass, B. C., about 60 miles northwest of the type locality, shells of the *apiarium* shape are associated with others of ordinary *subrudis* proportions. Material seen from several localities appears to indicate that *apiarium* is not really separable from *limitaris*. It seems to be a matter of how far it is worth while to go in naming stages in a continuous series.

(*Apiarium*, beehive.)

Oreohelix subrudis rugosa (Hemphill)

Fig. 313 j, k, n.

Patula strigosa var. *rugosa* Hemphill, 1890, Nautilus, 4: 16; reprinted in Binney, 1892, 4th Suppl., Bull. Mus. Comp. Zool., 22: 174.

Oreohelix rugosa (Hemph.), Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 334.—Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 350, pl. 22, figs. 7, 7a (genitalia).

Patula strigosa var. *albida* Hemphill, 1890, Nautilus, 4: 17; reprinted in Binney, 1892, 4th Suppl., Bull. Mus. Comp. Zool., 22: 173.

“Shell umbilicated, elevated or globosely depressed, of a dull brown ash color; surface rough, covered with coarse irregular oblique striae, and microscopic revolving lines; whorls 5, convex, with or without one or two narrow faint revolving bands. In most of the specimens the bands are obsolete; spire elevated, obtusely conical; suture well impressed; umbilicus large, deep; aperture nearly round, lip simple, thickened, its terminations approaching and joined by a thin callus. Height of the largest specimen $\frac{3}{4}$ inch, greatest diameter 1 inch. Height of the smallest specimen $\frac{1}{2}$ inch, greatest diameter $\frac{3}{4}$ inch.” (Hemphill.)

UTAH: “New Brigham City”¹ (Henry Hemphill), Type 7639 C.A.S., near Boxelder Canyon, limestone ledges at 5000 feet. (Hemphill, on labels in A.N.S.P.); a little north of west of Clarkston, about halfway up the mountain under scrub oak and sage brush (Henderson and Daniels). Also near Logan (Hemphill), for “var. *albida*.” (Localities plotted as circles on map.)

The shell is light buff with some indistinct vinaceous-buff mottling and streaking, mainly above the periphery. The striation is somewhat rougher on the last third of a whorl, and there are interrupted and more or less granulose spirals. It appears to be a race of *O. subrudis*. The latter, if occurring in the same districts, may be at higher levels.

The penis is about two-thirds the diameter of the shell in specimens from Clarkston. Its internally costate anterior portion is relatively decidedly longer than in *O. s. depressa*, being over half the total length, agreeing with that of *O. subrudis*. Inside, the lower part has 5 or 6 fleshy ribs, smooth, as usual, and the upper part has about the same number, but they are much

¹“New Brigham City” is apparently a typographical error for *near* Brigham City, or Brigham, as it is now called. This is in Boxelder Co. Dr. Hertlein informs me that Hemphill's type and two other lots are labelled “Box Elder Co., Utah”, no. 7639, 7640 and 7641 C.A.S.

lower, and both ribs and intervals are papillose. The duct of the spermatheca is longer than in *O. s. depressa*. Length of penis 16 mm., costate part 11 mm., epiphallus 6 mm., vagina 6 mm., spermatheca and duct 29 mm., diameter of shell 24.5 mm. There are about 13 lateral teeth on each side, the inner 9 to 11 without side cusps. The transition to marginals is very gradual.

The shell of *O. subrudis rugosa* is similar to that of *O. strigosa carnea* from Salt Lake City; I cannot find any significant difference, and would not hesitate to unite them were it not that the penes differ specifically in several of each dissected.

Some very large shells collected by E. R. Eller from the north slope of Book Cliffs, 12 miles north of Wellington, Carbon County, Utah, resemble the more depressed examples of *rugosa* closely, but they are more widely umbilicate, so that until dissected the species is uncertain. Two measure: 13.5 x 24.5 mm., umbilicus 6.5 mm., and 15.3 x 27.6 mm., umb. 6.7 mm.

(*Rugosus*, wrinkled.)

Patula strigosa var. *albida* Hemphill (Fig. 313 l), was thus described: "Shell broadly umbilicated, greatly depressed, white, tinged with horn color; surface covered with fine oblique striae and fine microscopic revolving lines; whorls 6, convex, the last falling in front; spire very little elevated, apex obtuse, aperture oblique, nearly round; lip simple, thickened, sub-reflected at the columella, its terminations approaching, joined by a thin callus. Height $\frac{1}{2}$ inch, greatest diameter 1 inch, lesser $\frac{3}{4}$ inch." (Hemphill.)

The locality was near Logan, Utah; lectotype 7138 C.A.S. (H. Hemphill). Logan Canyon, 5000 feet (Hemphill on labels). Also near Morgan (Henderson and Daniels).

The shell is white to ivory with vinaceous-buff marbling above (sometimes lacking), the inner whorls cinnamon, the base white. Striation irregular, and becoming quite coarse on the latter third of the last whorl, where it is also spirally striate, the striae either very distinct, as in the enlarged figure, or varying to almost entirely absent. In some small specimens spirals are wanting. The diameter of Hemphill's type is about 25 mm.; other specimens from him run from 13.6 x 24.4 mm. to 10.5 x 19 mm. Umbilicus about 5 times in diameter. In most of the small shells of 16.5 to 20 mm. diameter, the periphery is distinctly though bluntly angular in front. They are dirty white with pinkish inner whorls, and sometimes two weak bands. By themselves, the small, subangular form appears quite unlike the large form, but there appear to be all grades in the Hemphill series. As a whole, this Logan Canyon form does not seem distinguishable from *rugosa*. Specimens from Morgan seem exactly like Hemphill's typical *albida*.

" [*Patula cooperi* var.] *alba*, white with rough striae, Utah (Hemphill) " of Cockerell (*Nautilus*, 3: 9, May, 1889) may be this form, but being without definite locality, adequate description, figure, or type specimen, it is not determinable.

Oreohelix junii Pilsbry

Fig. 338: 7, 7a, 8.

Oreohelix junii Pilsbry, 1934, Proc. Acad. Nat. Sci. Phila. for 1933, 85: 397, pl. 15, figs. 7, 7a, 8; text-figs. 14, 15, 15a. (*O. julii*, by a typographic error, p. 406.)

The shell is strongly depressed, openly umbilicate, the umbilicus contained four times in the diameter; moderately solid, whitish with the usual two bands cinnamon-brown, the base streaked with corneous, the upper surface with cinnamon-brown radial streaks and lighter suffusion. Striation is fine and irregular; spiral lines extremely faint or wanting. The whorls are moderately convex, the last weakly angular or subangular close in front of the aperture, elsewhere rounded, descending rather deeply to the aperture, which is very oblique, rounded-oval, the peristome very slightly expanded, thickened within, margins strongly converging and connected by a short parietal callus.

Height 11 mm., diameter 21.8 mm.; 5½ whorls. Type (Fig. 338: 7, 7a).

Height 10 mm., diameter 18 mm.; 5¼ whorls.

Height 12 mm., diameter 22 mm.; 5½ whorls.

WASHINGTON: Blue Lake, Grand Coulée (R. E. Snodgrass and Junius Henderson), Type 147014 A.N.S.P., from upper end of the lake. Also around Park Lake, Grand Coulée.

This species resembles *O. jugalis* (Hemphill) very closely, and if that form proves to be similar anatomically, the Grand Coulée form will probably be considered a subspecies. *O. junii* differs by having the umbilicus up to the last whorl decidedly narrower than that of *jugalis*, though in the last whorl it expands to about the same width. Usually it has a somewhat longer parietal callus. The localities of the two are rather widely separated. It is a case where the status of the form rests on anatomical characters. The small caliber of the whorls and the wide umbilicus separate *O. junii* from *O. subrudis*, which seems to be the most nearly related species anatomically. It is named for Professor Junius Henderson.

Specimens from Park Lake are mostly smaller: height 7.3 mm., diameter 14.5 mm., to 9 x 17 mm.

The reproductive organs (Figs. 315: 14, 15, 15a) resemble those of *O. subrudis* by having the ribs within the anterior part of the penis extend to or slightly past the middle of its length. The ribs and their intervals are minutely punctate or spongy. The vas deferens is folded considerably. Talon black, as in other northern species.

	Length of penis	Length of ribbed part	Diam. of shell	Museum No.
Upper end Blue Lake	11 mm.	6 mm.	23 mm.	147010
Park Lake	7 "	4 "	18.5 "	147008
" "	8 "	4 "	19 "	147015
" "	6.3 "	3.5 "	14-16 "	147015
" "	8 "	5.5 "	19 "	147015

This shell was included by Henderson in *O. strigosa strigosa* (Univ. of Colo. Stud., 17: 88, 89; 1929). The extension of the ribs to or beyond the middle of the penis and the shortness of the penis relative to the

diameter of the shell show at once that it is a member of the *subrudis* group, and not nearly related to *O. strigosa* as formerly thought.

Oreohelix jugalis (Hemphill)

Fig. 322 a, b, c.

Patula strigosa var. *jugalis* Hemphill, 1890 (April), Nautilus, 3: 134.—Binney, 1890 (May), 3d Suppl., Bull. Mus. Comp. Zoöl., 19: 215, text-fig.; 1892, 4th Suppl., Bull. Mus. Comp. Zoöl., 22: 169, reprint of Hemphill's desc.—Pilsbry, 1893, Man. Conch., 8: 117, pl. 41, figs. 93-95.

Oreohelix strigosa jugalis Hemph., Henderson, 1924, Univ. Colo. Stud., 13: 118, pl. 3, fig. 7.

Oreohelix jugalis (Hemph.), Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 398.

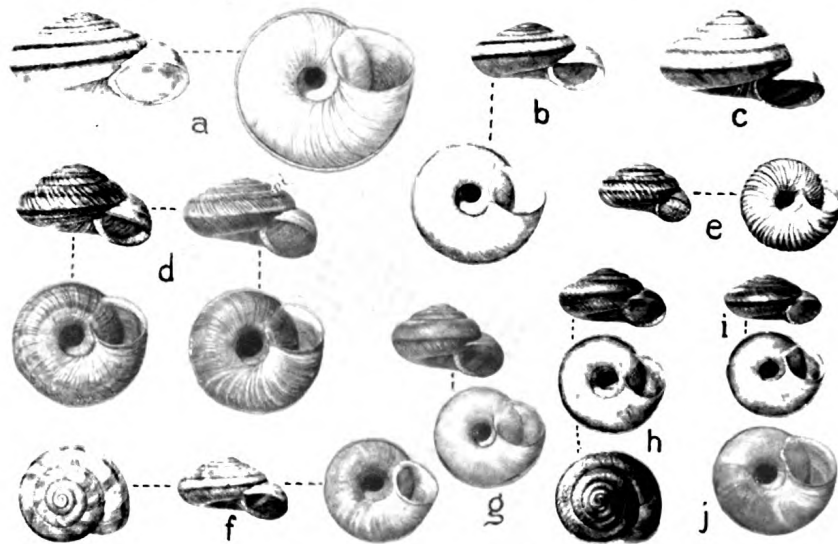


Fig. 322. a-c, *Oreohelix jugalis*; d, e, *O. j. intersum*; f, *O. j. flammulifer*; g-j, *O. j. vortex*.

The shell is depressed, with low-conoidal spire, openly umbilicate, the umbilicus contained $4\frac{1}{4}$ to $4\frac{3}{4}$ times in the diameter. White with pinkish buff (or light brown to gray) streaks, spreading to form indistinct patches on the upper surface, the inner whorls usually light brown; there are two cinnamon-brown bands. Sculpture of irregular, rather coarse but weak wrinkles of growth which are usually cut superficially by very weak, much interrupted spiral impressed lines on the upper and peripheral surfaces (but spirals are sometimes wanting). The periphery of the last whorl is angular in front (or often rounded, the angle disappearing earlier); it descends deeply (or sometimes only moderately) to the aperture. The aperture is shortly ovate, the peristome thin, margins strongly converging, joined by a very short parietal callus.

Height 13 mm., diameter 24 mm.; $5\frac{3}{4}$ whorls.

Height 9.3 mm., diameter 18 mm.; $4\frac{3}{4}$ whorls. Topotype.

Height 10.8 mm., diameter 20.4 mm.; $5\frac{1}{2}$ whorls. Topotype.

Height 13.2 mm., diameter 22.3 mm.; 6 whorls. Topotype.

IDAHO: Banks of the Salmon River (Henry Hemphill), lectotype 62272 A.N.S.P. Lucile (Hemphill).

Oreohelix jugalis is mainly characterized by the very wide umbilicus, rather capacious within, the closely approaching upper and columellar margins of the peristome, which is occasionally continuous, and the weak or obsolete spiral sculpture. The striation is irregular and not strong. The shell usually measures from 18 to 24 mm. in diameter. It is opaque whitish buff with two narrow brown bands and more or less brown suffusion on the upper surface. Umbilicus unusually wide, one-third the diameter.

The shell figured by Binney is abnormal or at least unusual in the deep descent of the last whorl. Those figured in Man. Conch., vol. 8, figs. 93, 94, and by Henderson, are the normal form of the species. The typical form was found under stones close to the banks of the Salmon River. The exact place was not stated in Hemphill's description, but one of the specimens from him is marked Lucile, Idaho.

The *jugal* series is known only by Hemphill's collections made about 1889, from which he sent out numerous lots. As the anatomy is not known, its status and relationship remain in suspense. The shell seems near *O. junii* of the *subrudis* group, but also resembles *O. strigosa*, of which it has been rated as subspecies.

(*Jugal*, yoked together, referring to the lip-ends.)

***Oreohelix jugalis vortex* Berry**

Figs. 322 g, h, i, j; 323 a.

Oreohelix vortex Berry, 1932, Journ. Ent. & Zool. Pomona Coll., 24: 57, figs. 1, 2.

Oreohelix flammulifer Berry, Journ. Ent. & Zool. Pomona Coll., 24: 58, figs. 3, 4.

"Shell rather small, thin, low-conic; whorls about $5\frac{1}{4}$ to $5\frac{1}{2}$, rounded, strongly convex, carinate in the immature stages but the carina in the adult fading out near the beginning of the body-whorl, the latter descending strongly just back of the aperture. Suture distinct and quite deeply cut. Aperture rounded-ovate, somewhat compressed above, very oblique, its terminations strongly approaching and connected by a thin callus. Peristome hardly thickened and with even the columellar reflection slight. Umbilicus exceptionally broad and funicular, its diameter contained on an

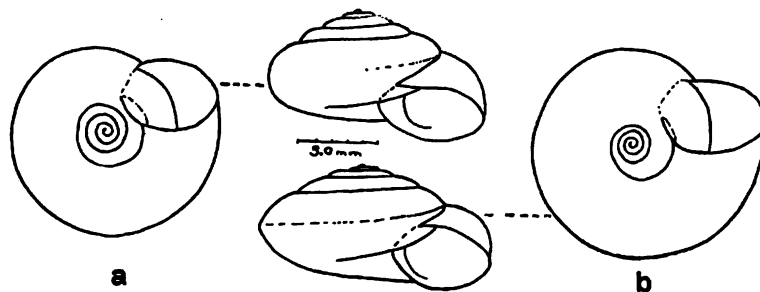


Fig. 323. a, *Oreohelix jugalis vortex*, type, $\times 2$; b, *O. jugalis vortex* color-form *flammulifer*, type, $\times 2$. (After Berry.)

average less than $3\frac{1}{2}$ times in the major diameter of the shell. Periostracum microscopically spirally striate, the striations considerably interrupted by the rather coarse and irregular lines of growth which form the only sculpturing readily evident to the unaided eyes. Embryonic shell almost vitreous and very delicately sculptured in some specimens, but in others some of the growth lines are accentuated to form almost a weak ribbing on the earlier whorls. Color of upper surface avellaneous to wood brown, suffused buffy brown and more or less clouded with mars brown, a sometimes rather ill-defined band of mars brown perhaps 1 mm. wide encircling the shell just below the periphery, with a narrower secondary band of the same hue usually present on the shoulder; base tiller buff suffused avellaneous." (Berry.)

Height 8 mm., diameter 14.2 mm., umbilicus 4.3 mm.; $5\frac{1}{2}$ whorls. Type.

Height 7.6 mm., diameter 12.6 mm., umbilicus 3.5 mm.; $5\frac{1}{2}$ whorls. Smallest paratype.

IDAHO: Salmon River, White Bird, Idaho County (Henry Hemphill), Type 7283 Berry Collection. Form *flammulifer*, same locality and collector, Type 7284 Berry Collection.

This race is known only by the collections of Hemphill. It was apparently found in abundance, as there are 41 specimens in our museum. It differs from *O. jugalis* proper by its small size and partly diverse coloration. The sculpture is the same in *jugalis*, *vortex* and *flammulifer*, minute spiral lines being present though weak in most examples, although in some scarcely a trace can be found. They are alike in having the peripheral angle of the neanic stage continued on the front of the last whorl in most individuals, but the periphery generally becomes rounded sooner in *jugalis* than in the smaller races. However, the angulation varies individually from distinct to obsolete in all of these races.

Typical *O. j. vortex* is brown of various shades above, usually with a narrow darker band above the light peripheral zone; below the periphery is a wider brown band, the rest of the base having a warm grayish tint. The diameter varies from 12 to 17 mm. in specimens at hand.

The form *flammulifer* Berry (Figs. 322 f; 323 b) is more opaque, being cartridge buff with dilute brownish streaks and patches above, some warm gray streaks on the base, with a rather wide band below the periphery, a narrow one on the upper surface (the upper band or both sometimes lacking). Sometimes the grayish tint predominates, leaving opaque whitish streaks on the base. I can not see any constant difference from *vortex* in shape or sculpture. The diameter varies from 14.1 to 15.7 mm. As the specimens occurred with *vortex* in two of the Hemphill lots, I consider it a color-strain of the same race rather than a distinct species. Berry's description follows:

"Shell a little larger than that of the preceding species, fairly heavy, low-conic; whorls usually $5\frac{1}{4}$ to $5\frac{1}{2}$, convex, somewhat shouldered, carinate in the younger stages but the last half of the adult body-whorl becoming

subcarinate, finally descending moderately to strongly just back of the aperture. Suture distinct. Aperture rounded-ovate, its terminations usually quite closely approximating and connected by a thin to heavy callus. Peristome hardly thickened and nowhere everted except for the slight columellar reflection. Umbilicus only moderately wide in young shells but expanding broadly on the last half-turn to attain a maximum diameter contained only $3\frac{1}{2}$ to a trifle better than 4 times in the major shell-diameter (average 3.8 times in specimens measured). Periostracum everywhere rather crudely and irregularly spirally striate, the striae best to be seen on the lower surface, but always interrupted and to a large extent obscured by the very coarse and heavy lines of growth, some of which on the very early whorls are occasionally nearly rib-like. Color of shell variegated above with whitish (near tilleul buff) and avellaneous, and with radial flame-like splashes of cinnamon brown; an unusually conspicuous band of cinnamon brown perhaps 0.7 mm. wide encircles the shell sub-peripherally with a narrower and more delicate band of slightly less intense coloring on the shoulder; base whitish or tilleul buff with deeper cloudings and rarely obscure traces of (one to three) bands."

Oreohelix jugalis intersum (Hemphill)

Fig. 322 d, e.

Patula strigosa var. *intersum* Hemphill, 1890, *Nautilus*, 3: 135. Binney, 1892, 4th Suppl., *Bull. Mus. Comp. Zool.*, 22: 170, reprint of preceding.—Pilsbry, 1893, *Man. Conch.*, 8: 117, pl. 41, figs. 91, 92.

Oreohelix intersum (Hemphill), Berry, 1932, *Journ. Ent. & Zool. Pomona Coll.*, 24: 62, figs. 9, 10.

Oreohelix jugalis intersum (Hemph.), Pilsbry, 1934, *Proc. Acad. Nat. Sci. Phila.* for 1933, 85: 406.

"Shell umbilicated, sublenticular, depressed, thin, dark horn color more or less stained with darker chestnut. Whorls $5\frac{1}{2}$ or 6, somewhat flattened above, more convex beneath, obtusely carinated at the periphery, and bearing numerous coarse, oblique, rib-like striae, and two dark revolving bands. Suture well impressed. Umbilicus large, pervious. Aperture oblique, sub-angulated; lip simple, thickened, its terminations joined by a thick callus. Height of the largest specimen $\frac{1}{2}$ inch, breadth $\frac{3}{4}$ inch. Smallest specimen height $\frac{5}{16}$ inch, breadth $\frac{7}{16}$ inch." (Hemphill.)

IDAHO: Stone piles at the foot of a steep bluff back some distance from the banks of the Little Salmon River (Hemphill), Lectotype 5638 C.A.S.

Paratypes measure 7.3 x 12.6 mm., $5\frac{1}{2}$ whorls; 11.2 x 18.2 mm., $5\frac{1}{2}$ whorls; 11.5 x 17.3 mm., $5\frac{1}{2}$ whorls. Only the most depressed individuals can be termed "sublenticular"; usually the spire is distinctly conoidal. Quite old shells have the parietal callus thick; generally it is thin. The color varies from buff with one or two dark bands to suffused with dilute walnut-brown above, lighter beneath, with two walnut-brown bands and occasionally some narrow bands and lines on the base. The strong, irregular rib striation is well developed on the 22 shells we possess, though variable, either fine or coarse. Just where on the Little Salmon River Hemphill found this snail is not known. His vague statements about localities are irritating.

(*Intersum*, coming between.)

Oreohelix amariradix Pilsbry

Fig. 324.

Pyramidula strigosa var., Elrod, 1902, Bull. Univ. Montana, no. 10, pl. 27, 3d column of figures.

Oreohelix amariradix Pilsbry, 1934, Proc. Acad. Nat. Sci. Phila. for 1933, 85: 394.

The shell is openly umbilicate, the umbilicus contained about 4 times in the diameter; biconvex, with the periphery rather sharply angular, the angle disappearing on the last third of a whorl. Whorls $5\frac{1}{3}$, the embryonic $2\frac{1}{3}$ moderately convex and nearly smooth. Subsequent whorls rather coarsely and irregularly wrinkle-striate, without spiral striation, but there is often a

Fig. 324. *Oreohelix amariradix*, type.

spiral impression above the suture on the penult whorl. The last whorl descends shortly in front. Aperture rather strongly oblique, shaped much as in *O. jugalis*. The specimens are bleached but show a reddish band immediately below the periphery, another a short distance above it.

Height 8.5 mm., diameter 14.5 mm.

MONTANA: Bitter Root Mountains, along bluffs of Lo Lo Creek at 5000 feet (Morton J. Elrod), Type 79801, paratypes 78737 A.N.S.P.

Only bleached specimens are known to me. Relationships are somewhat uncertain, but the characters of the shell suggest that *O. jugalis* (Hemphill) and this species should be compared when living examples are available. Neither of them has yet been dissected. The locality is about 16 or 17 miles southwest of Missoula.

(*Amariradix*, bitter root.)

Oreohelix alpina (Elrod)

Fig. 325.

Pyramidula strigosa Gld., var. *alpina* Elrod, 1901, Rocky Mountain Magazine, 2: 696, figs.; 1902, Bull. Univ. Montana, no. 10, pp. 172, 177, pl. 27, right hand figs.; 1903, Nautilus, 17: 2.

Pyramidula strigosa var. *montana* Elrod, 1902, Bull. Univ. Montana, no. 10, p. 121 (error for *alpina*, corrected on p. 177).

Fig. 325. *Oreohelix alpina*, topotype (enlarged and actual size).

"Shell small; brownish-gray, tending toward light horn color, in dead shells turning to pearly white; lustre somewhat silky; shell flat, little elevated; lines of growth, under hand lens, fine, an occasional increment of growth giving the appearance of sculpturing; suture well impressed, the periphery well rounded; aperture nearly circular, slightly obovate, somewhat higher than wide; markings as in *strigosa*, the upper band continuing in the spire, gradually disappearing; umbilicus medium, circular, deep, subcylindric. Large diameter 7-10 mm., average of ten specimens, 8.91 mm.; greatest depth 3-5 mm., average of ten, 4.34 mm.; aperture 3.65-4.38 mm., average of eight, 3.99; whorls 4-4.50, average of ten, 4.26." (Elrod.)

The shell is very thin, somewhat lens-shaped with low conoid spire, and umbilicus contained $4\frac{1}{2}$ to $5\frac{1}{2}$ times in diameter; matt brown with two dark bands and light base. Striation fine and irregular. There is no spiral sculpture. The last whorl is strongly angular at periphery but the angle disappears near the end, where the whorl descends slightly.

Height 5.4 mm., diameter 9.4 mm., $4\frac{1}{2}$ whorls.

MONTANA: Mission Range on Sinyaleamin Mountain, 8500 feet, type in University of Montana Museum. McDonald Peak from 7800 to nearly 8500 feet (M. J. Elrod).

The special features of this form, small size and thin, angular shell of few whorls, are those of immaturity, and are characteristic of some races at high elevations and in other unfavorable stations. It is therefore possible that when collections are made at intermediate elevations some connecting links may be found with the large, elevated *O. subrudis* of lower levels (McDonald Lake at 3300 feet, etc). No form of *O. strigosa* is known to occur in or near the Mission Range. I have been unable to obtain material for dissection. Pending further field and anatomic studies *O. alpina* may well be allowed specific rank.

OREOHELIX YAVAPAI GROUP

Oreohelix concentrata (Dall)

Figs. 326, 327.

Patula strigosa var. *concentrata* Dall, 1890, Proc. U. S. Nat. Mus., 18: 1; 1897, 19: 336.

Oreohelix strigosa concentrata (Dall), Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 273, pl. 24, figs. 25-32; pl. 25, fig. 60.

Oreohelix concentrata (Dall), Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 352, pl. 22, fig. 9 (genitalia).

Helix (Patula) hemphilli Newc., Stearns, 1893, Proc. U. S. Nat. Mus., 16: 745 (Fort Huachuca).

Patula strigosa Gld., Dall, 1896, Proc. U. S. Nat. Mus., 19: 335 (excl. of Hachita Grande record).

"*Pyramidula strigosa huachucana* Pilsbry, 1902, Proc. Acad. Nat. Sci. Phila., p. 511.

Oreohelix strigosa huachucana Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 275, pl. 24, figs. 1-24; pl. 25, figs. 33-43; pl. 22, fig. 5.

Oreohelix concentrata huachucana (Pils.), Pilsbry & Ferriss, 1923, Proc. Acad. Nat. Sci. Phila., 75: 95, fig. 11.

Oreohelix concentrata form *huachucana* Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 354.

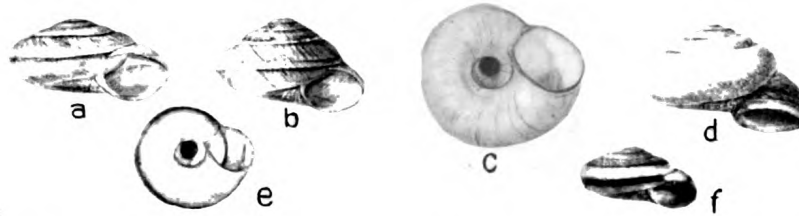


Fig. 326. a, b, *Oreohelix concentrata* form *huachucana*, Carr Canyon; c, d, Ida Canyon. e, f, *O. concentrata*, paratype.

The small shell is depressed, with umbilicus contained about $3\frac{3}{4}$ times (typical), to about 5 times in the diameter. The whorls are convex, the last descending a little in front, rounded at periphery but perceptibly angular close above the aperture; pale buff or white, with a chocolate band below the periphery, a narrower one some distance above it (but both may be absent, or may be wide, the upper one sometimes covering most of the whorl). Surface with weak, irregular oblique striation; no spiral striae.

"Alt. 8, diameter 16 mm." Type.

Height 7.8 mm., diameter 15 mm.; 5 whorls. Paratype.

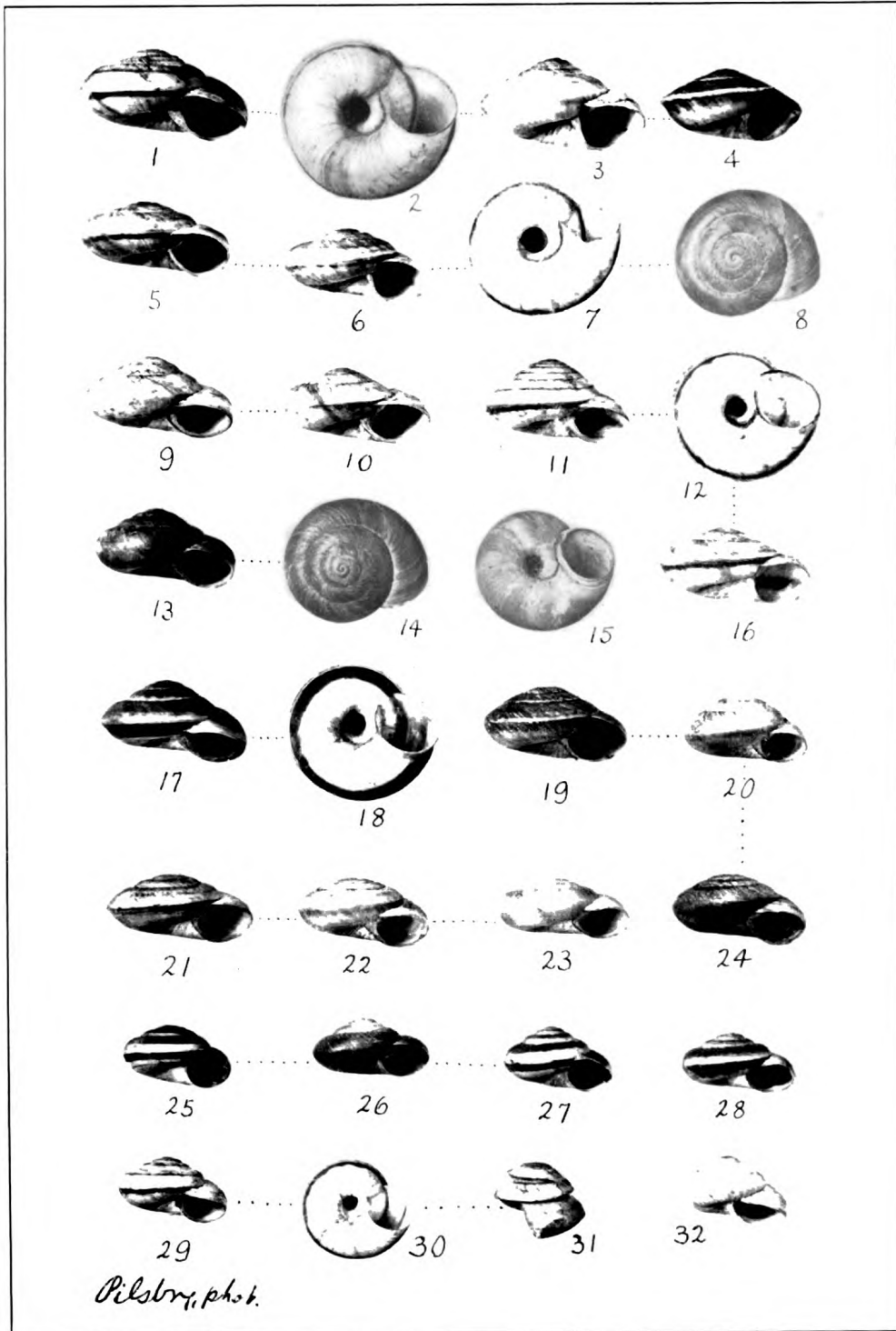
ARIZONA: Summit of Huachuca Mountains (E. A. Mearns), Type 129999 U.S.N.M. Limestone Mt., west of upper Ramsey Canyon; upper Carr Canyon and Carr Peak; Miller Peak (J. H. Ferriss and others); 7000 to 9200 feet elevation.

Large form (*huachucana*) in the Huachuca Mountains: Ramsey Canyon up to 7000 feet, Type 83370 A.N.S.P.; Brown Canyon, 7000 feet; Carr from 5500 to 6500 feet; Miller Canyon 5000 to 6500 feet; Miller Peak; Bear Canyon, 6000 feet; Cave, 5500 feet; Ida, 7000 feet. Mustang Mountains, subfossil only. Whetstone Mountains in many places. Dragoon Mountains in Tweed Canyon, fragments buried under stones (Ferriss and Pilsbry).

MEXICO: San José Mt., 5-6 miles south of international boundary, east of San Pedro River (E. A. Mearns).

The uterine young of about $2\frac{1}{2}$ whorls, 6 to 6.5 mm., diameter, are acutely keeled, flattened above, the first $1\frac{1}{2}$ whorls light brown, with some rather weak radial striation; following whorl usually mottled, with some rather sparse radial wrinkles, and generally traces of two or three spirals bearing cuticular fringes. The base shows 3 to 6 spiral series of short scales, varying from very weak to well developed. In the neanic stage the periphery is acutely carinate, and this keel extends upon the first half of the last whorl, either strong or reduced to an angle. In some lots of the large form, as one from Carr canyon at 5500 feet, the keel is strongly

Fig. 327. *Oreohelix concentrata*. 1-4, Miller Canyon, 5000 ft.; 5-8, Ramsey Canyon; 9-14, 16-18, Brown Canyon, 7000 ft.; 15, same, 6000 ft.; 19-20, 24, Carr Canyon, 6000 ft.; 21-23, same, 5500 ft.; 25-27, 29-32, Limestone Mt., 8000 ft.; 28, Carr Canyon, 7000 ft. Figures 1-24 are the form *huachucana*, figures 25 to 32 being *concentrata* proper. See p. 503.



developed almost to the end, as in Fig. 326 a, b. Some shells of this lot show fine engraved spiral lines on the last whorl, an extremely rare feature in this species. In some other lots the keel does not reach the last whorl, which is rounded throughout. The surface of the later whorls is usually dull, with rather coarse, low, irregular wrinkle striae. The whorl usually descends a little in front, but sometimes very deeply. The margins of the aperture converge and are connected by a short parietal callus.

This species was based upon the dwarf forms of the high peaks of the Huachucas,¹ described above, and represented in Figures 326 e, f, and 327: 25-32. The first three references given above pertain to this form. The long series collected by Ferriss shows that complete intergradation of size exists between the smallest *concentrata* and the large, generally distributed form described as *huachucana*, of mainly lower elevations. There is no reason to believe that the small forms found on different peaks of the Huachucas are genetically related except through their ancestral large forms of lower levels.

These dwarf snails are variable in color, size, degree of elevation and width of umbilicus, in the same colony; thus, shells from a Carr Peak lot measure from 8.5 x 17 mm. to 9 x 14.3 mm. It is rarely brown throughout, the spire paler. Greenish white albino shells were found on Miller Peak, typical in form but about 16.5 mm. in diameter. The description and Figure 326 e, f are from one of Dall's type lot.

The genitalia agree with the large form of the species. Genitalia of a specimen from Miller Peak were figured in Proc. Acad. Nat. Sci. Phila. 1916, pl. 22, fig. 9. The penis is swollen below the middle, length 8 mm., length of internally costate part 4.5 mm.; of epiphallus 4 mm.; of vagina about 3.6 mm.; diameter of the shell 15.5 mm.

The large form of the species usually measures around 20 to 23 mm. in diameter, the type of "form *huachucana*" 10.5 x 21.3 mm.; but in any lot smaller ones may occur. Thus, in a Bear Canyon lot from 6000 feet the diameters are from 15 to 21.5 mm. The largest shell seen measures 24.9 mm. There are several color patterns: 1, marbled with opaque white on a fleshy ground, with or without a dark band below the periphery; this varies to white, speckled and streaked with flesh tint or gray. 2, Nearly uniform wood brown. 3, Above and below the periphery, with broad walnut brown bands, which may spread into chocolate clouds, leaving the center of the

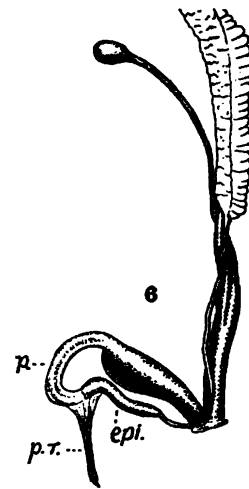


Fig. 328.

¹ It seems to have been confused with a superficially similar snail of Big Hatchet Peak in Dall's papers, but the type lot, which I have examined, is the Huachucan form.

base, periphery and a sutural line white. This pattern varies in width of the bands in any colony. Transitional patterns are frequent.

Genitalia of a paratype of *huachucana* figured (Fig. 328). Lower half of the penis much swollen. Internally the narrower basal part has strong, acute folds, becoming weak in the swollen part, which contains a large, fleshy body adnate to the upper side. The contracted upper half of the penis is papillose within, with three low ridges. Length penis 14 mm. from shell of 21 mm.

The radula has 30.130 teeth. Those of the median area are unicuspid with lateral overhang of the mesocones. The ectocone begins weakly on the sixth or seventh, and is well developed on the eleventh tooth. The marginal teeth are all bicuspid, the cusps not split.

The Whetstone Mountain form is generally more depressed and more widely umbilicate than is usual in the Huachucas, but some Huachucan



Fig. 329. *Oreohelix concentrata*, form *huachucana*. Whetstone Mountains.

examples are entirely similar, and some from the Whetstones are elevated. They are always angular or keeled in front or throughout. Fully adult specimens measure:

Height 13.3, diameter 22 mm.	Height 12.3, diameter 24.5 mm.
Height 10.3, diameter 18 mm.	Height 12.5, diameter 22.7 mm.
Height 13.3, diameter 25 mm.	Height 9.3, diameter 20.4 mm.
Height 8.7, diameter 17.3 mm.	

In the Mustang Mountains only fossil specimens were found. Those from Station 157 measure 20-22 mm. in diameter, have a moderately raised spire, and are practically typical of the form *huachucana*. At Station 153 the shells are smaller, 15 to 19 mm. in diameter.

(*Concentratus*, condensed.)

Oreohelix swopei Pilsbry & Ferriss

Fig. 330.

Oreohelix swopei Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 93, pl. 9, figs. 2, 3-3b, 13; text-fig. 3.

The shell resembles *O. strigosa depressa*. It has an ample umbilicus, a low, conic spire, obtuse and rounded at the summit, and a slightly angular periphery. Color fawn or vinaceous fawn, with two chocolate or lighter bands in the usual positions, sparsely mottled with opaque, and finely, irregularly speckled and streaked with creamy markings, partly the result of wear. The surface is glossy where unworn, marked with irregular growth-

lines and fine wrinkles. No spiral striation. The embryonic shell, of $2\frac{1}{3}$ flat whorls, shows growth-lines and faint traces of microscopic spirals, and on its last third there are usually several small spiral threads (Fig. 333: 13). The young stages have an acutely angular periphery, which becomes bluntly angular on the last whorl, which descends very little in front. The aperture is strongly oblique.

Height 12 mm., diameter 21 mm.; $5\frac{1}{2}$ whorls. Type, lower figures.

Height 12 mm., diameter 22 mm.

Height 13.5 mm., diameter 20 mm. Upper figures.

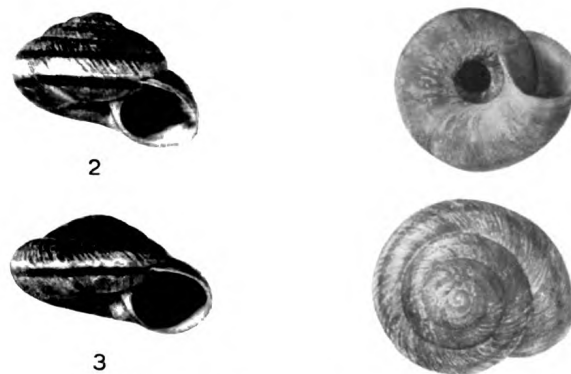


Fig. 330. *Oreohelix swopei*, slightly enlarged.

NEW MEXICO: Black Range, at head of Morgan Creek, Type 112896 A.N.S.P.; Black Canyon, 4 miles below Reed's ranch; on Diamond Creek, about 3 miles below the summit, and again about half way down (Ferriss and Pilsbry).

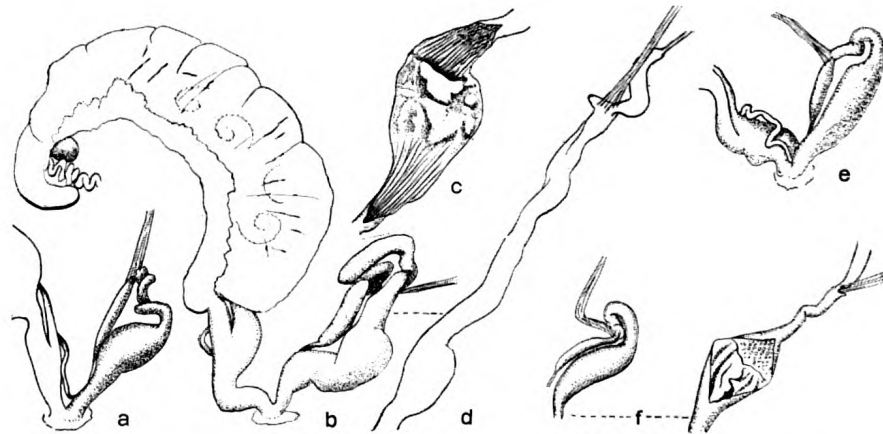


Fig. 331. a, Penis of *Oreohelix metcalfei radiata*. b, c, d, *O. swopei*: genitalia, opened penis, and penis straightened. e, *O. pilsbryi*. f, *O. metcalfei hermosensis*: penis and same opened.

With a strong superficial resemblance to *O. strigosa depressa*, this snail differs by the absence of spiral striation on the last whorl, by the far smoother embryonic shell, and especially by the soft anatomy, the male organs being quite different in the two species. In *O. s. depressa* the lower part of the penis is not swollen, and its cavity contains four or five subequal longitudinal ridges. These structures have been found constant in a great many specimens dissected, from Utah, Colorado, Arizona and New Mexico. In *O. swopei* the lower part of the penis is conspicuously swollen, its cavity containing several large, irregular, fleshy bodies, below which there are many small longitudinal cords (Fig. 331 b, c, d). *O. concentrata* differs by its far shorter penis. Length of penis 22 mm.; epiphallus 4.5 mm.; penial retractor 7 mm.; vagina 6.5 mm.; spermatheca 21 mm.; diameter of shell 21 mm.

In the specimen dissected, taken about September 15, there were eight embryos (Fig. 333: 13), the largest 4.2 mm. in diameter. The base shows many smooth spiral lines and bands cutting through densely crowded, crinkled radial striae. When these are worn off it appears almost smooth, the apparently strong spiral sculpture shown in the figures being cuticular.

In the field this shell was taken for *O. s. depressa*. It was found among rocks on the well-shaded slopes of ravines, usually with *Ashmunella* and *O. subrudis*. A few albino shells were found in one rock pile on Morgan creek.

(Named in honor of Dr. S. D. Swope, of Deming, New Mexico, who assisted materially in our Black Range expedition.)

Oreohelix metcalfei Cockerell

Fig. 332: 5.

Oreohelix strigosa metcalfei Cockerell, 1905 (February), *Nautilus*, 18: 113.—Pilsbry, 1905 (May), *Proc. Acad. Nat. Sci. Phila.*, p. 278, pl. 25, figs. 44, 48, 52.

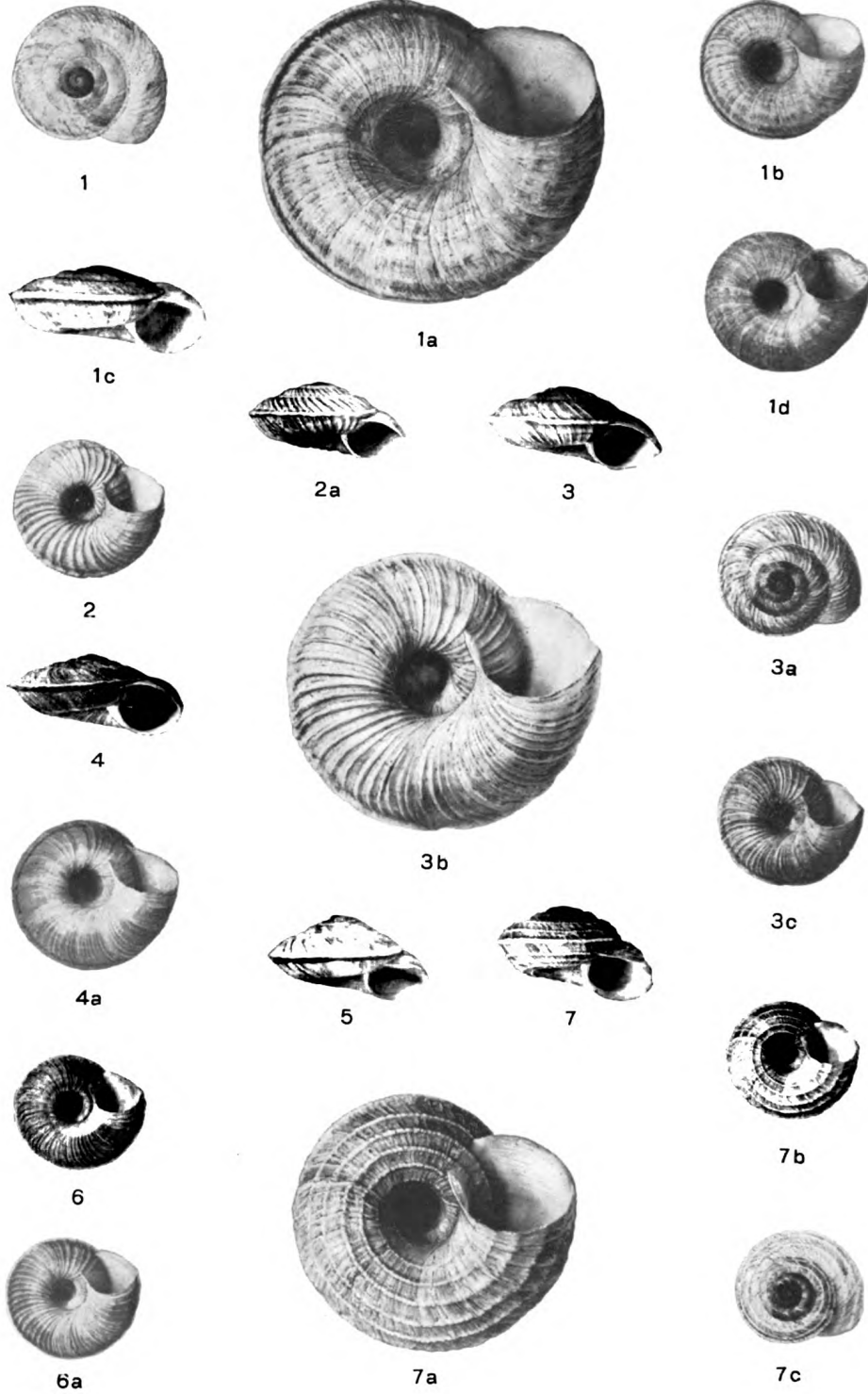
Oreohelix metcalfei Ckll., Pilsbry & Ferriss, 1917, *Proc. Acad. Nat. Sci. Phila.*, p. 95, pl. 8, fig. 5.

“Shell with max. diameter of 20 to 21 mm., alt. about 11 mm.; periphery with a strong but rather obtuse keel, just below which is a single brown band; umbilicus broad, not contracting rapidly within; the grayish-olivaceous cuticle is confined to the apical whorls in the adult; the ‘costulation’ of the apical whorls is evident, and the oblique striation of the last whorl above is very coarse and prominent.” (Cockerell).

After the light brown embryonic shell the surface is white with scattered pale brown streaks and some gray dots, base whitish with a walnut brown band below the strongly pinched keel, which continues to the aperture. The second whorl has fine, sharp retractive costulae; subsequent whorls with rather rude, unequal wrinkles of growth, partly coarse on the last two whorls and the base. Spiral striation is very weakly developed over the base and in places on the upper surface of the last one or two whorls. Umbilicus contained $4\frac{1}{2}$ times in diameter.

Height 10.8 mm., diameter 20.4 mm.; $5\frac{1}{2}$ whorls.

NEW MEXICO: Black Range, “mountains near Kingston”, Sierra County (O. B. Metcalfe), Type 10941 A.N.S.P.



This species is related to *O. socorroensis*, but that is a smaller form with the whorls more convex and the peripheral keel weak or obsolete on the last. Exactly where *O. metcalfei* was taken remains uncertain. Ferriss and I hunted it around Kingston one day without success. The country near the town is rather discouraging—steep stony hills with practically no shade, though there is abundant limestone. Probably we did not go far enough afield. The colony was perhaps higher on the mountains, not in the immediate vicinity of the town. The subspecies of *metcalfei* we collected were all in the forest zone, 7500 to 8000 feet elevation.

With the lectotype figured, the only live specimen, there were four dead shells. In two of them the umbilicus is wider, approaching *O. m. concentrica*, and all have the basal spiral lines rather deeply incised. Broken, immature shells found in Sam's canyon, about 6 miles south of Chloride, were at one time referred to this species, but they may be a form of *O. socorroensis*.

It appears that the *O. metcalfei* group, in Luna, Grant, Sierra and Socorro counties, comprises a series of forms largely parallel to the *O. haydeni* series in Utah and Colorado, and equally remarkable in its extremes of form and sculpture. On the west slope of the Black Range there are two forms: (1) in the south, *O. m. concentrica*, broadly umbilicate, with low, wide spiral cords on the base, and (2) farther north, *O. m. radiata*, with strong radial sculpture, remarkably like *O. elrodi*. On the eastern slope we have: (3), southward, *O. m. acutidiscus*, broadly umbilicate, with fine spiral and coarser radial sculpture, and (4) farther north, *O. m. hermosensis*, nearly smooth, angular only in front. Farther northeast was found *O. m. cuchillensis*, which is so weakly angular that we at first thought it a form of *O. strigosa depressa*. Farther west *O. pilsbryi*, closely similar to *O. haydeni*, was found. Sixty to seventy miles across the desert southward, in the Florida and Tres Hermanos ranges, another race, *O. m. florida* occurs, possibly now extinct. The *metcalfei* group therefore comprises, besides the original type, forms resembling *O. haydeni*, *O. elrodi* and *O. strigosa depressa*; each being alone in its district.

***Oreohelix metcalfei concentrica* Pilsbry & Ferriss**

Fig. 332: 1-1d.

Oreohelix metcalfei concentrica Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 97, pl. 8, figs. 1-1d; pl. 9, fig. 10.

The shell is much more broadly and openly umbilicate than *O. metcalfei*, the umbilicus contained $3\frac{1}{2}$ times in diameter; cartridge buff, inconspicuously mottled with gray or light drab, the embryonic whorls pinkish cinnamon, and the peripheral keel bordered below with a brown band. Sculpture of about five extremely low spiral cords on the base, and usually traces of two

Fig. 332. 1-1c, *Oreohelix metcalfei concentrica*, type; 1d, dark specimen. 2, 2a, *O. m. radiata*; 3-3a, same, type. 4, 4a, *O. m. acutidiscus*, type. 5, *O. metcalfei metcalfei*, type. 6, 6a, *O. m. radiata*. 7-7c, *O. pilsbryi*, type. Figures 1a, 3b and 7a about double natural size. See p. 508.

or three above, their intervals finely and sharply striate spirally, and there are very fine, irregular striae along growth-lines, sharp where they pass over the keel and spiral cords, elsewhere weak. The last whorl does not descend in front.

Height 9.3 mm., diameter 21.5 mm.; 4½ whorls.

NEW MEXICO: Southern end of the Black Range, Silver Creek, above 7500 feet, numerous colonies on limestone outcrops. Type 115755, A.N.S.P., from above the box of Silver Creek, on the north side (Pilsbry & Ferriss).

In most specimens the intervals between the cords on the base are dull brown, or when concolored the spiral striae make them appear darker, giving an appearance of relief to the cords. A few individuals from Station 11 (a branch ravine of Silver Creek south of Gray's cabin) have the base blackish chocolate. Specimens with the spiral cords on the base less conspicuous and the color usually darker—clouded and banded with dull walnut brown in varying degree—were found at the Grand Central Mine; Station 19, the next gulch north of that where the mine is; also Station 22, the succeeding gulch north (Fig. 332: 1d). At a station on the west side of Sawyer Peak about 500 feet below the summit, similar shells were found, varying from nearly typical color to broadly banded below with chocolate, the spiral cords therefore inconspicuous. An elevated shell in the type lot measures 11.5 x 21 mm.

Genitalia as in *O. m. radiata*. The embryonic shell (Fig. 333: 10) is very beautiful. The first whorl is smooth, cuticular laminae along growth-lines then appearing gradually. From these triangular processes rise, forming 3 or 4 spiral series above, usually 4 below a peripheral series of larger processes. The embryos of *radiata*, *acutidiscus* and *hermosensis* are identical with those of *concentrica*.

Oreohelix metcalfei acutidiscus Pilsbry & Ferriss

Fig. 332: 4. 4a.

Oreohelix metcalfei acutidiscus Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 98, pl. 8, figs. 4, 4a.

Broadly umbilicate, like *O. m. concentrica*, from which this race differs by having stronger growth-wrinkles (though much less coarse than in *O. m. radiata*), and in place of the spiral cords of *concentrica* there are slightly enlarged striae, the whole base being finely striate spirally between the riblets. It is mottled and clouded profusely, above and below, with walnut brown. The keel is very acute.

Height 10.5 mm., diameter 22.7 mm.; 5½ whorls.

NEW MEXICO: Black Range, at Station 23, about 1000 feet below the summit of Sawyer Peak, east of and below the camp site on the saddle, on a small outcrop of limestone (Pilsbry and Ferriss, 1915), Type 115757 A.N.S.P.

In another place down the mountain southeast from camp, station 18, we found a colony differing by being cartridge buff, a few with a band below the periphery. Both of the localities are on the opposite side of the

mountain from the known colonies of *O. m. radiata*. The embryonic shells are like those of *radiata* and *concentrica*.

Oreohelix metcalfei radiata Pilsbry & Ferriss Fig. 332: 2, 2a, 3, 3a-3c, 6, 6a.

Oreohelix metcalfei radiata Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 97, pl. 8, figs. 2, 2a, 3, 3c, 6, 6a; pl. 9, fig. 11.

Oreohelix metcalfei Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 352, pl. 22, fig. 10.

The shell is more openly umbilicate than *O. metcalfei*, with irregular sculpture of strong wrinkles in the direction of growth-lines, the lens showing fine spiral striae between the wrinkles of the lower surface, very few on the upper surface. Faint traces of a few coarse spirals on the base may be

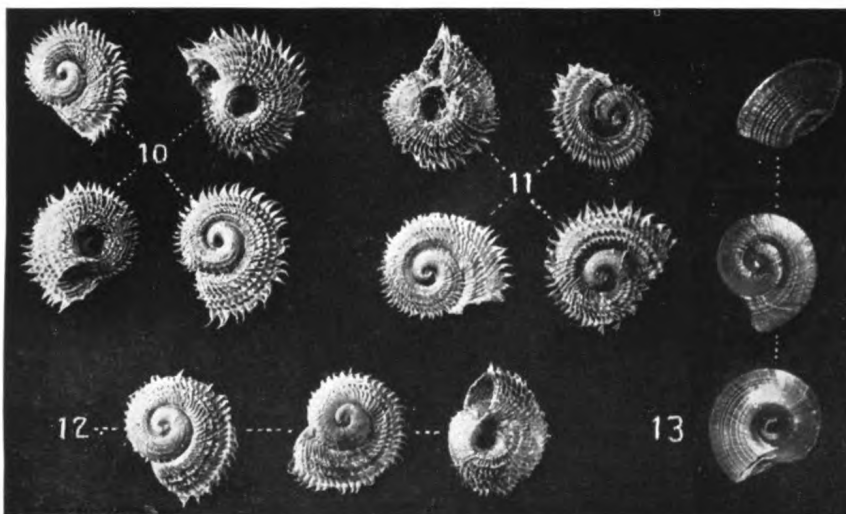


Fig. 333. 10, embryos of *Oreohelix metcalfei concentrica*; 11, *O. m. radiata*; 12, *O. m. hermosensis*; 13, *Oreohelix swopci*. (All $\times 4\frac{1}{2}$.)

discerned in most examples. The last whorl usually does not descend in front (but in some exceptional specimens it descends). The typical color is cartridge-buff, with some cream-buff clouding above, the early whorls being light pinkish cinnamon; but it varies, some shells having a bister band below the periphery, or this may be widened, suffusing much of the base (Figs. 6, 6a), with also a cinnamon line on the upper surface. In a few examples, all of the base except within the umbilicus is between chocolate and black, the upper surface being brownish.

Height 9 mm., diameter 19.7 mm. Figures 3-3c.

Height 10 mm., diameter 20.7 mm. Figures 2, 2a.

NEW MEXICO: Black Range, limestone outcrops on Iron Creek, Station 16, some distance above the confluence of Spring Creek, and on Spring Creek, Station 15 (Ferriss & Pilsbry), Type 112899 A.N.S.P.

The penis resembles that of *O. concentrata* and *O. pilsbryi*, the median portion being much swollen, with very thick walls, and broad, longitudinal

ribs inside. The much narrower, twisted upper portion has coarse papillae within, and one longitudinal papillose rib. Length of penis 12 mm., of its internally costate portion 7 mm.; of epiphallus 4 mm.; vagina 4 mm. Diameter of the shell 19.5 mm. Fig. 331a.

The radula has 12 lateral teeth on each side, like those of *O. s. depressa* except that the cusps are more slender.

Embryonic shell (Fig. 333: 11) as in *O. m. concentrica*.

Oreohelix metcalfei hermosensis Pilsbry & Ferriss

Fig. 334.

Oreohelix metcalfei hermosensis Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 98, pl. 9, figs. 4-4b, 12.

The shell is solid, cartridge buff or whitish with a narrow chocolate band below the periphery, and some indistinct pinkish cinnamon mottling, especially above. The surface is nearly smooth, having light irregular



Fig. 334. *Oreohelix metcalfei hermosensis*.

growth-lines and no spiral striae. The last whorl descends in front. It is strongly angular in front of the aperture, the angle becoming weak on the last half. The umbilicus is about as in *metcalfei*.

Height 12 mm., diameter 21.7 mm.; $5\frac{1}{2}$ whorls.

NEW MEXICO: Near Hermosa, Sierra County (J. H. Ferriss), Type 115759 A.N.S.P.

This subspecies resembles *O. metcalfei* in color and the smooth surface, but differs by wanting the strong keel of the last whorl; however, in some examples the front of the last whorl is sharply carinate, and some angulation extends to the aperture.

Genitalia are substantially as in *O. m. radiata*. The penis is figured (Fig. 331 f). The lower portion has several very irregular and unequal fleshy ridges within, upper portion papillose. Length of penis 13 mm., of its thickened lower part 5 mm.; length of epiphallus 3.5 mm.; of penial retractor 6 mm. Diameter of the shell 20.5 mm.

The embryonic shells (Fig. 333: 12) are exactly as in the forms of *metcalfei* from the Black Range. In the adult shell the embryo photographs abnormally dark on account of its yellow hue.

Oreohelix metcalfei cuchillensis Pilsbry & Ferriss

Fig. 335.

Oreohelix metcalfei cuchillensis Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 99, pl. 9, figs. 1-1b.

This form is smaller than *hermosensis*, and the peripheral angle in front of the aperture is weaker, scarcely noticeable. Typically there are very

minute and superficial spiral striae, but on many specimens these cannot be made out. The last whorl descends little or not at all in front. There is about a half whorl less than in *hermosensis*.

Height 9 mm., diameter 18.2 mm.; $4\frac{1}{4}$ whorls.

NEW MEXICO: Cuchillo Mountains, Sierra County, at two stations about two miles apart, at the southern end of the range (J. H. Ferriss), Type 115760 A.N.S.P.

We hesitated between uniting this with *O. m. hermosensis* and giving it separate standing. The sizes intergrade in a small number of specimens, *cuchillensis* varying from 15.4 to 20 mm. diameter; yet where this is the



Fig. 335. *Oreohelix metcalfei cuchillensis*.

case, the specimens are readily separable by other characters. Except for one specimen of 20 mm. diameter, none of the lot of over 200 specimens exceeds 19 mm.

The genitalia are substantially similar to *O. m. hermosensis* except for the smaller size. Length of penis 7, of its thickened lower portion 4 mm.; of epiphallus 3 mm.; of penial retractor 6.5 mm.; diameter of shell about 17.5 mm. No embryos were found in a few specimens preserved in spirit, taken in October.

Oreohelix metcalfei florida new subspecies

Oreohelix strigosa var., Pilsbry & Ferriss, 1915, Proc. Acad. Nat. Sci. Phila., p. 349.

The shell is moderately elevated, strongly carinate in youth, in the adult stage showing a flattening or an impressed line above the suture of early neanic whorls, becoming rounded at periphery in the adult, though noticeably angular in front of the aperture. Umbilicus contained $4\frac{2}{3}$ times in diameter. There is a brown band below the periphery. Embryonic sculpture like that of adult *O. metcalfei* and *O. socorroensis*; later whorls rather rudely, irregularly wrinkle-striate, without spiral striation.

Height about 11 mm., diameter slightly over 17 mm.

NEW MEXICO: Florida Mountains, near the central peak above the spring on the west side (Ferriss and Pilsbry), Type and paratype 103243 A.N.S.P. Southern peak of the Tres Hermanos at about 4700 feet (Pilsbry and Harvey).

In the Floridas we found two old "bones" only, buried in the soil. Possibly it exists in the southern end of the range or elsewhere where we did not search, but it may be extinct. It is more like the most distant northern races of *metcalfei*, such as *hermosensis* than those nearer, in the

southern part of the Black Range about fifty miles from the Floridas. Several "bones" were found in the Tres Hermanos, where it probably will be found alive when adequate search is made higher than we had time to go. One has a diameter of 16.3 mm.

Oreohelix pilsbryi Ferriss

Fig. 332: 7-7c.

Oreohelix pilsbryi Ferriss, 1917, Nautilus, 30: 102.—Pilsbry & Ferriss, 1917, Proc. Acad. Nat. Sci. Phila., p. 100, pl. 9, figs. 5-9.—Pilsbry, 1916, Proc. Acad. Nat. Sci. Phila., p. 352, pl. 22, fig. 8 (genitalia).

The shell is thin, biconvex with low spire, obtuse summit and carinate periphery; width of umbilicus contained $4\frac{1}{2}$ times in the diameter; pinkish buff, the last whorl sometimes lighter. The embryonic whorls are dull brown, the first nearly smooth, the next more convex, with rather close, fine retractive riblets, which are often laminar in the outer suture, and often with one or two low spiral ridges. The following whorls are rudely striate and with two or three cord-like spiral ridges, another in the suture; these cords are irregularly beaded by the striae. The last whorl descends in front, is convex above and below, with sculpture of two or three spiral cords above and four or five below the peripheral keel. There are fine incised spiral lines between the cords on the base, and sometimes on the upper surface also. The aperture is very shortly oval, the margins of the peristome approaching, connected by a short parietal callus.

Height 10.3 mm., diameter 17.8 mm.; $4\frac{1}{2}$ whorls.

NEW MEXICO: Oliver's mine on Mineral Creek, 5-6 miles above Chloride, Sierra County (J. H. Ferriss), Lectotype 112918 A.N.S.P.

While closely related to *O. metcalfei* by the reproductive organs and the embryonic whorls of the shell, this form appears to be sufficiently distinct for specific rank. It is more like *O. m. concentrica*, but differs by the narrow, strongly raised spiral lirae and the smaller umbilicus. It is also relatively higher, and has an astonishing resemblance to some forms of *O. haydeni*, of Utah, which is known to belong to a different group, not directly related to *O. pilsbryi*.

There are usually four spirals on the base, two on the upper surface. The embryonic whorls of adults and the genitalia are substantially as in *O. metcalfei radiata* and the other forms of that species. Embryos were not found in the uterus in the few specimens preserved in spirit, collected in October.

Living snails were found in abundance under limestone spawls and fallen timber. They have an enemy which breaks a hole about 2 mm. in diameter in the upper surface of the shell.

Genitalia (Fig. 331 e). The swollen part of the penis has about 6 unequal ribs within; these project slightly into the cavity of the papillose portion, which has one longitudinal rib. Length of penis 12, of the ribbed portion 7 mm.; epiphallus 4 mm.; penial retractor 4 mm.; vagina 4 mm.; spermatheca and duct 15 mm.; diameter of the shell 17.6 mm.

Oreohelix socorroensis Pilsbry

Fig. 336a.

Oreohelix strigosa socorroensis Pilsbry, 1905 (May 18), Proc. Acad. Nat. Sci. Phila., p. 279, pl. 25, figs. 49-51.

The shell is thin, with $2\frac{1}{2}$ embryonic whorls, the first smooth, the next with fine, close and sharp retractive riblets, most shells with a few low, coarse spirals on the last embryonic whorl. Whorls $4\frac{1}{2}$ to $4\frac{3}{4}$, convex, the later ones rudely but not very coarsely wrinkled, without noticeable spirals above, but the base is very densely and distinctly striate spirally. The last whorl is quite convex above and below a cord-like peripheral keel, which extends nearly or quite to the aperture. The last whorl descends a little and slowly in front. The umbilicus is rather small, but enlarges at the opening, and is contained $4\frac{2}{3}$ times in the diameter. The aperture is slightly longer than wide, the basal margin deeply concave; peristome thin.

Height 8.7 mm., diameter 15.2 mm. Type.

NEW MEXICO: Negra Mountains, Socorro County. Type and paratypes 58128 A.N.S.P., received from Dr. W. D. Hartman, collector unknown.



Fig. 336. a, *Oreohelix socorroensis*. b, *O. s. magdalanae*.

This species was described from a lot of 8 very dead shells, entirely white except that one shows rusty brown embryonic whorls. In some shells the keel extends to the peristome, but in one it is scarcely visible on the last half whorl. Immature shells are strongly keeled.

I do not find any "Negra Mts." on maps consulted. Possibly it is a name for some northern outlier of the Black Range.

Oreohelix socorroensis magdalanae new subspecies

Fig. 336 b.

The shell is similar to *O. socorroensis* in size and apical sculpture, but somewhat less depressed, the umbilicus contained slightly more than four times in the diameter. Surface with rather rude and irregular striation, less coarse than in *O. socorroensis*, but without spiral striation on the last two whorls. Periphery weakly angular in front of the aperture, wholly rounded in the last half turn. The whorl scarcely descends to the aperture. Color light buff with some opaque mottling, a 1 mm. wide cinnamon-brown band below the periphery, a much narrower one some distance above it.

Height 10.3 mm., diameter 15.8 mm.; $4\frac{2}{3}$ whorls.

NEW MEXICO: Magdalena, Socorro County (J. H. Ferriss), Type and paratypes 158166 A.N.S.P.

Living specimens were not found, but the "bones" are in good condition.

Oreohelix houghi Marshall

Fig. 338:9-12.

Oreohelix houghi Marshall, 1929, Proc. U. S. Nat. Mus., vol. 76, art. 5, p. 2, pl. 1, figs. 7, 8, 9, 10.—Pilsbry, 1933, Proc. Acad. Nat. Sci. Phila., 85: 403, pl. 15, figs. 9-12; text-figs. 17-19a.

Oreohelix houghi winslowensis Marshall, 1929, Proc. U. S. Nat. Mus., vol. 76, art. 5, p. 3, pl. 1, figs. 4, 5, 6, 12.

Patula strigosa Gld., Stearns, 1892, Nautilus, 6: 1; 1893-4, Proc. U. S. Nat. Mus., 16: 745.

“Shell depressed, low conic, upper surface of whorls slightly rounded. Early whorls (as shown by young shells) sharply angled, and with a white cord-like keel which fills all the sutures to the aperture, in front of which the keel disappears but the periphery for a short distance remains angular; on the back of the body-whorl the angle fades out and just behind the aperture the whorl is well rounded. Upper part of each whorl attached to under side of the carina.” (Marshall.) Umbilicus contained from about 5 to 6 times in the diameter.

Live specimens are rather glossy, cartridge buff above, white below, smeared with oblique cinnamon streaks, and two chestnut brown bands which are of uneven width, often spreading into spots at the oblique smears; embryonic whorls cinnamon-buff. Four and two-thirds (or in the largest individuals 5) whorls, the first $2\frac{2}{3}$ forming the embryonic shell, marked off from succeeding whorls by an inconspicuous line; the first two whorls are strongly convex, the next more or less impressed near the outer suture, all of them finely striate without spiral striation. Post-embryonic whorls are somewhat less convex, the last whorl usually more or less angular in front of the aperture, the angle soon disappearing, leaving the periphery rounded; suddenly but not deeply descending in front. Sculpture of light, irregular wrinkles of growth. The shortly oval aperture is but little wider than high, strongly oblique, the parietal callus short.

Height 13 mm., diameter 20 mm.; umbilicus 4 mm.; 5 whorls.

Height 9.4 mm., diameter 18 mm.

Height 9.5 mm., diameter 16.5 mm.

Height 10.5 mm., diameter 16.5 mm.

“Height 9.5 mm., diameter 17.5 mm., type; largest paratype 12 x 21.75 mm.” (Marshall.)

ARIZONA: Southeastern Coconino County in Canyon Diablo and Meteor Crater (Marcus Baker, J. H. Ferriss). Navajo County at Heber (Dr. Walter Hough), Type 334603 U.S.N.M. Clear Creek near Winslow, Type of *O. h. winslowensis* Marshall, 181309 U.S.N.M.; Holbrook (U.S.N.M.) Apache County at Hardscrabble Draw near Zuñi Sacred Lake (U.S.N.M.).

This species of the Colorado Plateau in the Little Colorado River valley is a very pretty shell when in good condition. The irregular or spotted bands, absence of spiral striation, and the unusually large embryonic shell are its main features. An embryo is acutely carinate, 6.2 mm. in diameter, of nearly three whorls, the mother measuring 11.5 x 18 mm.

The study of a large series collected by Mr. Ferriss, together with an examination of the original types and other specimens in the U. S. National Museum, shows that the small differences between *O. houghi* and *O. h.*

winslowensis are individual and not racial. Both forms occur together in some of our lots, with intergrading examples. Marshall's material was not in good condition, all dead "bones," none of the shells showing much color. The species is very distinct from other known forms.

It is an abundant snail in Meteor Crater and Canyon Diablo, on the Kaibab Limestone. Its area covers about 100 miles from west to east, 40 or 50 north and south.

Genitalia (Fig. 337). The penis is swollen in the lower half, which contains four or five unequal fleshy ribs which do not reach to the base. The upper two-fifths is thin-walled, granulose within. In the specimens opened it is more or less introverted at the apex as is usually the case in

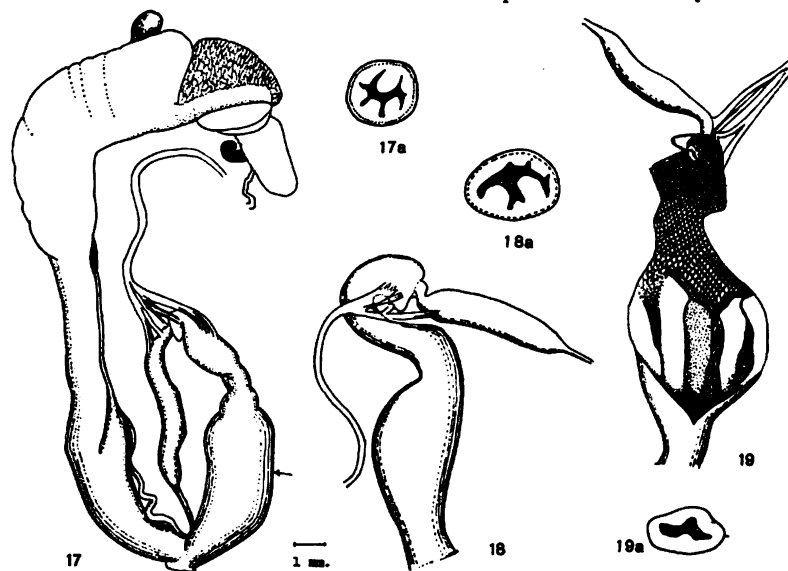


Fig. 337. 17, *Oreohelix houghi*, Old Trail Highway, Canyon Diablo. Genitalia: 17a, transverse section of penis. 18, North side of Canyon Diablo, penis; at 18a a transverse section. 19, Meteor Crater, opened penis; at 19a a transverse section at lower fourth.

Oreohelix, sometimes giving the appearance of a short verge, as in Figure 337: 19, though the orifice is generally lateral on the papilla. The distal end is truncate and slightly cornute as usual. The very long penial retractor is much split, branches being inserted on both penis and epiphallus. The vas deferens is inserted subcentrally or a little to one side of apex of the epiphallus. It is not coiled around under the vagina. Length of penis 8.5 mm., of internally ribbed part 5 mm.; of epiphallus 3.5 mm.; penial retractor 7 mm. In another example the dimensions are: Length of penis 9.5 mm., of ribbed part 5.5 mm. The talon is brown, large, simple and recurved as usual.

***Oreohelix yavapai* Pilsbry**

Fig. 339 a.

Oreohelix yavapai Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 281, pl. 25, fig. 53; pl. 11, fig. 13 (embryonic shell); pl. 19, fig. 7 (penis); pl. 22, fig. 7 (teeth).

Shell thin, whitish, the spire dull brown; with a faint brown band above and another close below the periphery. A peripheral keel extends to the aperture, but is pinched up less than in *neomexicana*; the last whorl elsewhere is well rounded, the earlier whorls flattened, the keel filling the suture. Embryo of $2\frac{1}{4}$ whorls, the first nearly smooth, convex, the next more flattened, finely, densely striate obliquely, and very strongly striate and

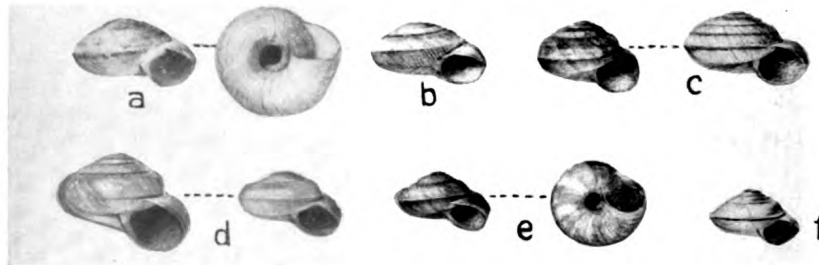


Fig. 339. a, *Oreohelix yavapai*, type. b, *O. y. neomexicana*, Canyon Diablo; c, top highest peak Sandia Mts.; d, Grants; e, Golden. f, *O. y. compactula*, type.

ribbed spirally. At the end of the embryonic stage this spiral sculpture abruptly stops, and is succeeded by sharp oblique striation which becomes cut by a few spiral lines. On the last whorl there are more spirals, the larger ones, especially on the base, emphasized as series of granules (bearing short cuticular processes in perfectly fresh shells). Whorls about $5\frac{1}{3}$, the last hardly descending in front. The umbilicus is ample, contained $3\frac{3}{4}$ times in the diameter. Aperture oblique, rounded, with thin lip.

Height 9.2 mm., diameter 16.8 mm.

ARIZONA: Purtyman's ranch, on Oak Creek, Yavapai County, about 40 miles from Jerome (E. H. Ashmun), Type and paratypes 79415 A.N.S.P. Also found on the summit of Mt. Mingus, near Jerome, and fossil in a road cutting in Walnut Gulch, near Jerome (Ashmun).

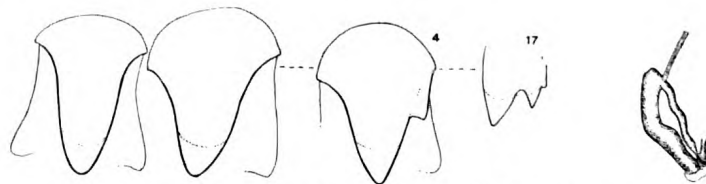
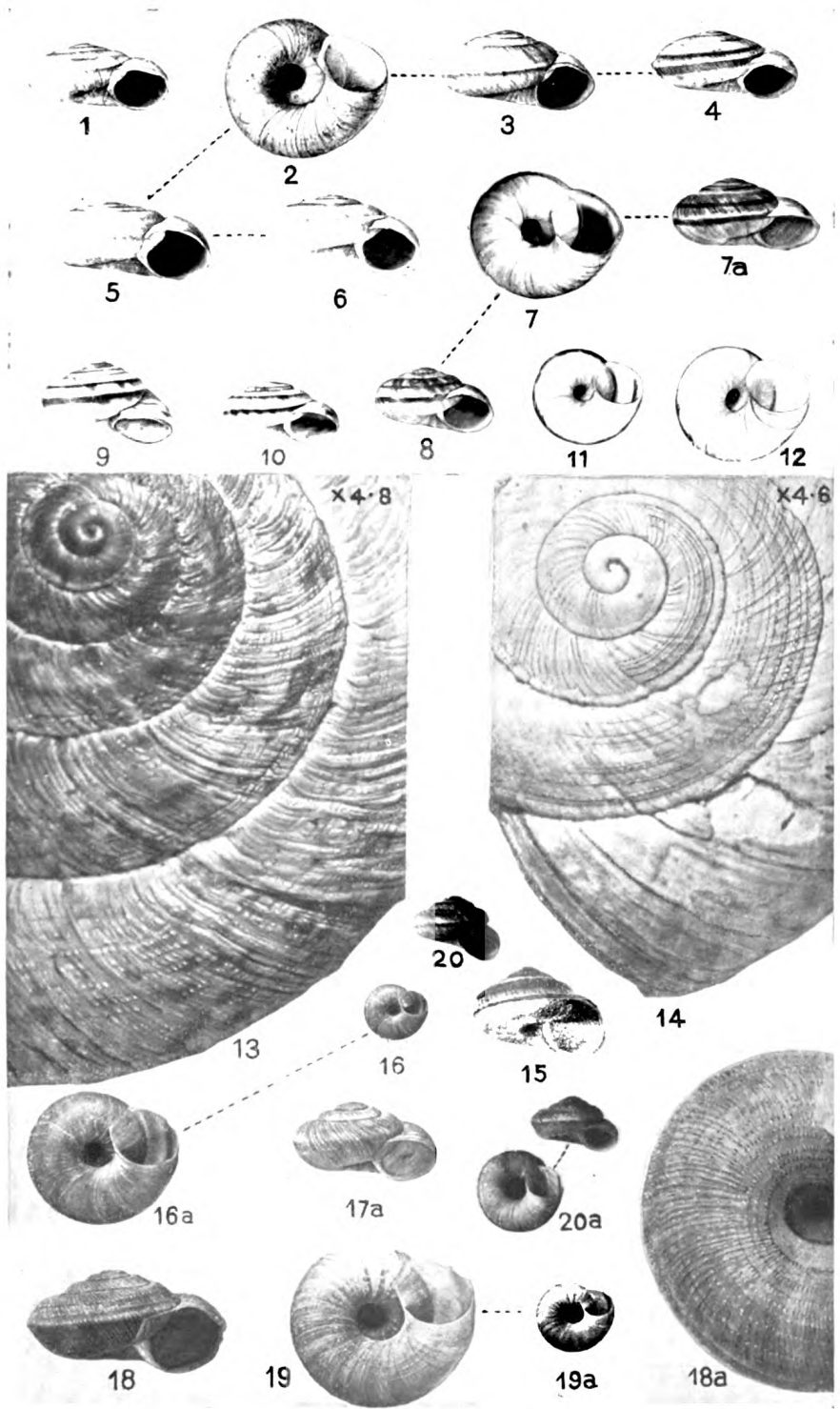


Fig. 340. Teeth and penis of *Oreohelix yavapai*.

The radula of one of the type lot has 26.1.26 teeth. Central and inner laterals unicuspid; outer laterals with a strong outer cutting point, becoming a well developed ectocone on the marginals (Fig. 340).

Fig. 338. 1-6, 14, *Oreohelix yavapai fortis*. 7, 7a, 8, *O. junii*. 9-12, *O. houghi*. 13, *O. strigosa*, Spokane Falls. 15, *O. subrudis* (after Reeve). 16, 16a, 17a, 20, 20a, *O. yavapai clutei*. 18, 18a, 19, 19a, *O. y. cummingsi*. (Figs. 1 to 12 somewhat reduced; 15, 16, 17, 19a, 20, 20a natural size; the others enlarged.) See p. 518.



The penis (Fig. 340, right) resembles that of *O. y. neomexicana* except by being larger, and the vas deferens enters the epiphallus centrally. There were 10 embryos in the uterus of the individual opened.

***Oreohelix yavapai neomexicana* Pilsbry**

Fig. 339 b, c, d, e.

Oreohelix yavapai neomexicana Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 282, pl. 11, figs. 8, 9; pl. 19, fig. 59 (penis); pl. 25, fig. 59.

The shell differs from *O. yavapai* by being more depressed, with the carina stronger, the surface above and below it concave, and the whorls are conspicuously swollen below the suture. Wrinkle striation rude and irregular typically, but variable. Granose spirals are from moderately to quite weakly developed, sometimes obsolete in old shells. Embryonic whorls 2-2½, impressed above the suture, densely, finely striate, and with faint spirals on the second whorl. The type lot consists of relatively large shells, thin and dull brown (in the young and) on the spire, the last whorl whitish and calcareous. Umbilicus ample within and rather widely open, contained 4 times in the diameter.

Height 8.8 mm., diameter 15.8 mm.; 5½ whorls.

Height 7.5 mm., diameter 14.6 mm.; 4¾ whorls.

NEW MEXICO: Southern end of the Rocky Mountains, in San Miguel County, Canyon Diablo near Rowe (Mary Cooper), Type 84297 A.N.S.P. Arroyo Pecos, Las Vegas, Quaternary (T. D. A. Cockerell & Mary Cooper). Beulah, 8000 feet (T. D. A. and W. P. Cockerell). Sandia Mountains, Bernalillo County, near and at the top of the highest peak (C. M. Barber). Las Huartes Canyon (Mary Cooper). North side of the Sandia Mountains, and near Golden (J. H. Ferriss).

Of two lots taken from the highest peak of the Sandia Mountains, by C. M. Barber, one from near the top consists of large shells, up to 10 x 17 mm., 5½ whorls, umbilicus from somewhat over 4 to over 5 times in diameter; the last whorl is less depressed and much less carinate than typical *neomexicana*, about as in *yavapai*. Color white, slightly to profusely streaked and clouded with brown, and two-banded. The second lot, from the summit, is a dwarf or paedomorph of the other, thinner, somewhat more sharply carinate, 4.9 x 8.2 mm., of 4 whorls, umbilicus a little more than one-fourth the diameter. It is much like the Beulah lot, also from a high station.

Lots taken by Ferriss at Golden and on the northern side of the Sandias measure about 7.4 x 12.5 mm., 4½ whorls, umbilicus fully 5½ times in diameter. By the small umbilicus this form is like *compactula*, but the periphery is more obtuse, and in appearance it is like the other Sandia shells.

At Grant, Valencia County, the shells resemble those of the Sandia Mountains. They are thin, brown, with weak sculpture; the keel is weaker than in *neomexicana*, and in one old shell is reduced to an inconspicuous angle. Two measure: 8.8 x 14.3 mm., 4¾ whorls, umbilicus 5 times in diameter, and 12.7 x 17.9 mm., 5½ whorls, umbilicus 5¾ times in diameter. The definition of *neomexicana* hardly covers these or the Sandia shells; but

little seems gained by multiplying ill-characterized subspecies where the shells are known from only a few widely scattered localities.

The penis (Fig. 341) has the usual form in this group, the lower half being swollen. The epiphallus is large, shorter than the penis, the vas deferens entering at the side of its end, not centrally.



Fig. 341.

The radula has 19.1.19 teeth, similar to those of *O. yavapai*. The ectocone is developed on the fifth or sixth teeth. Marginals are bicuspid, as in *O. yavapai*.

***Oreohelix yavapai compactula* Cockerell**

Fig. 339 f.

Oreohelix yavapai compactula Cockerell, 1905 (August), *Nautilus*, 19: 46.

Smaller than typical *O. y. neomexicana*, higher, with narrower umbilicus, contained $5\frac{1}{2}$ times in the diameter.

Height 7.7 mm., diameter 12.5 mm.; 5 whorls. Other specimens measure 11 to 13 mm. diameter.

NEW MEXICO: Pecos Canyon a few miles above the Valley ranch, in a Pleistocene deposit (W. P. Cockerell and M. Grabham), Lectotype 91098 A.N.S.P.

In the Sacramento Mountains near the head of the southern branch of Alamo Canyon (south of Alamogordo), under high cliffs, I found old, broken shells of a form of *neomexicana* near *compactula*, diameter 12.2 mm., umbilicus $6\frac{2}{3}$ times in diameter. The granular basal spirals are well developed and the shape about as in *neomexicana*. The locality is about 170 miles south of that of *neomexicana* and *compactula*. This and *O. s. nogalensis* are the only records for *Oreohelix* in these mountains, or anywhere east of the Rio Grande in southern New Mexico. Living shells should be looked for higher than my locality, which is far below timber line.

***Oreohelix yavapai cummingsi* "Ferriss" Pilsbry**

Fig. 338: 18, 18a, 19, 19a.

Oreohelix yavapai cummingsi Ferriss, 1920, *Nautilus*, 34: 5, name only. — Pilsbry, 1934, *Proc. Acad. Nat. Sci. Phila.* for 1933, 85: 401, pl. 15, figs. 18, 18a, 19, 19a.

It has about the shape of typical *neomexicana*, but the shell is always smaller with the last whorl more swollen below the suture; thin without much calcareous matter, uniform brown. The peripheral keel extends to the aperture. The sculpture is of irregular, fine striae, and weak spirals which are granose at the striae, and often bear cuticular scales on the granules, especially prominent on the base, as in the type (Figs. 18, 18a).

Height 6 mm., diameter 12 mm., umbilicus 3 mm.; $4\frac{1}{2}$ whorls.

UTAH AND ARIZONA: On and around Navajo Mountain. Type 44510 A.N.S.P., from reservoir of Yellow House Ruins, 2 miles south of Endishe Springs, Arizona (J. H. Ferriss).

This form is close to the Sandia race of *neomexicana*, but the spiral striation is far better developed on the upper surface of the last whorl, and the striae and granules bear cuticular appendages.

In other places on and around Navajo Mountain the shells are smaller, about 10 mm. in diameter, or in some lots even smaller, these very small shells being to some extent transitional to *clutei*.

The "*O. y. neomexicana*" reported by Ferriss, *l. c.*, from a canyon west of Endishe Springs are large *cummingsi*.

Navajo Mountain, the home of these snails, is a sandstone dome "rising four thousand feet above the flat floor of the Rainbow Plateau, an island in the midst of a sea of water-worn and wind-worn brilliantly colored sandstone." It reaches a height of 10,416 feet. Endishe Springs is in Arizona, but nearly all of the mountain lies in Utah.

Farther north, in the "Blue," or Abajo Mountains, near Monticello, San Juan County, Utah, the form *cummingsi* is abundant (*Nautilus*, 34: 12). The largest specimens measure up to diameter 12.5 mm., are strongly keeled, well sculptured and have two bands; but in some places only small ones occur, diameter 8.5 mm., uniform brown.

(Named for Dr. Byron Cummings of the University of Arizona.)

***Oreohelix yavapai clutei* "Ferriss" Pilsbry** Fig. 338: 16, 16a, 17a, 20, 20a.

Oreohelix yavapai clutei Ferriss, 1920, *Nautilus*, 34: 5, name only. — Pilsbry, 1934, *Proc. Acad. Nat. Sci. Phila.* for 1933, 85: 401, pl. 15, figs. 16, 16a, 17a, 20, 20a.

The shell is pale brownish, more or less extensively suffused with opaque white, with a brown band below the middle of the upper face of the last whorl, another immediately below the periphery. Embryonic shell of about $2\frac{1}{2}$ rather strongly and evenly convex whorls, with sculpture of light growth lines only, or with weak, well-spaced wrinkles also, without spiral sculpture. The subsequent whorls have fine, close, retractive wrinkles, which in immature shells show minute cuticular appendages arranged in spiral series. The last whorl is strongly angular in front, the angle disappearing on the last third, where the whorl descends slowly, well below the periphery of the preceding whorl; it is closely wrinkle-striate, the base smoother and sometimes showing weak traces of spaced spiral threads in places. The aperture is very shortly oval, nearly round, the peristome thin, margins converging and connected by a short, thin callus.

Height 9.2 mm., diameter 13.5 mm., umbilicus 4 mm.; $5\frac{1}{2}$ whorls. Type.

Height 8.5 mm., diameter 13.5 mm.

Height 8.7 mm., diameter 12.8 mm.

ARIZONA: Navajo Mountain at New Trail Spring, on the south side (J. H. Ferriss, 1919), Type and figured paratypes 159216 A.N.S.P.

This appears to be a quite distinct race. It approaches *O. y. profundorum* P. & F. in shape, but that is much more calcareous with a heavy parietal callus. Their resemblance is doubtless a case of convergence, as it is likely that their ancestors were diverse forms of *O. yavapai*.

There is also a dwarf form of *clutei* (Figs. 338: 16, 16a, 17a) from "south side Navajo Mt." and "above Two Springs." The last whorl descends very little. It measures, height 5.1 mm., diameter 8.5 mm.; 4½ whorls.

(Named for Willard S. Clute, the authority on ferns, who was a member of the Navajo expedition.)

Oreohelix yavapai fortis Cockerell

Fig. 338: 1-6, 14.

Oreohelix strigosa depressa (Ckll.). Pilsbry, 1921, *Nautilus*, 35: 48.

Oreohelix yavapai subsp. *fortis* Cockerell, 1927, *Nautilus*, 40: 101.

Oreohelix yavapai vauxae Marshall, 1929, *Proc. U. S. Nat. Mus.*, vol. 76, art. 5, p. 1, pl. 1, figs. 1, 2, 3, 11.

The shell is large, solid, often showing two bands in the typical positions on a pale flesh to white ground. It is sharply angular in front of the aperture but soon becomes rounded; the umbilicus is broadly open, contained from 3.5 to 4.4 times in the diameter; spiral lines are often well developed on penult and some earlier whorls (Fig. 4), but frequently absent, and generally not visible on the base in adults. Peristome continued in a short, thick callus ledge across the parietal wall.

Height 10 mm., diameter 21 mm. Type (Fig. 1).

Height 10.5 mm., diameter 21.2 mm.; Fig. 4.

Height 11.5 mm., diameter 25 mm. Largest topotype (Fig. 5).

ARIZONA: Grand Canyon, in the red earth about half-way down the Bright Angel Trail (T. D. A. Cockerell), Type 141875 A.N.S.P. Also found by J. H. Ferriss and by C. Montague Cooke, "from 1000 to 3400 feet below the rim, from the last pine trees to just below 'Jacob's Ladder'." Canyon at Supai, Coconino County (Mary Vaux Walcott, type of *O. y. vauxae*).

The largest shell seen measures 25.8 mm. in diameter, the smallest adult 19.7 mm. As Professor Cockerell noted, "The shells have in general the characters of *O. y. extremitatis*. . . . The larger size is possibly correlated with a moister climate in past times, and the form may be regarded as a race or subspecies *fortis*, closely related to the much smaller *O. yavapai angelica* P. & F. which occurs living higher up on the Bright Angel trail."

Over 80 specimens in the collection of the Academy show a considerable range of variation. Usually the acute peripheral keel of the neanic stage persists in front of the aperture and for a varying distance on the last whorl, but almost always it disappears on the last part of the last whorl. In the very large shell (25 mm. diameter) represented in Figure 338: 5 the keel disappeared before reaching the last whorl, which is rounded throughout. In a few adult but small individuals, such as Figure 4, the angle continues weakly to the aperture.

The red earth in which the shells are found is presumed to be Pleistocene. Those from Supai Canyon were in a similar red earth deposit.

Assisted by Junius Henderson, I made a careful comparison of Grand Canyon *fortis* with the type lot of *O. yavapai vauxae* from Supai, about 30 miles west-southwest of Grand Canyon. We were unable to detect any

constant difference, but in the Supai shells spiral rows of granules are generally well developed in some places on the intermediate whorls, while in the Grand Canyon *fortis* these granules are generally quite obsolete, though sometimes well developed, as in Fig. 338: 14. This sculptural feature is also variable in *O. y. angelica*, and it is common to nearly all the races of *O. yavapai*. The type of *vauxae* measured 10.5 x 23 mm.

(*Fortis*, robust.)

***Oreohelix yavapai profundorum* Pilsbry & Ferriss**

Fig. 343: 1-14.

Oreohelix yavapai profundorum Pilsbry & Ferriss, 1911, Proc. Acad. Nat. Sci. Phila., p. 182, pl. 12, figs. 1-14; text-figs. 4, 5.

The shell is opaque-white with some brownish, corneous streaks and often two fleshy, brown bands, the inner whorls more or less flesh-tinted; solid; with sculpture of rather wide, irregular, subobsolete growth-wrinkles, but no spiral striae in the adult stage. Whorls $4\frac{1}{2}$ to 5, the last angular or subangular in front, descending moderately or deeply to the aperture, often becoming shortly free. Aperture very oblique or subhorizontal, the peristome slightly thickened and brownish, continuous and free or in contact with the preceding whorl for a short distance.

Height 11 mm., diameter 18 mm. Lectotype (Fig. 4).

Height 12.8 mm., diameter 14.3 mm. Figure 2.

ARIZONA: Grand Canyon, in the head of a recess in the cross-bed sandstone south of where the Mystic Spring or Bass Trail zigzags down, in a talus resting on the red sandstone forming the Le Conte Plateau. Elevation about 5700 feet (Pilsbry and Ferriss), Type 103234 A.N.S.P.

Out of 100 shells from the type locality, taken at random, 56 per cent resemble Fig. 343: 1-3, 44 per cent being like Fig. 343: 4, 5. The race is therefore markedly senile.

Adult shells measure from 13 to $17\frac{1}{2}$ mm. in diameter.

Genitalia (Fig. 342). The lower half of the penis is much swollen, the upper half slender and cylindrical, the retractor muscle inserted at its apex. The short epiphallus is rather stout. Vagina short and very large. The uterus in the individual figured contained four embryos; the shells 4.7 mm. in diameter, with $2\frac{3}{4}$ whorls and acutely carinate periphery. The podocyst is larger on the upper embryos, but present in all. Length of penis, 6.7 mm.; epiphallus, 3 mm.; vagina, 4 mm.; spermatheca and duct, 17 mm.

The embryonic shell, of $2\frac{1}{2}$ whorls, shows fine subregular ripples along the lines of growth, and in places some fine, very faint spiral striae may be traced; on

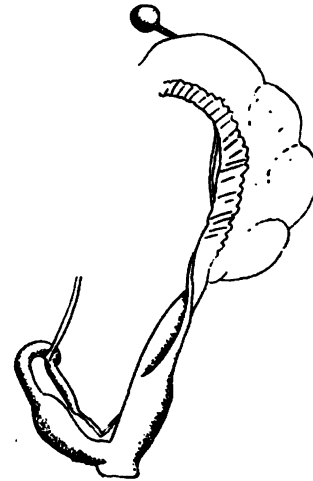


Fig. 342. *Oreohelix yavapai profundorum*, paratype.

the base these spirals are more distinct. They continue there during the first part of the neanic stage, but disappear after a diameter of 8 or 9 mm. has been attained. The main spirals are widely spaced, as in *O. yavapai*, but at all stages of growth they are very weak. The embryonic shell is light brown. Some maculae and streaks of opaque cream-white appear after the third whorl. In the adult stage the surface becomes dull white and somewhat chalky from loss of the very thin cuticle which is present in the embryonic and early neanic stages.

In the series of several thousand shells taken there was one sinistral example.

(*Profundorum*, from the deeps.)

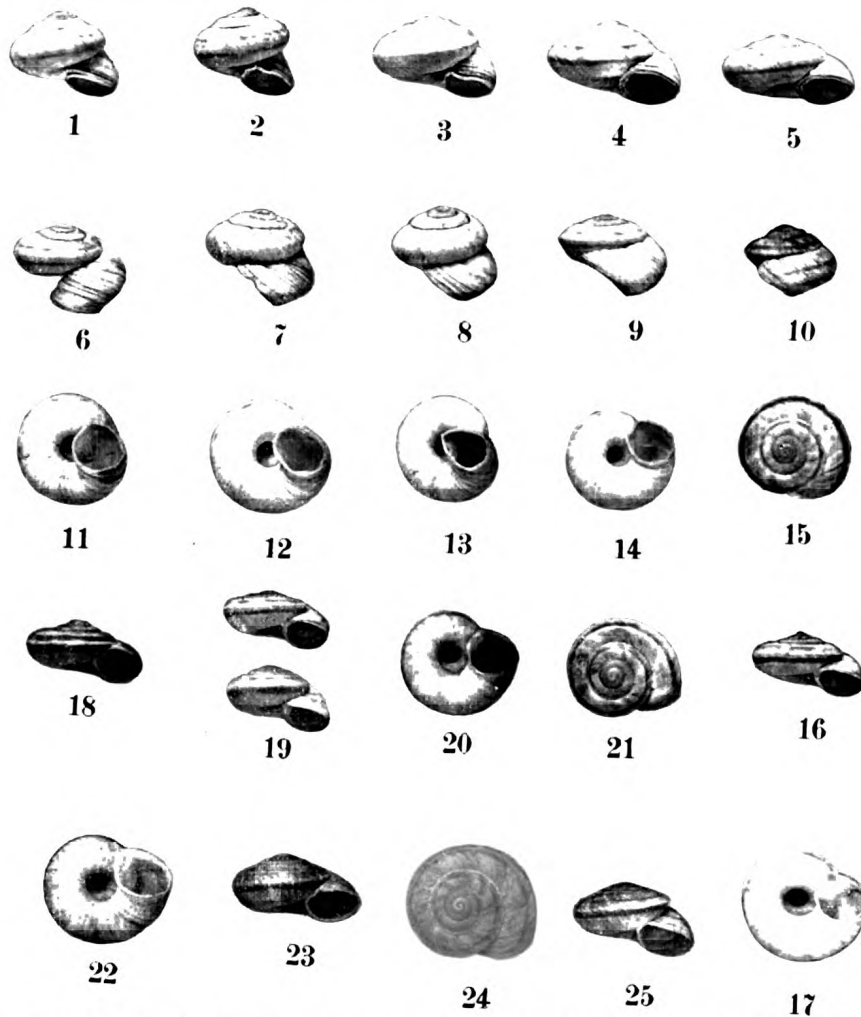


Fig. 343. 1-14, *Oreohelix yavapai profundorum*. 15-21, *O. y. extremitatis*, Bass Trail. 22-25, *O. y. extremitatis (angelica)*, Bright Angel Trail.

Oreohelix yavapai extremitatis Pilsbry & Ferriss

Fig. 343: 15-21.

Oreohelix yavapai extremitatis Pilsbry & Ferriss, 1911, Proc. Acad. Nat. Sci. Phila., p. 184, pl. 12, figs. 15-21.—Pilsbry, 1913, Nautilus, 27: 50; 1916, Proc. Acad. Nat. Sci. Phila., p. 351, pl. 22, figs. 6, 6a.—Henderson, 1918, Nautilus, 32: 45; 1924, Univ. Colo. Stud., 13: 128, pl. 3, fig. 6; 1936, Univ. Colo. Stud., 23: 94.

Oreohelix yavapai angelica Pilsbry & Ferriss, 1911, Proc. Acad. Nat. Sci. Phila., p. 185, pl. 12, figs. 22-25.

The shell is more depressed than *O. y. profundorum*, less solid and less calcareous, invariably two-banded. The surface is more or less suffused with light brown, especially on the spire, and the very thin pellucid cuticle is retained, so that the shell has a slight luster. The embryonic whorls are like *profundorum*; the first third or half of the last whorl is acutely carinate in front, and the latter part descends very little (as in Fig. 18, 67 per cent of the shells examined) or somewhat deeply (Fig. 19, 33 per cent). Widely spaced granose spirals (such as are characteristic of *O. yavapai*) are visible on the base in front of the aperture in most of the shells. Umbilicus contained $4\frac{1}{2}$ to $4\frac{1}{2}$ times in the diameter. The aperture is contracted less than in *O. y. profundorum* and the peristome is not thickened.

Height, 9 mm., diameter 16 mm.; $4\frac{3}{4}$ whorls.

The largest topotypes measure 9.6 x 17 mm., the smallest 7 x 13.7 mm.

ARIZONA: Grand Canyon, at and near the head of Bass's Trail, about 200 feet below the rim (Pilsbry & Ferriss), Type and paratypes 103236 A.N.S.P.

WYOMING: Shell Creek Canyon, 10 miles northeast of Shell; Dry Gulch, $2\frac{1}{2}$ miles east and 2 miles north of Shell; White Creek Canyon, 8 miles east of Shell; Trapper's Creek, 7 miles east of Shell (J. Henderson, Don W. Walker).

MONTANA: Bridger Canyon near Bozeman, Gallatin County, at 5000 feet (S. S. Berry).

At the type locality these snails were found in abundance on a steep slope of soil and stones with some sheltering bushes.

The snail described as *O. y. angelica* (Figs. 343: 22-25) is merely a local form of *extremitatis*, not deserving racial distinction, as I view it now. It occupies the same zone (Kaibab limestone), about 20 miles farther east, on the Bright Angel Trail at Grand Canyon, from 100 to 400 feet below the rim, which has here an elevation of 6866 feet. The shells resemble *O. y. extremitatis* in contour, except that the last whorl is somewhat less depressed. The color is light brown with darker streaks, usually with a brown band below the periphery, sometimes with another above. It is thinner and in the average larger than *extremitatis*, and spaced spirals are more distinct, being well-developed on both the base and upper surface. The embryonic whorls have faint spiral lines. The first part of the neanic stage (up to at least 11 mm. diameter, with nearly 4 whorls in some individuals) bears spiral rows of cuticular scales readily visible to the naked eye. There are about 8 spirals above, 10 below the periphery on the last whorl. The last

whorl is but slightly deflexed in most examples, rarely (8 per cent) more or less deeply so, approaching Figure 343: 25, which is an extreme individual, 9.5 x 18 mm. Lectotype and paratypes of *angelica* are 103239 A.N.S.P.

The Wyoming herd is more than 600 miles from the Grand Canyon locality, yet some of the shells seem to be quite indistinguishable, and no differences could be found in the genitalia and teeth. They vary in size, width of umbilicus and color in different lots, but also in the same colony. Specimens from White Creek measure:

9.7 x 18.7 mm.; 5½ whorls; umbilicus 4½ times in diameter.

9.2 x 14 mm.; 5 whorls; umbilicus 4 times in diameter.

10.6 x 16.2 mm.; 5½ whorls; umbilicus 5½ times in diameter.

In a lot from Shell Creek Canyon they measure from 7.4 x 12.1 mm. to 8.1 x 15.1 mm.

The bands are distinct in some lots, faint to wanting in others. The keel varies in strength; it may continue weakly to the aperture or the latter part of the whorl may be quite rounded. The basal spirals are generally weak or wholly wanting, but they are distinct in the lot described below.

“Just within the mouth of Shell Creek canyon, on the south side of the creek, we found a small colony of the snails on a limestone ledge devoid of all vegetation except closely clinging lichens on the rocks. We obtained 145 living examples clinging to the open, barren face of the rock, north and east exposure, though the weather was hot and dry. There were no shrubs, leaves, rock slides or other cover. The shells (Fig. 344 d) were more depressed and much more sharply keeled than those found in more favorable situations farther up the canyon, and especially those under good cover at the base of a precipice in a place seldom reached by the sun's rays, on the south side of White Creek Canyon (Fig. 344 f).” (Henderson.)

In a specimen from Shell Creek the animal is purplish black above and on the sides, the sole cream colored. The penis is short, its lower two-thirds swollen, upper third cylindrical; internally there are very low, short folds bounded above by a low narrow transverse ridge, in the enlarged part, the upper part having densely papillose walls. Figure 6a represents the penis opened and pinned flat. The papillae in the upper portion are represented diagrammatically. The epiphallus is not quite half as long as the penis. The base of the spermatheca duct is enlarged, as usual. The uterus contained 8 embryos in the individual figured, the largest of 2½ whorls. Length of penis 7 mm., of its internally costate part 4.5; epiphallus 3.3 mm.; vagina 2 mm.; spermatheca and duct 13 mm.

The central and 5 or 6 inner lateral teeth have no side cusps. The seventh lateral has a well developed ectocone.

An embryonic shell has 2½ whorls, is convex above with an angular, not acute, periphery. The first 1½ whorls are convex with irregular growth striae, some microscopic spirals then appearing. The last third of a whorl has about 5 coarse but very low spirals, and the cuticle, under a high power, is seen to be minutely crinkled, also on the base.

Specimens from Bridger Canyon near Bozeman, Montana, are similar, varying to a little more elevated, the spirals are slightly stronger on the base. The keel is strongly developed. They are white with an inconspicuous band below the keel and sometimes another above. The one figured measures 10 x 16.1 mm. (Fig. 344 g).

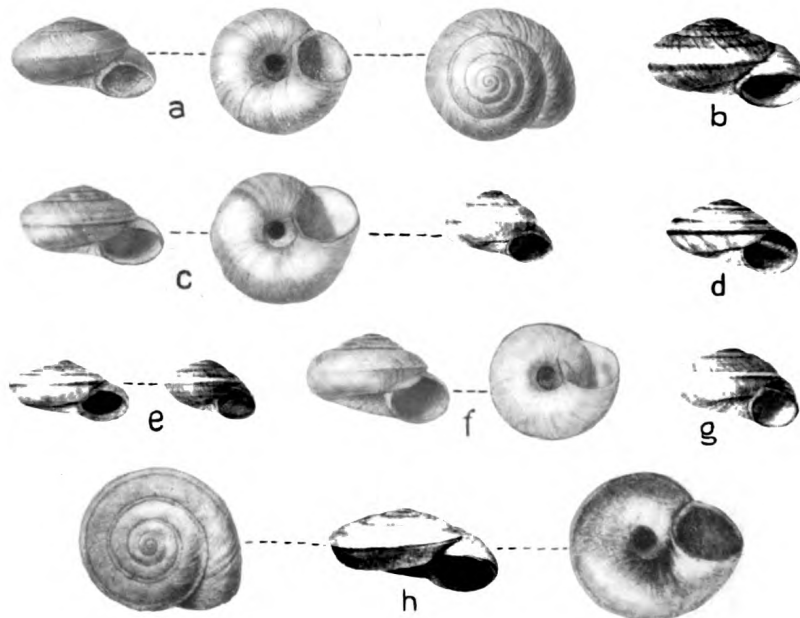


Fig. 344. a, b, *Oreohelix yavapai magnicornu*. c, d, e, f, *O. y. extremitatis*, Shell Creek; g, same, Bridger Creek. h, *O. y. mariae* (after Bartsch).

(*Extremitatis*, of the furthest part.)

***Oreohelix yavapai mariae* Bartsch**

Fig. 344 h.

Oreohelix yavapai mariae Bartsch, 1916 (Nov. 24), Proc. U. S. Nat. Mus., 51: 331, pl. 31, figs. 1-3.

“Shell decidedly depressed helicoid, almost lenticular, flesh colored, with a narrow brown band on the upper surface, which is a little nearer the peripheral cord than the suture, and a second even narrower one bordering the peripheral cord on the lower surface. Nuclear whorls scarcely differentiated from the succeeding turns, bearing the same sculpture as the adult whorls, but a little less strongly expressed. Periphery of the whorls provided with a cord-like keel, which becomes somewhat weakened on the last quarter of the last turn. Entire surface both above and below marked by slender thread-like incremental lines and fine spiral striations; last whorl slightly descending near the aperture. Base broadly, openly umbilicated, well rounded; a little more convex at the umbilical wall than at the lateral margin. Aperture very oblique, oval; peristome neither thickened nor reflected at the edge; parietal wall strong, rendering the peristome complete. Alt. 10 mm., greatest diameter 22.5 mm.; 5.6 whorls.” (Bartsch.)

MONTANA: Squaw Creek near the mouth of Gallatin Canyon (Mrs. Mary Walcott), Type 215132 U.S.N.M., paratype 113374 A.N.S.P.

In the type lot of nine examples the diameters run from 18.3 to 22.5 mm. The size thus intergrades with Wyoming shells referred to *extremitatis*, but the average diameter (20.69 mm.) is greater. In degree of carination the Wyoming *extremitatis* varies from sharper than *mariae* to much blunter. The separation of this form from *extremitatis* may prove difficult or perhaps impracticable.

Oreohelix yavapai magnicornu Pilsbry

Fig. 344 a, b.

Helix cooperi in part, Binney & Bland, 1869, L. & Fr. W. Sh. N. A., 1: 78, figs. 135, 137.

Patula cooperi W. G. Binney, 1878, Terr. Moll., 5: 158, fig. 66.

Patula strigosa Gld., Binney, 1885, Man. Amer. L. Sh., p. 166, fig. 154.

[*Patula strigosa*] var. *utahensis* "Hemphill", in part, Binney, 1886, 2d Suppl., Bull. Mus. Comp. Zoöl., 13: 33 (exclusive of reference to p. 30); 1892, 4th Suppl., Bull. Mus. Comp. Zoöl., 22: 173 (exclusive of same reference).—Pilsbry, 1892, Man. Conch., 8: 118, descriptive note taken from Binney, but not pl. 42, figs. 10, 11 = *utahensis* Hemphill.

Oreohelix strigosa magnicornu Pilsbry, 1916 (April), Nautilus, 29: 141.

The shell is solid, carinate, with low, conic spire and convex base, the umbilicus contained about 5.3 times in the diameter. The shells are bleached but show pale brown inner whorls and sometimes two bands on the last one. The early whorls are but weakly convex, some of them impressed over the keel which fills the suture, the last whorl descending in front, the periphery from strongly angular to keeled in front, the angle more or less obsolete in the last half. The last two turns have irregular wrinkle-striae and no spiral lines. The aperture is shortly oval, the peristome continuous as a short callous ridge across the parietal wall.

Height 10.7 mm., diameter 18.1 mm.; 5½ whorls.

Height 11.5 mm., diameter 20.4 mm.

WYOMING: Big Horn Canyon, Big Horn Mountains (F. V. Hayden), Type 1907 A.N.S.P.

The Big Horn mountain snail is heavier, less depressed and less widely umbilicate than Wyoming forms referred to *O. yavapai extremitatis*, the whorls of the spire are somewhat less convex and the parietal callus thicker; yet some examples of *extremitatis* from Shell Creek partially bridge the gap between them. If I am right in thinking this a variety of *O. yavapai*, young shells should show granose spirals; but at present the Big Horn form is known by adult "bones" only.

All the above references to the works of Binney contain substantially the same brief descriptive matter and the same figures. Both originated in the work of 1869, and were afterwards reprinted with a change of the specific name. Binney gave no locality for the shell he figured, but in 1886 he referred it to *utahensis* Hemphill, an Oquirrh Mt. form which had been characterized briefly in matter quoted from Hemphill on a prior page of Binney's paper. Two species were thus involved in the accounts of

“*utahensis*” published in 1886, though neither was adequately defined. J. Henderson and other authors, including myself, have accepted Hemphill's understanding of *utahensis* in preference to Binney's, which confused two species and was on a later page of the same paper.

***Oreohelix hemphilli* (Newcomb)**

Fig. 345

Helix hemphilli Newcomb, 1869, Amer. Journ. Conch., 5: 165, pl. 17, fig. 4.

Patula hemphilli Newc., Binney, 1878, Terr. Moll., 5: 159, fig. 69; pl. 4, fig. J (teeth). 1885, Man. Amer. L. Sh., p. 168.

Patula strigosa var. *hemphilli* Newc., Binney, 1886, 2d Suppl., Bull. Mus. Comp. Zoöl., 13: 33 (not pl. 2, fig. 15, which is *O. haydeni* f. *gabbiana*).

The shell is rather thin, depressed, with low-conic spire, carinate periphery and perspective umbilicus contained 5 times in the diameter. The spire is pale brown, the last whorl clouded and streaked with whitish, and with two brown bands, the base whitish with gray radial streaks. The



Fig. 345. *Oreohelix hemphilli*, White Pine Co., Nevada; three figs. at left the type.

whorls are strongly convex below the suture, prominent in the middle and concave above the keel, which is irregularly crenulate. The last whorl descends slowly to the aperture, is rather strongly carinate in front, the keel becoming weak in the last half turn. Embryonic shell of $2\frac{1}{2}$ whorls, very finely striate radially, becoming more coarsely striate after the second whorls and with some subgranose spirals. The last $1\frac{1}{2}$ whorls are rather coarsely, irregularly striate, with a few weak, widely spaced spirals; base distinctly striate, with numerous weak spirals; at intervals some spirals are slightly stronger, but chiefly visible by the low granules where they intersect the striae. The aperture is roundly oval, the peristome thin, margins joined by a short, thin parietal callus.

Height 10.6 mm., diameter 16.7 mm.; $5\frac{1}{2}$ whorls.

NEVADA: “White Pine Mining District, 8000 feet” (H. Hemphill), Type and juv. paratype 23060 A.N.S.P. Hamilton, White Pine County (Hemphill).

IDAHO: Lost River Mountains, Needle Park, among rocks at 10,000 to 11,000 feet (Bailey and Dutcher).

The type specimen described and figured by Newcomb is illustrated. Binney's figure represents a young shell.

The radula of a topotype collected by Hemphill was recovered from a dried specimen (Fig. 346). It has 22.1.22 teeth, the central and laterals with ectoconal cutting edges, a distinct ectocone appearing about the 7th tooth. Marginals with two simple cusps as usual. Binney figured the central and inner lateral teeth with fully formed ectocones, and stated that

"the first laterals are distinctly bicuspid." I found distinct ectocones only on the transitional and marginal teeth, the central and inner laterals having well developed cutting edges, not distinct cusps. Binney did not give the locality of material furnishing the radula he examined.

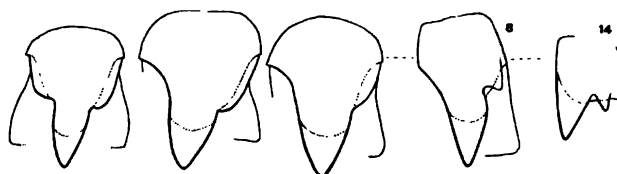


Fig. 346. Teeth of *Oreohelix hemphilli*.

The genitalia are unknown, and while the species is here placed next to *O. yavapai*, it may possibly belong to the *haydeni* series. The dissection of this snail is a desideratum, as it should enable us to clarify the relations of *O. yavapai*, *O. carinifera* and *O. eurekaensis* with *O. hemphilli*. *O. yavapai* differs by the entire absence of ectocones or cutting edges on the central and inner lateral teeth, where *hemphilli* has broad cutting edges, though not distinct ectocones; but this is not a wholly satisfactory specific distinction.

***Oreohelix carinifera* Pilsbry**

Fig. 347.

Oreohelix carinifera Pilsbry, 1912, Nautilus, 26: 89.— 1933, Proc. Acad. Nat. Sci. Phila., 85: 398, fig. 16.

The shell is lenticular, carinate, umbilicate, the umbilicus contained $4\frac{1}{2}$ times in the diameter. The whorls increase slowly, the first $2\frac{1}{2}$ strongly convex, the rest strongly convex around the upper (inner) part, becoming concave near the outer (peripheral) edge. The embryonic whorls are very finely, obliquely striate; later whorls rather coarsely wrinkle-striate, with some weak spiral striae in places; the last whorl is concave above and below the peripheral keel, descends very little or not at all in front, and on the base shows some weak spirals of indistinct granules. The aperture is about as high as wide, and shows a slight angle at the end of the keel.

Height 5 mm., diameter 9.5 mm.; $4\frac{1}{2}$ whorls. Type.

Height 7 mm., diameter 12 mm.; 5 whorls.

Height 6.8 mm., diameter 11 mm.

Height 6 mm., diameter 11.5 mm.

Height 5.4 mm., diameter 9.2 mm.; $4\frac{1}{2}$ whorls.

MONTANA: Garrison, Powell County (J. A. G. Rehn and M. Hebard), Type 99253 A.N.S.P. Also taken by H. Burrington Baker "mainly close under bushes on an open slope."

The small specimens are from the dryer upper part of the ridge.

The color is light avellaneous, the base paler or sometimes grayish white. There is a light brown band above the periphery, and the first two whorls are often reddish brown. The granules in spiral series on the last whorl bear short epidermal appendages in immature shells, mostly worn off in adults. There may be as many as eight of these wreaths on the base. In life the surface is covered with a thin coat of dirt.

In genitalia (Fig. 347 c) *O. carinifera* resembles *O. yavapai*. The short penis ($4\frac{1}{2}$ mm.) is hardly half the diameter of the shell, strongly swollen in the middle, the lumen there containing three strong ridges which extend to the distal three-fifths of the length. Above them the wall is thin and papillose internally. The epiphallus is relatively long, the vas deferens entering it laterally, the rounded end of the epiphallus projecting slightly beyond the insertion, and more prominent than in any other *Oreohelix* I have examined. Penial retractor is short. The spermathecal duct is much swollen near the base. The black talon is coiled and relatively longer than usual in the genus. The rather thick-walled uterus is distended with young in the specimen drawn, and as usual in this stage, the albumen gland and ovotestis are much reduced.

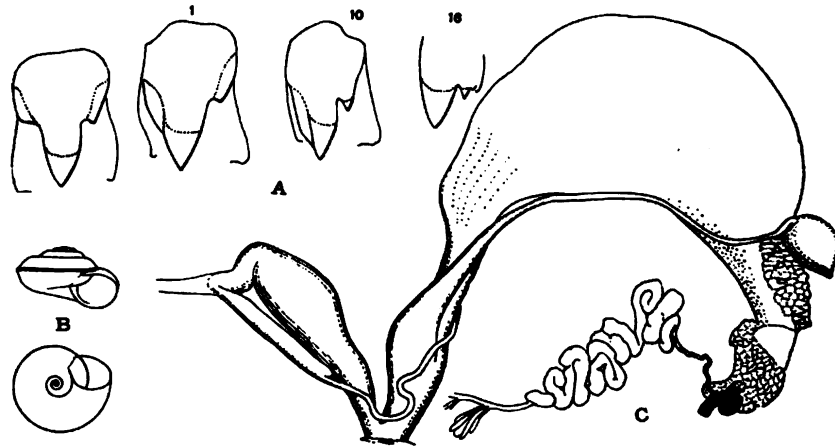


Fig. 347. Teeth, shell and genitalia of *Oreohelix carinifera*.

The jaw is strongly arched with fine vertical striae and longitudinal fibres.

Radula (Fig. 347 a) with 21.1.21 teeth, six laterals. The centrals have strongly developed side cusps. Laterals with strong ectocones and a rather wide overhang on the inner side of the mesocone. The marginals have a strong simple mesocone and small ectocone, which is twinned on some of the teeth.

O. carinifera differs from *O. hemphilli*, *O. yavapai*, *O. y. neomexicana*, and the Wyoming form of *O. y. extremitatis* by the strong development of ectocones on central and all lateral teeth. In those forms I found the central and five or six laterals on each side to be unicuspid. The shell is much like *O. hemphilli* in miniature but it differs (1) by the smaller size. (2) the embryonic whorls of *O. carinifera* are very strongly convex throughout, the second showing no trace of a concavity above the suture; the surface has weak ripples of growth but scarcely any trace of spiral striae. In *O. hemphilli* the second whorl is conspicuously concave above the suture, the

growth ripples are sharper, and spiral striae are noticeable though not strong. (3) The umbilicus is a little narrower than in *O. hemphilli*—a feature of little importance in this genus.

(*Carinifera*, bearing a keel.)

Oreohelix eurekaensis Henderson & Daniels

Fig. 348, upper figures.

Oreohelix hemphilli eurekaensis Henderson & Daniels, 1916, Proc. Acad. Nat. Sci. Phila., p. 321, pl. 15, figs. 7, 8.—Pilsbry, 1917, Proc. Acad. Nat. Sci. Phila., p. 45, fig. 4a (genitalia).

Oreohelix eurekaensis H. & D., Henderson, 1924, Univ. Colo. Stud., 13: 127.

The shell is small, subenticular, about equally convex above and below the peripheral keel, with a low-conoidal spire and an umbilicus contained 4.4 to 5 times in the diameter. Spire pale brown, the last whorl grayish white with white streaks and maculae; two indistinct pale brown or gray

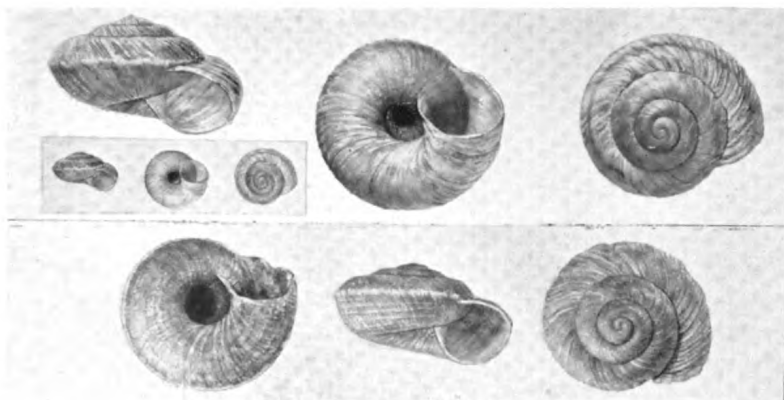


Fig. 348. Upper figures, *Oreohelix eurekaensis*. Lower figures, *O. eurekaensis uinta*. (Actual size and enlarged.)

bands in the typical positions. The whorls are strongly convex in the upper part (below the suture), rising above the well-impressed suture, then flattened or slightly concave and sloping steeply to the periphery. The last whorl is strongly carinate, the keel tending to weaken towards the aperture. The embryonic shell of about 2 whorls is very lightly striate, almost smooth, but with an appearance of delicate spirals on the second whorl (often not visible in adults). Last whorl with rather coarse, unequal striae; "spiral sculpture consists, in the type, of 6 minute, beaded lines below the periphery, with very indistinct lines in the interspaces and in the edge of the umbilicus; similar sculpture above, but not so well defined nor so plainly of two grades; on the cotypes the lines are not so well defined and not so plainly of two grades." On many specimens beaded spirals are weak, and visible only in places on the base; there may be 6 to 8 larger ones. The aperture is subcircular, the peristome thin, its insertions connected by a thin parietal film.

Height 5.5 mm., diameter 9.7 mm.; $4\frac{1}{2}$ whorls. Type.

Height 4.8 mm., diameter 8.8 mm.; $4\frac{1}{2}$ whorls.

UTAH: Eureka, on the north side of Godiva Mountain, on Paleozoic limestone, under shrubs, etc. (J. Henderson and L. E. Daniels), Type in University of Colorado Museum, cotype 113287 A.N.S.P.

Topotypes dissected. It groups with *O. yavapai*, having the internally ribbed part of the penis more than half the total length, the latter less than the diameter of the shell. Length of penis 4.4 mm., of the internally ribbed portion 2.5 mm.; epiphallus 2 mm.; penial retractor 6 mm. (Fig. 349 a).

There are distinct side cutting edges on the central and two or three lateral teeth, after which there are distinct side cusps. There are about 7 lateral teeth. Transition to marginals very gradual.

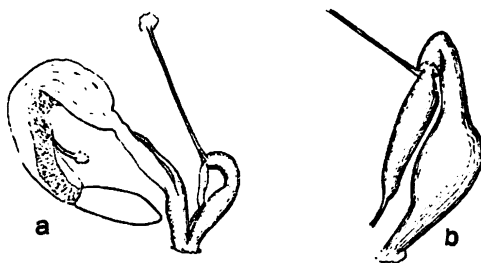


Fig. 349. a, genitalia of *Oreohelix eurekaensis*.
b, outline of penis and epiphallus of *O. handi*.

***Oreohelix eurekaensis uinta* Brooks**

Figure 348, lower figures.

Oreohelix eurekaensis uinta S. T. Brooks, 1939, *Nautilus*, 52: 105.

"It resembles *O. eurekaensis* H. & D. closely in shape, texture, color and sculpture, but differs by the somewhat wider umbilicus, contained about $3\frac{3}{4}$ times in the diameter of shell. Height 8 mm., diameter 4.2 mm.; $4\frac{1}{4}$ whorls." (Brooks.)

UTAH: Hominy Creek near Whiterocks, Uinta county (E. R. Eller), Type Carnegie Museum, paratypes in A.N.S.P.

It is the first *Oreohelix* to be reported from the Uinta range.

***Oreohelix handi* Pilsbry & Ferriss**

Fig. 350.

Oreohelix handi Pilsbry & Ferriss, 1918, *Nautilus*, 31: 94.—Pilsbry, 1917, *Proc. Acad. Nat. Sci. Phila.*, p. 46, fig. 4b (anat.).¹—Berry, 1931, *Ann. & Mag. Nat. Hist.*, (10), 8: 117, figs. 3-5.

A member of the *O. hemphilli* group. The shell is thin, depressed, very strongly keeled throughout, irregularly striate, decussated by spiral lines producing a rather indistinct granulation. On the base there are spiral series of granules. In young shells and most adults there are short cuticular processes on the granules and at the periphery. There are $4\frac{1}{2}$ whorls. The first $2\frac{3}{4}$, forming the embryonic shell, are strongly convex, the first whorl almost smooth, after which radial ripples appear. The last embryonic whorl

¹This notice was published before the description of the shell, but it contained nothing diagnostic of the species. The penis, which was figured, does not differ from that of allied forms. Some details of shell structure are essential in establishing a species of *Oreohelix*.

is very convex but begins to be impressed near the periphery. Subsequently the whorls are excavated on both sides of the suture, and the last one is concave above and below the peripheral keel; in front it descends a little below the keel. The umbilicus is rather large and funicular, contained



Fig. 350. *Oreohelix handi*, type and paratype (enlarged and actual size).

about $3\frac{3}{4}$ times in the diameter. Aperture rather small, the margins converging, thin. There is a band of dark livid brown above and one close below the keel, the rest of the upper surface being clouded or suffused with the same color with lighter patches and streaks; keel somewhat crenulated, usually whitish.

Height 5.7, diameter 10.3 mm.

NEVADA: Charleston Mountain, Lincoln County; this is about 30 miles north of Las Vegas. Collecting was done for about a mile southward from Griffith's Hotel, the elevation about 9000 to 9500 feet (J. H. Ferriss), Type 115521 A.N.S.P. MacFarland's Spring, Charleston Mts., 9200 feet, and north slope of Potosi Mt., 1 mile west of main peak, Clark County, 7500 feet, among fir needles and limestone fragments (Edmund C. Jaeger).

This species is related to *O. hemphilli* and *O. eurekaensis*, but differs from both by its more depressed, much more strongly keeled shell. *O. hemphilli* is also much larger and more solid.

Some hundreds of specimens were collected. There is slight variation in sculpture, but very little in form or size.

One of the original lot collected on Charleston Mountain was dissected. The penis is 3 mm. long, epiphallus 1.3 mm. The internally thickened part of the penis is about half the total length and much swollen, Fig. 349 b.

On Potosi mountain the shells average smaller, 4.6 x 8.6 mm., $4\frac{1}{2}$ whorls, to 4.4 x 8 mm., $4\frac{1}{3}$ whorls.

(Named for Edwin E. Hand, who was Mr. Ferriss' companion on collecting trips in California and Nevada.)

***Oreohelix handi jaegeri* Berry**

Figure 351.

Oreohelix handi jaegeri Berry, 1931, Ann. & Mag. Nat. Hist., (10), 8: 118, figs. 6, 7.

"Shell similar to that of typical *handi*, but much larger (adult diameter ca. 14-16 mm.), strongly lenticular, the spire usually much flattened; carina pinched out into a strong keel which continues to the aperture as in the typical race; growth-lines coarse and spiral sculpturing strongly developed

in both young and adult, especially on the base; young shells ornamented with conspicuous periostracal excrescences or fringings in connection with the spiral sculpture and about the periphery." (Berry.)

Height 7 mm., diameter 14.4 mm., umbilicus 3.8 mm.; $5\frac{1}{2}$ whorls. Type. 7.5 x 13.7 mm., 5 whorls, to 7.6 x 16.1 mm., $5\frac{1}{2}$ whorls. Paratypes.

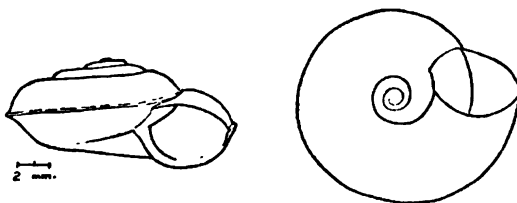


Fig. 351. *Oreohelix handi jaegeri*, type $\times 2$ (after Berry).

NEVADA: Charleston Mountain, on detrital ridge west of Griffith's Hotel, 7500 feet (Edmund C. Jaeger), Type 7186 Berry Collection, paratype 161522 A.N.S.P.

***Oreohelix californica* Berry**

Fig. 352.

Oreohelix californica Berry, 1931, Ann. & Mag. Nat. Hist., (10), 8: 115, figs. 1, 2.

"Shell small, thin, low-conic; the whorls usually about 5, convex, simply carinate; body-whorl slightly to strongly descending back of the aperture, and with the carina generally almost obsolete before it reaches the lip. Aperture small, rounded or very weakly shouldered, its outline only slightly influenced by the carination, very oblique; margins converging. Peristome thin, not expanded, scarcely reflected at the umbilicus; umbilicus wide and funicular, at its best expansion contained 4 to 5 times in the diameter of the shell. Embryonic whorls $1\frac{1}{2}$ measured medially, 2 measured suturally; planulate above, the first half-turn weakly concentrically wrinkled, the wrinkles thence becoming much stronger, especially on the last embryonic half-turn, and crossed by a very fine, rather irregular spiral striation; growth-lines on lower surface much finer and more even, being little, if any, stronger than the spirals; spiral sculpture on later whorls weakly developed (strongest on base of juvenile shells), often largely obscured by the numerous irregular growth-lines, which, however, are sufficiently delicate



Fig. 352. *Oreohelix californica*, $\times 2$. (After Berry.)

so that the surface is quite smooth and lustrous to the unaided eye. Color of upper surface avellaneous to buffy brown with darker or lighter suffusions, the spire sometimes deepening to hair-brown; base lighter, tulleul-buff to light drab or buffy brown, varying rayed and clouded with avellaneous to wood-brown; peripheral carina usually marked by a narrow buffy-white band, with a wider brown band (wood-brown to buffy brown) just below it and a smaller band above not quite halfway to the suture; 2 or 3 not

very constant semitranslucent bands often visible on the base. Height 5.6 mm., diameter 10 mm., width umbilicus 2.3 mm.; 5 whorls." (Berry.)

5.1 x 9.2 mm., $4\frac{1}{2}$ whorls (apparently not mature but containing young); 7 x 10.5 mm., $5\frac{1}{2}$ whorls. Paratypes.

CALIFORNIA: Head of gulch on west side of Clark Mt., northeastern San Bernardino County, among limestone fragments and fir needles in rock slides at about 7500 feet (Edmund C. Jaeger), Type 7182 Berry Collection, paratype 161523 A.N.S.P.

"This is a modest-appearing but very pretty little snail of the general type of *O. eurekaensis* Henderson & Daniels, *O. handi* Pilsbry, and other species, but it most closely approximates to *handi*, with which, perhaps, some students would prefer to unite it as a subspecies. Nearly as small as this last, and admittedly not strongly differentiated, it nevertheless stands apart by reason of the more elevated and simply carinate (not pinched), less lenticular shell, rounded aperture, weak spiral sculpture regardless of age, relatively smooth and lustrous surface, and lack of periostracal fringes in the young. The species agrees with the typical section of the genus in being ovo-viviparous; for, as noted in the table of measurements, two of the living specimens, although thin-lipped and apparently a trifle short of full maturity, proved to contain embryos." (Berry.)

Oreohelix barbata Pilsbry

Fig. 353.

Oreohelix barbata Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 279, pl. 25, figs. 57, 58; pl. 19, fig. 5 (genitalia); pl. 22, fig. 6 (teeth).—Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 91, pl. 6, figs. 1-5, text-fig. 14; 1918, Proc. Acad. Nat. Sci. Phila., p. 325.

Oreohelix barbata minima Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 94, pl. 6, figs. 6, 7; text-fig. 15.

The shell is broadly and openly umbilicate, depressed, biconvex, carinate, pale brown, lusterless; obliquely closely lamellose costulate, the lamellae lengthened into a cuticular fringe at the periphery, and at several places on

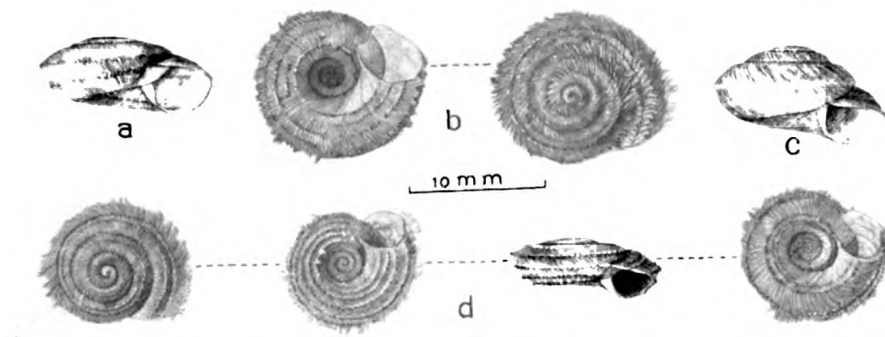


Fig. 353. *Oreohelix barbata*. a, type; b, Cave Creek near head; c, Cave Creek near falls; d, Rucker Canyon.

the base, forming circular fringes there. A similar but less developed one runs in the middle of the upper surface of the last whorl. The embryonic shell of two whorls has the first three-fourths to one whorl smoothish; the second is obliquely costulate, the riblets in perfectly preserved examples having cuticular edges; they project upon the next whorl over the suture. There are sometimes weak traces of a few coarse, low spiral lines. Whorls rather rapidly increasing, the last slowly descending in front, very convex beneath. The aperture is very oblique, shortly pear-shaped, the peristome simple, upper and lower margins strongly converging and straightened, connected by a short and thin parietal callus.

Height 7 mm., diameter 13.5 mm.; $4\frac{1}{2}$ whorls.

Height 5.5 mm., diameter 12.7 mm.; $4\frac{1}{4}$ whorls.

The foot of *O. barbata* is small, slate-blackish above and finely granulated. No genital furrow is discernible, but there is a pair of dorsal grooves. The tail is flattened and pale above. The mantle edge is very thick and fleshy.

The genitalia of one of the types are figured (Fig. 354). The lower half of the penis is much swollen, the upper half smaller and cylindrical. Internally the anterior, larger portion has 4 or 5 large and some smaller longitudinal folds, the upper part is densely papillose inside. The epiphallus bears the penis-retractor muscle, some distance from its base, and the vas deferens enters centrally at the end. The duct of the spermatheca is somewhat swollen basally. The uterus contained neither eggs nor embryos, the specimens having been collected in February.



Fig. 354.

The radula has 23.1.23 teeth. The mesocones are long, and all the teeth have well-developed ectocones. The marginal teeth are bicuspid as usual, the cusps not split.

ARIZONA: Chiricahua mountains, from the head of Pinery Canyon to Rucker Canyon, 6000 to 10,000 feet (Ferriss, Daniels and Pilsbry). Type 87011 A.N.S.P., from Cave Creek near the falls.

NEW MEXICO: Mogollon Mountains in Dry Creek, Cave Spring Canyon and Willow Canyon (J. H. Ferriss).

Thin, triangular cuticular processes or hairs are often present on the shells of very young *Oreohelices*, but in this one their development culminates in the adult snail. Their projection at the angle of the whorls of the spire makes the lamellae look continuous over the sutures. When denuded the shell is sharply striate, with some ill-defined spiral welts marking the positions of the more prominent cuticular wreaths. Besides those described above, there are some minor and variable spirals on the most perfect specimens.

The processes are very efficient as gatherers of soil, which is probably glued on by the mucous of the animal, as usual.

By its tricuspid central and bicuspid lateral teeth, as well as by the general form of the shell, *O. barbata* recalls the species of *Radiocentrum*.

The insertion of the penial retractor solely on the epiphallus is also like *Radiocentrum*, and unlike any of the typical *Oreohelices*, but the penis has the normal *Oreohelix* structure.

O. barbata lives in moist places in talus, rock slides, and among rocks on the slopes of ravines. In Cave Creek and Rucker Canyons I have taken them usually under one or two feet of rocks. Ferriss and Daniels found the finest specimens under two to three feet of rock well covered with sod, together with *Ashmunella chiricahuana*, *A. proxima* var., and *Sonorella virilis*. In the Chiricahuas about twenty colonies have been found within the limits noted above,—a belt of about twelve or thirteen miles along the high part of the range, and about two or three miles wide. It does not occur in the dryer northern half of the range. The colonies are usually small, isolated, and more or less differentiated by peculiarities of the shells. In color they run from dark brown to a light greenish tint, some having two indistinct reddish bands. The cuticular wreaths vary in number from 5 to 10, in some colonies persisting to the adult stage, in others partially or wholly wanting in adults. The size varies from 14.5 mm. to 10 mm. diameter, and is not correlated with elevation of the station. The last whorl may be moderately or very deeply deflected in front. These local and colonial variations have been discussed by P. and F., 1910.

(*Barbatus*, bearded.)

Form *minima* Pilsbry & Ferriss (Fig. 355), is a diminutive race found in the head of Rucker canyon and the Rucker "box". The last whorl is regularly angular, the angle weakening near the aperture in old shells. Toward the end the whorl falls deeply at maturity. There are from 6 to 7 spiral fringes in the best preserved examples, but adults generally are denuded or show only traces of the spiral wreaths. The margins of the lip converge and form a perfect union in maturity, being joined by a very short parietal callus, which is sometimes raised free from the penultimate whorl. The shells from the head of Rucker are uniform brown in color and measure: 5 x 10 to 10.3 mm., $4\frac{1}{4}$ to $4\frac{1}{2}$ whorls; the figured specimens are 9.8 and 10 mm. in diameter. In Rucker "box" they are sometimes albinistic, light green, and measure from 5 x 10 to 6 x 10 mm.



Fig. 355. *O. barbata* form *minima*, Rucker Canyon box ($\times 3$).

An entirely similar small form occurs in the Mogollons. In both areas the larger forms of *barbata* have been found both higher and lower in the same districts, and no local condition accounting for the dwarfing was noted.

O. barbata is abundant in the Mogollon Range, New Mexico, more than 100 miles northeast of its area in the Chiricahuas. The spiral wreaths are

usually numerous, 8 to 11, though in some lots cuticular appendages are mostly or entirely lost in adult shells. The diameter runs up to 15.5 mm. In Willow Creek and some places in Dry Creek the size is reduced, as mentioned above, diameter 11 to 12 mm. In Cave Spring Canyon all are small, about 10 mm. in diameter.

Subgenus *RADIOCENTRUM* Pilsbry

Radiocentrum Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 283, type *Oreohelix chiricahuana*.

Oreohelices with an embryonic shell of about $1\frac{1}{2}$ radially ribbed whorls; penis club-shaped, the walls of its cavity plain in the anterior part, having oblique ridges irregularly en chevron in the middle and posterior parts, wide and truncate at the end; epiphallus about as long as in the penis, slender anteriorly, the penial retractor inserted on it a short distance from its entrance in the penis. Reproduction oviparous.

Distribution.—Southern New Mexico and Arizona, northwestern Chihuahua, Santa Catalina Island, California. The map (Fig. 286) does not show distribution in Chihuahua.

This is a strongly characterized group, the shells readily known by the few-whorled and ribbed embryonic stage, the genitalia by the equality in length of penis and epiphallus, and by the internal structure of the former. Of the seven recent species now known, five occur in our limits, two in Chihuahua. There and in northeastern Sonora others doubtless will be found.

(*Radius*, ray, *κέντρον*, center.)

Key to Species of Radiocentrum

1. Shell calcareous, opaque whitish with some gray or brownish streaks or bands, cuticle inconspicuous.2
Shell covered with a green to brown cuticle, which is either smooth, or lamellose with cuticular processes.4
2. Surface cut into granules above and below; sharply carinate, at least in front; 6 x 11 to 8 x 14 mm.; Santa Catalina I.*O. avalonensis*
Surface smoothish or striate, not granulose.....3
3. Periphery angular or carinate; striate; Chiricahua Mts.*O. chiricahuana*
Peripheral angle rounded; depressed; Big Hatchet Mts.*O. hachetana*
4. Strongly depressed; umbilicus about 4 times in diameter; Big Hatchet Mts.
O. ferrissi
Moderately depressed; umbilicus 5 to 6 times in diameter. Chiricahua Mts.
O. clappi

Oreohelix hachetana Pilsbry

Fig. 357: 1-1d, 6.

Oreohelix (Radiocentrum) hachetana Pilsbry, 1915, Proc. Acad. Nat. Sci. Phila., p. 330, pl. 6, figs. 1-1d, 6; text-fig. 4a.

The shell is depressed, umbilicate, the umbilicus about one-fourth the diameter of the shell; moderately solid, but thin, opaque whitish, obliquely streaked or smeared with various shades from light cinnamon-drab to pale

ecru-drab, often having a band of the same below the periphery; embryonic whorls fawn color. Spire convex or very low conic, $1\frac{3}{4}$ embryonic whorls convex, sculptured with delicate, retractive radial rib-striae, a few very fine spiral lines in the intervals (Fig. 6); following whorls irregularly marked with weak growth-lines, less convex, a little flattened or impressed above the suture, the last whorl convex, very indistinctly angular at the periphery, slowly descending to the aperture, convex beneath. The aperture is very oblique, about as high as wide. Peristome thin, the upper and basal margins somewhat prolonged and a little straightened, converging, joined by a thin, adnate parietal callus.

Height 9 mm., diameter 15 mm.; $5\frac{1}{2}$ whorls.

Height 8.5 mm., diameter 15.8 mm.

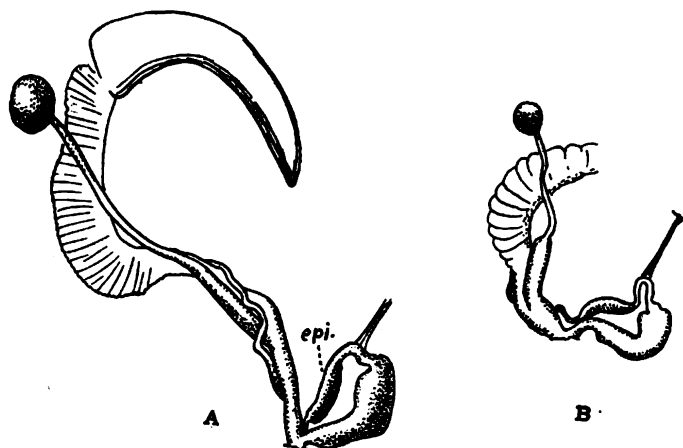


Fig. 356. A, Genitalia of *Oreohelix hachetana*. B, *Oreohelix ferrissi*.

Genitalia (Fig. 356 A). The penis is very short, its distal half enlarged. The walls of the rather large cavity are densely papillose, the papillae long, arranged in oblique rows in some parts. Epiphallus about equal in length to the penis, its distal half enlarged. Vagina equal to the penis in length. Length of the penis, epiphallus and vagina 5 mm.; length of spermatheca and duct 15 mm.

NEW MEXICO: Summit of Hacheta Grande Mountain, 8366 feet (H. A. Pilsbry), Type 112282a A.N.S.P. Also about a mile down the northeast ridge (Pilsbry and Daniels).

This species was collected in considerable quantity—several hundred living specimens. The “bones” are seen all over the upper four or five hundred feet of the peak. Living snails were all taken on the west side and were most abundant at the summit near the north of the small stone “monument” or cairn which marks the summit, on and under stones. Also on the precipitous western slope.

The species is very uniform in all its characters. The size varies from 14 to 16 mm. diameter, and in some shells the last whorl descends more than in others. Very few have the parietal callus thickened and a little raised.

It differs from all forms of *O. strigosa* by its convex, radially costellate embryonic whorls, but in many adult shells this sculpture is effaced. *O. ferrissi* is probably the most nearly related species, though very different.

***Oreohelix hachetana cadaver* Pilsbry**

Figure 357: 2.

Oreohelix hachetana cadaver Pilsbry, 1915, Proc. Acad. Nat. Sci. Phila., p. 332, pl. 6, fig. 2.

The shell is larger than *hachetana*, the periphery rounded in adults except near the aperture in front, where it is distinctly but bluntly angular. Umbilicus smaller, about $5\frac{1}{2}$ times in the diameter of the shell.

Height 11.4 mm., diameter 18.5 mm.; barely 5 whorls.

NEW MEXICO: Big Hatchet Mountains, below the cliffs on the north side of the summit of Daniels Mountain (Daniels and Pilsbry), Type 112283 A.N.S.P.

Only a few long-dead shells were found in this dusty place, where, at the base of the cliffs there are a few small pinyon pines, mostly dead or moribund. *Holospira* and *Ashmunella mearnsi* live here in abundance.

***Oreohelix ferrissi* Pilsbry**

Fig. 357: 4-5d.

Oreohelix (Radiocentrum) ferrissi Pilsbry, 1915, Proc. Acad. Nat. Sci. Phila., p. 332, pl. 6, figs. 4-5d; text-fig. 4b.

The shell is openly umbilicate, umbilicus conic, one-fourth the total diameter; slightly convex above, base strongly convex; thin, light dull brown. The embryonic shell of $1\frac{1}{2}$ convex whorls is finely lamellose striate radially (Fig. 5d). Post-embryonic whorls have the surface densely lamellose along growth-lines, the lamellae rising in triangular cuticular processes where they cross the spiral ridges of the shell. When denuded, the shell has a blunt, projecting peripheral carina; the upper surface has a wide, somewhat angular spiral ridge upon all the post-embryonic whorls, sometimes with one or two minor ridges; the lower surface has three to five low spiral ridges and some minute, weak spiral striae; the whole shell being closely thread-striate along growth-lines. The last whorl usually does not descend in front. Aperture oblique, irregularly rounded, lip simple, the margins rather widely separated, parietal callus thin. Shells denuded of the cuticular processes measure:

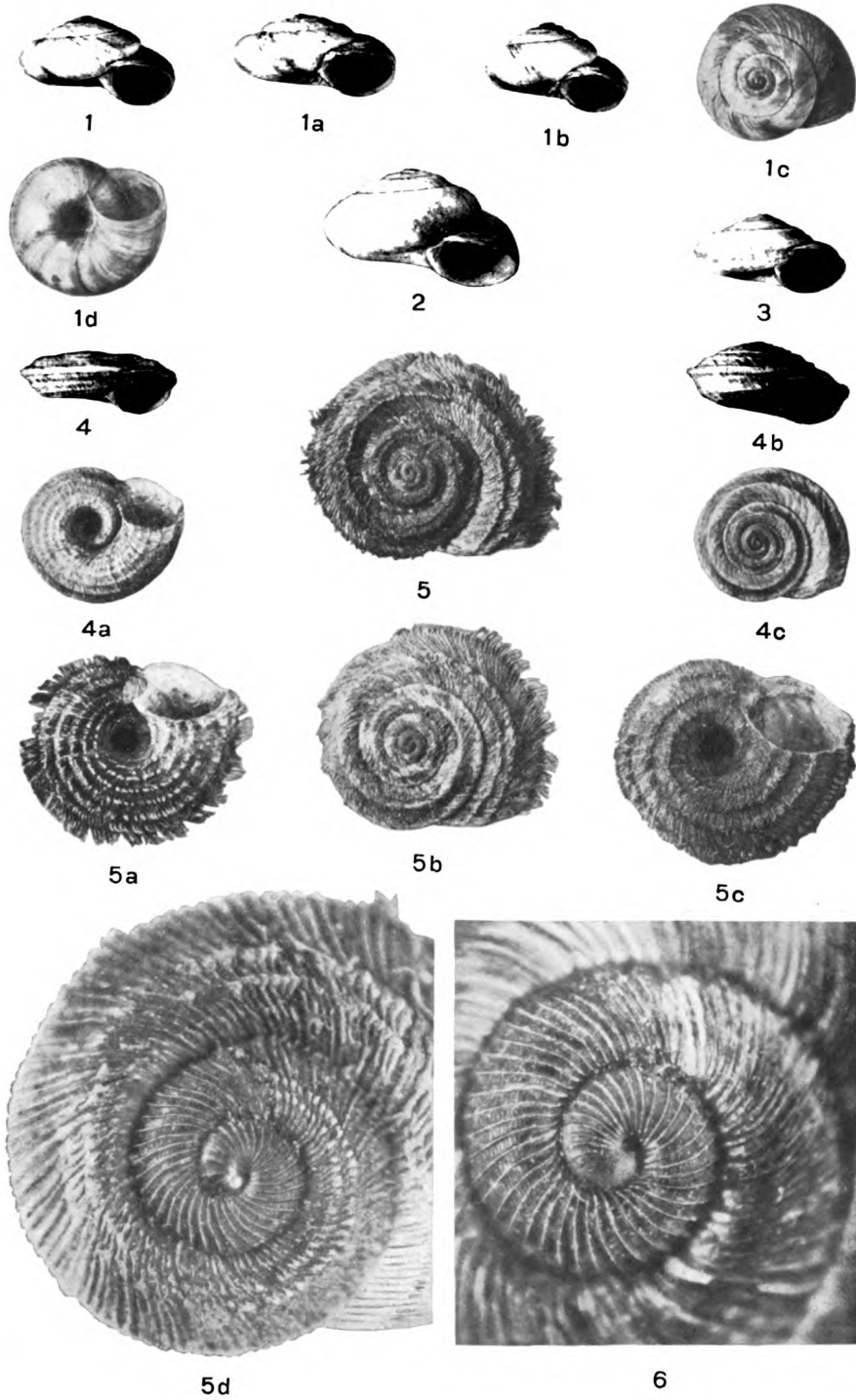
Height 6.5 mm., diameter 14.5 mm.; $4\frac{1}{2}$ whorls.

Height 6 mm., diameter 15 mm.; $4\frac{1}{2}$ whorls.

Genitalia similar to *O. hachetana*, except that the lower third of the duct of the spermatheca is more enlarged. Length of penis 5 mm.; epiphallus 5.5 mm.; spermatheca and duct 9 mm. (Fig. 356 B).

NEW MEXICO: Hacheta Grande Mountains, on ledges of high limestone cliffs opposite the mouth of Sheridan Canyon, under stones (Pilsbry and Daniels); Type 112276 A.N.S.P. Also on "Teocalli Butte."

Fig. 357. 1-1d, *Oreohelix hachetana*. 2, *O. h. cadaver*. 3, *O. ferrissi morticina*. 4-4c, *O. ferrissi*, denuded of cuticle. 5-5c, *O. ferrissi*; 5d, embryonic and first neanic whorls of same. 6, *O. hachetana*, embryonic and part of first neanic whorls. (Figs. 1-4c \times 1.43; 5-5c \times 2.5; 5d and 6 \times 14.) See p. 543.



O. ferrissi has much the appearance of the Chiricahuan *O. barbata* Pils., but this resemblance is superficial. When denuded of the cuticular fringes, the two are quite unlike, the Chiricahuan species being much smoother, without the strong spiral ridges of *O. ferrissi*. Moreover, the sculpture of the embryonic shell is different. The shape of penis and epiphallus in *O. ferrissi* is like *O. chiricahuana* and *O. clappi*, both organs being enlarged distally, while in *O. barbata* the lower half of the penis is enlarged, the distal portion slender.

In well-developed shells the last whorl scarcely descends anteriorly, the upper margin of the lip being inserted on the peripheral carina. In some of the smaller adults, diameter 13 mm., the last whorl is bent downwards; the upper and columellar margins of the lip converge and are connected by a raised parietal lamina, the mouth having a somewhat triangular contour.

At "Teocalli Butte" the shells are all convex above, with a noticeably smaller umbilicus. The largest measures, height 7.8, diameter 15 mm., with 5 whorls (Fig. 357: 4b). This small colony is probably extinct or nearly so, as no living shells were found.

The type station is on ledges of high cliffs facing the mouth of Sheridan Canyon, and especially on a bench about half-way up. Here Ferriss's *Oreohelix* lives on ledges of an almost inaccessible cliff looking out over the mesa into Mexico. There is little vegetation on the ledges. On the talus slope below the cliff there is a growth of dwarf oak about knee-high, charming big wild roses of a species which we saw nowhere else, *Cylindropuntia*, *Opuntia*, bisnagas, etc. On top, above the cliffs, the *Fouquieria*, sotol, mesal society is found. The *Oreohelix* colony is of small extent; the ledges where they were observed living are probably not over a couple of square rods in area, with perhaps an equal area on the talus below the cliffs, where dead shells were found. These estimates are from memory, as I neglected to note the figures at the time.

(Named for my companion of months in the field.)

***Oreohelix ferrissi morticina* Pilsbry**

Fig. 357: 2.

Oreohelix ferrissi morticina Pilsbry, 1915, Proc. Acad. Nat. Sci. Phila., p. 334, pl. 6, fig. 3.

Differs from *O. ferrissi* by the more convex spire and by the weakness of the spiral sculpture, there being no such pronounced spiral ridge on the upper surface of the whorls, and only very weakly sketched spirals on the base, whilst in *O. ferrissi* these ridges are very emphatic.

Height 7.4 mm., diameter 14.2 mm.; 4 $\frac{3}{4}$ whorls.

NEW MEXICO: Big Hatchet Mountains, below the cliffs on the north side of Daniels Mountain,¹ near the summit, with *Holospira*, etc., at about 6800 feet (Pilsbry), Type 112277 A.N.S.P.

¹ I gave the name of my companion on this trip to the long peak south of upper Thompson Canyon, marked as being 6829 ft., on the Big Hatchet Topographic sheet.

Only a few long-dead shells were taken, but these surely indicate a local race which has finally succumbed to the increasing aridity of their station. Of large shells only *Holospira* and *Ashmunella* survive on this mountain, both of them being burrowing animals.

(*Morticinus*, dead.)

***Oreohelix clappi* Ferriss**

Fig. 358.

Oreohelix clappi Ferriss, 1904, Nautilus, 18: 53.—Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 285, pl. 25, figs. 54-56 (shells); pl. 19, fig. 8, pl. 22, fig. 4; pl. 23, fig. 26 (anatomy).—Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 80, fig. 8.

“The shell is rather thin, moderately depressed, with tubular whorls and deep suture, the altitude about two-thirds the diameter and about equally convex above and below the peripheral angle. The umbilicus at the opening is about one-sixth ($5\frac{1}{2}$ to $6\frac{1}{2}$ times) in the diameter and contracts rapidly, only the penultimate whorl visible. Calcareous layer of the shell is brownish white under a thin greenish-yellow cuticle with some darker oblique streaks,

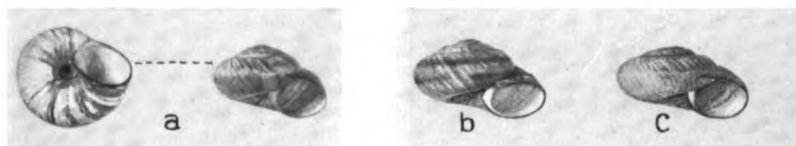


Fig. 358. *Oreohelix clappi*. a, Cave Creek; b, Rucker Canyon; c, Shake Gulch.

which become in mature shells darker and crowded near the aperture. Many possess two indistinct transparent olive spiral bands, one above, the other just below the periphery. In old individuals the cuticle remains only in ragged shreds. The first $1\frac{1}{2}$ embryonic whorls are strongly ribbed radially; these riblets are regular and narrower than their intervals. At the end of the embryonic shell the whorl slightly widens abruptly, with sculpture of rather coarse irregular obliquely radial wrinkles and traces of fine spiral striae. The last whorl has unequal, irregularly spaced oblique wrinkles, *weak and low at the base*, which is densely covered with minute wavy spiral striae, obsolete in old individuals. Where the wrinkles pass over the angular periphery they are sometimes somewhat more emphatic, a little pinched up. There are *no spaced circular threads or cuticular fringes on the base*. Whorls $4\frac{3}{4}$, convex, the last double the width of the preceding. Base very convex. The aperture is very shortly ovate or nearly circular, very oblique, and about one-half the diameter of the shell. The ends of the lips converge. The short parietal callus is a thin transparent film, or in old shells the peristome is continuous as a raised parietal ledge. Old age is expressed by a deeper descent of the last whorl and closer approach of the lip margins, as usual in the genus *Oreohelix*.”

Height 6.5 mm., diameter 14.8 mm.

ARIZONA: Chiricahua Mountains in Onion Creek and Cave Creek south to Rucker Canyon, Horseshoe Canyon and Shake Gulch (Ferriss, Daniels & Pilsbry), the Type, 87013 A.N.S.P., from Cave Creek. Elevation 5000 to about 7000 feet.

Clapp's mountain snail is strongly individualized by the possession of a green or olive periostracum. The type lot, described above, was from a branch of Cave Creek about half a mile south of Crystal Cave, where it occurred deeply imbedded in rotten shale near the water's edge, in the shade of a cliff. While doubtless calciphilous, like other *Oreohelices*, I have found it in igneous rock also.

The smoothish integument is blackish on the head and tail, and darker toward the foot margins, elsewhere tessellated with large polygonal gray pigment spots. Sole cream colored. There are two irregular dorsal grooves.

The kidney, 6.3 mm. long, is a thin-walled sack, its lumen large, with strongly corrugated walls. The pericardium is fully 4 mm. long.

The reproductive system (Fig. 359) resembles that of *O. chiricahuana*. The rather slender cylindric penis is enlarged at the summit. The epiphallus enters through a very small acorn-shaped papilla. The walls of the penis are thin, with a minute oblique corrugation meeting V-like on one side. Penis 7, epiphallus 7, vagina 6, spermatheca and duct 13 mm. long. The penial retractor is inserted about 1.5 mm. from the base of the epiphallus.

The jaw (Fig. 276, at right) is arcuate and striate vertically.

The radula has about 29.1.29 teeth, of the general form usual in *Oreohelix*. There are rudimentary ectocones on the central teeth, at least where they are unworn. The laterals have similar ectoconal cutting edges. The marginal teeth are bicuspid.

Nearly every colony is recognizable by peculiarities of the shell. In lower Cave Creek (Fig. 360) they are slightly more angular, and in



Fig. 359.

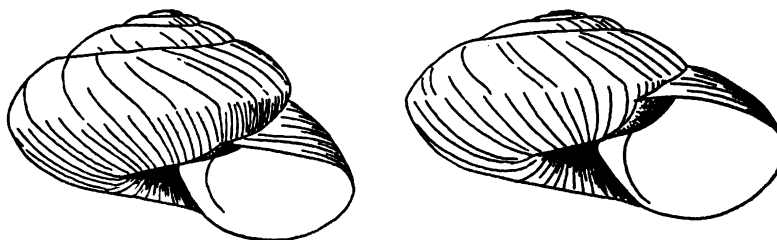


Fig. 360. *Oreohelix clappi*, lower Cave Creek. Diam. 14.7 and 15.7 mm.

immature shells the growth lines bear short cuticular laminae at the periphery, and often there are three concentric rows of minute granules at intervals on the base.

On Onion Creek the whorls are flatter, the last falling more deeply in front, and the peripheral angle continues to the lip. The light olive-green cuticle is persistent, lusterless, densely and distinctly striate spirally on the base. Size 8.8 x 15 mm. to 10.5 x 17.5 mm.

The form of Rucker Canyon is very glossy; the last whorl is only quite obtusely angular; aperture larger.

In Shake Gulch the shell is sharply angular, becoming obtuse near the lip; cuticle dull, obscure olive beneath, with a russet suffusion above.

(Named for George H. Clapp.)

Oreohelix clappi emigrans Pilsbry & Ferriss

Fig. 361.

Oreohelix clappi emigrans Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 79, fig. 7.

This shell is similar in outline to *O. clappi*, but more sharply angular at the periphery, or even carinate in front. Cuticle thicker, rough, usually persistent, dark olive brown in color, lusterless, not banded, coated with a caked deposit of humus. "The sculpture after the embryonic shell consists

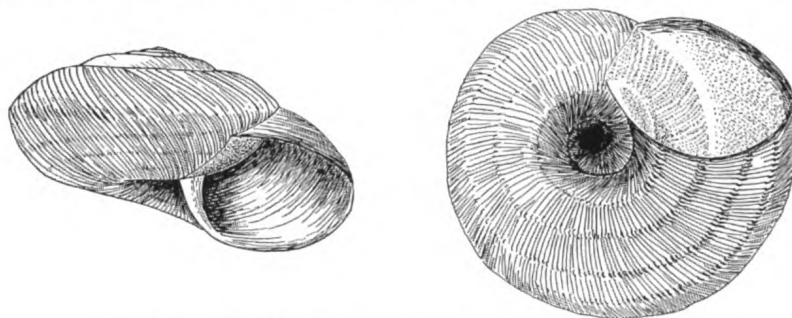


Fig. 361. *Oreohelix clappi emigrans*. Diameter 16.4 mm.

of oblique, uneven, rather sharp striae, and on the last whorl some coarse wrinkles. The striae are sharper than in *O. clappi* and close together up to the last whorl; on the base they are *thread-like, crimped and waved* at the intersections of four or five circular rows of short cuticular appendages, which are usually retained only on the latter part of the base. In immature shells the thread-like striae are surmounted by delicate cuticular laminae, more or less felted together by the adhering dirt." The aperture is rounded-piriform, the lip margins converging, thickened at the ends and connected by a thin film across the parietal wall. Interior bluish white.

Height 9 mm., diameter 16.4 mm.; whorls 5.

ARIZONA: Chiricahua Mountains on Rough Mountain,¹ on the south side of Emigrant Canyon, at about 7000 feet elevation, taken in some numbers in a shattered column of stone and also in a rock slide (Pilsbry & Ferriss), Type 99779 A.N.S.P.

This place is about 20 miles across the mountains northwest from the Cave Creek locality for *O. clappi*. *O. c. emigrans* is the dirtiest of the group—in its natural state as black as the soil. It is well distinguished by the sculpture, and would be considered a separate species in a less variable group than *Oreohelix*.

¹ Rough Mountain, 7277 ft., is the name given on the U. S. Topographic sheet, 1917, to what we called "Big Emigrant mountain" in our paper of 1910.

Oreohelix clappi cataracta Pilsbry & Ferriss

Fig. 362.

Oreohelix clappi cataracta Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 84, fig. 9.

The shell is strongly depressed, nearly lens-shaped; periphery strongly angular in front; bright olive green, thin, polished, translucent, occasionally marked with two transparent bands; $4\frac{1}{2}$ whorls, the last wider than in *clappi*, with the periphery near the flattened top, base strongly convex. Parietal callus short, merely a thin film on the penultimate whorl. Cuticle smooth and without "fringes" in young or old, very delicately striated spirally; sculpture of the embryonic whorl delicate, usually worn off.

Height 6.5 mm., diameter 13.7 mm.

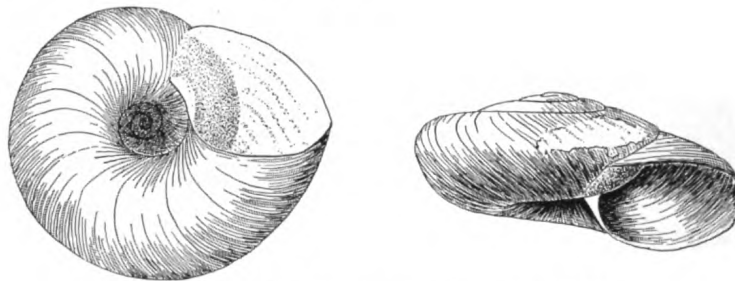


Fig. 362. *Oreohelix clappi cataracta*. Diam. 13.7 mm.

ARIZONA: Chiricahua Mountains at the Cave Creek falls in broken rock sprayed by the falls, and near the water's edge, in company with a very small form of *Ashmunella chiricahuana*. It was also found occasionally among the rocks higher up the slide with *O. barbata* and *Ashmunella angulata* (J. H. Ferriss), Type 99781 A.N.S.P.

O. clappi cataracta is quite a distinct race. The polished green base reminds one of *Mesomphix*. It is the smoothest and most depressed form of *O. clappi*.

(*Cataracta*, waterfall.)

Oreohelix chiricahuana Pilsbry

Figs. 363, 365 E.

Oreohelix chiricahuana Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., p. 283, pl. 11, fig. 1-3; pl. 19, fig. 4; pl. 23, fig. 24. Not pl. 22, figs. 10, 11.—Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 85, fig. 10.

The opaque, cretaceous shell is depressed, the altitude about .6 of the diameter, about equally convex above and below the peripheral keel. Umbilicus rather well-like, slowly contracting, and contained about $4\frac{1}{2}$ times in the diameter of the shell. Whitish, with an indistinct gray band near the middle of the upper surface and another immediately below the white keel, the early whorls dull brown; without perceptible cuticle. Sculpture of close but irregular and rather sharp growth-wrinkles, very indistinctly decussated with spiral striae on the base. The embryonic shell consists of only $1\frac{1}{2}$ whorls. The first half whorl is nearly smooth, the next whorl is sharply and finely but very regularly ribbed radially. With the compound

microscope some very weak spiral striation may be seen indistinctly in the intervals. At the end of the embryonic period the rib sculpture abruptly gives place to a lower, less regular oblique striation. The spire is convexly conic. Whorls 5, convex, impressed above the suture, where the keel projects a trifle. At the periphery the keel projects somewhat, the surface



Fig. 363. *Oreohelix chiricahuana*, type and paratypes. Diam. 10.5 to 11.3 mm.

being a little concave above and below it. Base convex. Aperture small, oblique, a little angular at the outer part. Lip simple, the ends approaching.

Height 6.5 mm., diameter 11.3 mm.; 5 whorls.

Height 6.7 mm., diameter 10.8 mm.

ARIZONA: Chiricahua Mountains, colonies of the several races scattered from Emigrant Canyon to Limestone Mountain (Ferriss, Daniels and Pilsbry), typical *chiricahuana* from Cave Creek valley only, the Type, 87012 A.N.S.P., from the slope below the cave.

This very distinct little snail is always found on limestone, never where the country rock is metamorphic or igneous. It is related to *O. avalonensis* and *O. hachetana*, in which the apex is of the same type.

The genitalia are drawn in Figure 364. The penis is cylindrical, a little flattened and protruding on one side at the distal end. The epiphallus is longer than the penis, club-shaped, the retractor inserted upon it not far from its base, the vas deferens inserted excentrically. The lower part of the spermatheca duct is enlarged and muscular. Talon of the usual shape, but not pigmented. The lengths of the organs are as follows: penis 4, epiphallus 4.7, vagina 3.5, spermatheca and duct 7.5 mm. The foot is scarcely granulose, the integument smoothish, tessellated in rather coarse pattern with blackish or gray spots. No genital furrow is visible. The mantle edge is thin.

The jaw (Fig. 276, left figure) is striate, somewhat less arcuate than that of *O. clappi*.

The radula (Fig. 277 F) has 26.1.26 teeth. They are rather shorter than usual in *Oreohelix*. The central and lateral teeth have well-developed ectocones. The marginal teeth are bicuspid, as usual in *Oreohelix*.

The type locality is on the slope with southern exposure below the cave in Cave Creek Canyon. The dry ravine has steep sides of steeply dipping,



Fig. 364.

more or less calcareous shale and residual earth. Dead shells are profusely scattered; living ones are under dead mesal (*Agave*), sotol (*Dasyllirion*) and bear-grass, with *Thysanophora horni*, *Succinea avara*, *Retinella indentata* and *Holospira*. The colony here is about 250 yards long and perhaps 100 wide in the widest place (distances paced). The shells are very uniform in size, diameter 10.5 to 11.5 mm., white, with the earlier whorls flesh-tinted, a faint fleshy-corneous band at the outer third of the top of the last whorl, which has two grayish or fleshy corneous bands on the outer half of the base or a general fleshy corneous suffusion there. A scalariform mutation rarely occurs. We found large colonies at intervals west of the cave nearly to the western rim of the valley. In some places the diameter is 12-13 mm.

The total area of *chiricahuana* with its subspecies is about 50 miles along the range, but because of its strictly calcicolous habit, occurrence is discontinuous, much of the sedimentary rock being blanketed by lavas. From Whitetail Canyon to the Cave Creek amphitheatre colonies are not widely separated, but there is a 25 mile gap from there to Limestone Mountain in the southern end of the range, according to our present records.

The several races differ as follows. While typically distinct, some intergradation is present in the long series of all collected.

1. Sculpture obsolete, the oblique striæ coarse and blunt, the base especially much smoother; spiral sculpture weak or wanting; diameter usually 12 to 15 mm., whorls $5\frac{1}{3}$ to $5\frac{1}{2}$ *O. c. obsoleta*
Sculpture of sharp fine striæ along the lines of growth, conspicuous on the base, where there are also weak spiral striæ and some widely spaced larger spirals. 2
2. Shell smaller, diameter about 11 mm., whorls $4\frac{1}{2}$ to 5; peripheral keel well expressed. *O. chiricahuana*
Shell larger, diameter about 14 mm., whorls $5\frac{1}{4}$; peripheral keel strongly projecting, the whorl hollowed above and below it. *O. c. percarinata*

***Oreohelix chiricahuana obsoleta* Pilsbry & Ferriss**

Fig. 365 A, B, C.

Oreohelix chiricahuana obsoleta Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 88, fig. 13.

The sculpture is rather rude and blunt, the striation less sharp than in the Cave Creek form, being effaced or subobsolete especially on the base where spiral lines are wanting or rarely weakly indicated (while Cave Creek *chiricahuana* has sharp, subregular striation and distinct spirals). Two or three inner whorls are brown, the rest being white with some faint gray streaks and scattered dots and sometimes two faint bands on the base. Whorls $5\frac{1}{3}$ to $5\frac{1}{2}$ ($4\frac{1}{2}$ in typical *chiricahuana*), the last carinate as in *chiricahuana*. The shape varies from that of typical *chiricahuana* to decidedly more elevated, and the size exceeds that of Cave Creek shells.

A series from the typical station, where it is abundant, measures 12 to 14.3 mm. diameter.

Height 9.3 mm., diameter 14.3 mm., type.

ARIZONA: Chiricahua mountains in Whitetail Canyon, 6-7000 feet (Ferriss and Pilsbry), Type 92318 A.N.S.P. Hand's Pass; head of Pinery Canyon; Onion Creek, between Jhus Canyon and Paradise; also Limestone Mountain at about 6500 feet (Ferriss).

Limestone Mountain is so remote from the area of *obsoleta* that one is inclined to think the shells a parallel race rather than directly related to those of the Whitetail region. They are the largest of the species, thick and rounded, opaque white or pink-white and very little clouded. The wrinkles are coarse but obtuse upon the upper surface, the base smooth, without a trace of spiral lines. The diameter is from 13.5 to 16 mm. (Figs. 365 B, C).

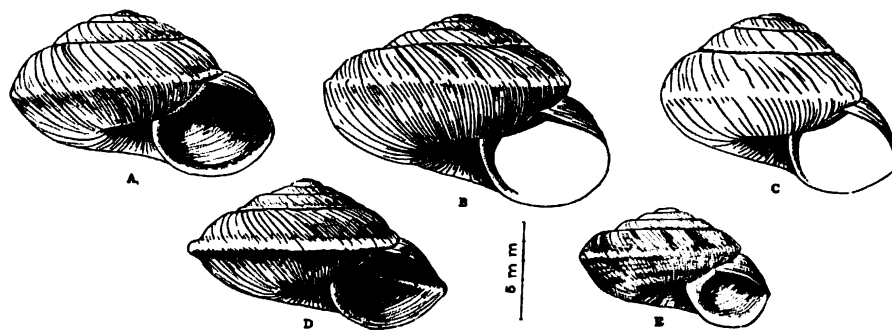


Fig. 365. A, *Oreohelix chiricahuana obsoleta*, Whitetail Canyon; B, C, Limestone Mt. D, *O. c. percarinata*, type. E, *O. chiricahuana*, topotype. (All \times about $2\frac{1}{2}$.)

***Oreohelix chiricahuana percarinata* Pilsbry & Ferriss**

Fig. 365 D.

Oreohelix chiricahuana percarinata Pilsbry & Ferriss, 1910, Proc. Acad. Nat. Sci. Phila., p. 87, fig. 11.

The shell is larger than typical *O. chiricahuana*, whitish, clouded and suffused with flesh color, depressed, with a compressed, projecting peripheral keel, the last whorl excavated, concave above and below the keel, elsewhere strongly convex. Striation oblique, rather coarse and quite irregular above, sharper and strongly arcuate below. Spiral threads few and fine or wanting on the upper surface; on the base there are two to four major spirals at wide intervals, with fine spiral threads over the whole, but all spirals are inconspicuous. The last whorl rarely falls far below the carina at the aperture.

Height 8 mm., diameter 14 mm.; whorls $5\frac{1}{2}$.

ARIZONA: Chiricahua Mountains, summit of Wood Mountain¹ near the mouth of Emigrant Canyon, 7300 feet (Pilsbry), Type 99749 A.N.S.P.

There is little vegetation of any kind on the upper part of Wood Mountain. The station is rocky, barren and exposed. The snails are

¹ This peak was called "Cross J mountain" in our paper, for the ranch of that name near its foot. The U.S.G.S. topographic sheet had not been issued at that time.

moderately abundant, though living ones are hard to get. This place is farther north than any other known colony of *Oreohelix* in the Chiricahua range. The *Oreohelices* were found around the summit and along the ridge northward, down about 500 feet, but not in the valley (Station 6), where *Sonorella* lives. The mountain is limestone, the rock at the summit somewhat metamorphic, angular, and friable where the oreohelices live.

On the south side of Paradise Canyon about two miles below the town of Paradise, *Oreohelix* was found in some abundance, but owing to the snow which covered the ground at the time we camped there (November 20)

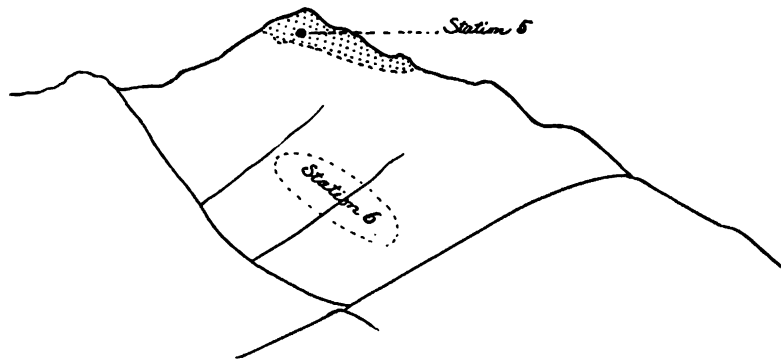


Fig. 366. Summit of Wood Mountain, seen from the mouth of Emigrant Canyon. Entire range of *O. c. percarinata* shaded. At Station 5 and over much of the slope around Station 6, *Sonorella optata* was found. High granitic spur on left.

but few living examples were taken. The form is almost identical with that of Wood Mountain, the adult differing only in having the radial striation on the base a little more regular, and the major spirals, of which there are three or four, often somewhat stronger, though in some shells they are hardly noticeable. In young and half-grown shells a thin cuticular thread runs along the summit of each of the striae, and at the intersections of the major spirals these threads rise in short triangular processes. This feature was not observed in the shells from Wood Mountain. Another similar lot was taken on the northern slope of the canyon. These places are probably not far from 5500 to 6000 feet, being thus much lower than Wood Mountain.

The separation of these colonies from the Wood Mountain colony of *O. c. percarinata* probably indicates independent evolution of partially similar characteristics, since an area occupied by *O. chiricahuana obsoleta* lies between Emigrant Canyon and Paradise.

***Oreohelix avalonensis* "Hemphill" Pilsbry**

Fig. 367.

Oreohelix avalonensis Hemphill in Pilsbry, 1905, Proc. Acad. Nat. Sci. Phila., pp. 283, 284, pl. 11, figs. 4-7.¹—Baily, 1935, West Coast Shells, p. 313, fig. 329.

Helix var. *avalonensis* Hemphill, 1911, Trans. San Diego Soc. Nat. Hist., 1: 104, pl. 4.

¹ About 40 years ago Mr. Hemphill distributed this species with the printed label "*Helix alternatus* var. *avalonensis*." Before writing the monographic account of *Radio-*

The shell is lens-shaped, sharply carinate; umbilicus contained slightly more than 5 times in the diameter. Spire dull brown, the last whorl cream white with streaks of light brown and gray, and two pale brown bands, the upper one a short distance above, the lower immediately below the periphery. Embryonic shell of $1\frac{1}{2}$ strongly convex whorls, the initial half turn smooth, the following whorl with strong radial ribs with wider, smooth intervals.

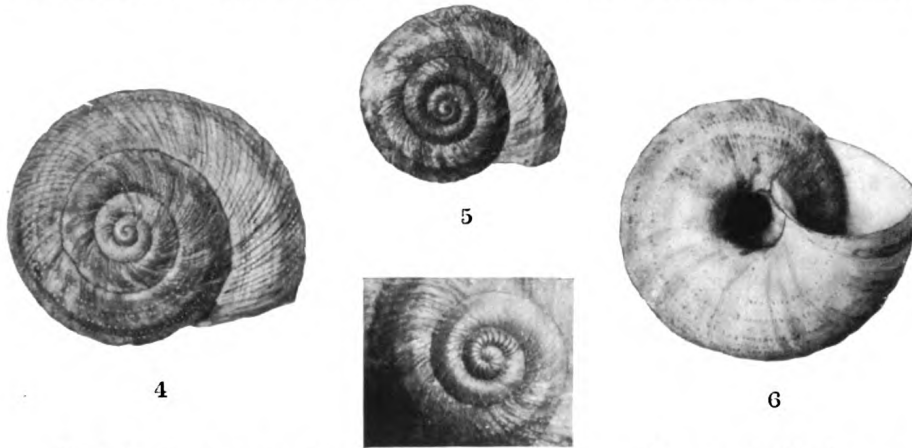


Fig. 367. *Oreohelix avalonensis*, type and paratypes. (Upper and side figures \times about $3\frac{1}{2}$.)

Later whorls with rough, irregular striation, irregularly cut into long granules by spiral impressions; base with irregular radial striae and fine, weak spiral striation, with about 5 stronger spirals at wide intervals. The last whorl is subangular in the middle of the upper surface, at least in front; and it does not descend to the aperture. The peristome is thin, its ends connected by a thin, rather long parietal callus.

Height 6 mm., diameter 11.2 mm.; $4\frac{1}{2}$ whorls.

Height 6.3 mm., diameter 11.4 mm.; $4\frac{2}{3}$ whorls.

"Height 8 mm., diameter 14 mm.; 5 or $5\frac{1}{2}$ whorls." (Hemphill.)

CALIFORNIA: Santa Catalina Island (Henry Hemphill), Type and paratypes 86671 A.N.S.P.

This has been considered to be a *Radiocentrum* on account of its apical sculpture, typical of that group; it also has some resemblance to *O. californica* and *O. handi*, which are geographically nearer.

Where on Catalina Hemphill found it is still unknown. Several naturalists, including myself, have looked for it in the neighborhood of Avalon, where from the name it would be expected to occur, but without success.

Hemphill states that the peripheral carina "becomes obsolete on the last half of the body-whorl of the single mature shell that I have."

(Named for Avalon, the pleasure city of Catalina Island.)

centrum published in 1905 I asked him to contribute a description to *Nautilus*, so that I might figure the species in my paper. His lengthy reply did not contain the description and details of locality I had requested, but gave permission to include the species in my paper.

Subfamily AMMONITELLINAE

Discoidal, umbilicate helices with the lip not expanded or reflected, the texture somewhat zonitid; periphery rounded at all stages of growth. Penis without a verge; epiphallus and flagellum present, the latter sometimes rudimentary. An accessory sac arises near junction of free oviduct and vagina. Spermatheca of the long type, its duct not branched. Talon of unusually great length. Kidney short or medium, from about as long as heart to twice that length. Left ocular and pharyngeal retractors either united, or separate nearly to columellar insertion, the right ocular and columellar muscles united. Ectocones developed on all central and lateral teeth.

This subfamily comprises the genera *Ammonitella*, *Polygyrella*, *Polygyroidea* and *Glyptostoma*. The first three have usually been associated with the Polygyridae, the fourth with dart-bearing helices.

There are indications that the Ammonitellinae are a very old group, for a long time declining, some genera now perhaps approaching extinction. All of the genera except *Glyptostoma* are monotypic, and the ranges of the species are narrowly limited, — characteristics of decadent groups. One genus, *Ammonitella*, is represented in the Miocene of Oregon by a species extremely similar to the living *A. yatesi*, showing that this genus, which has a highly specialized shell, was fully differentiated then. Indeed, the shell form indicates that it was already an aged genus in the Lower Miocene. *Polygyrella* is equally old. An Eocene species, "*Helix*" *spatiosa* Meek & Hayden, from the Wind River valley, Wyoming, has been referred with some doubt to *Glyptostoma*, but it has a higher spire than any known Ammonitellinae, and it is not described as having the characteristic parietal sculpture of *Glyptostoma*.

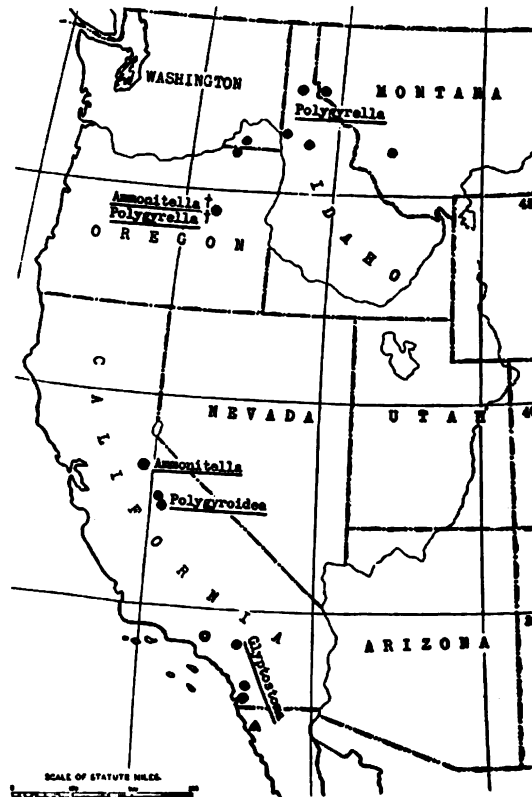


Fig. 368. Distribution of the genera of Ammonitellinae.

See White, Ann. Rep. U. S. Geol. Surv. 1882, pl. 30, figs. 1-3; and Henderson, 1935, Fossil Non-marine Moll. N. A., p. 136.

The distribution of the genera of Ammonitellinae is shown in Figure 368. At present, *Polygyrella* and *Glyptostoma* occupy the largest areas, the extreme points in each case being about 200 miles apart. The colonies of *Glyptostoma* are small and in part rather widely separated by areas where it is not known to exist. *Polygyroidea* and *Ammonitella* are known each from two contiguous localities; but the latter occurs also as a fossil, *Ammonitella lunata* (Conr.), in the Bridge Creek beds, John Day Valley, Oregon, probably of Lower Miocene age. G. D. Hanna reported *Polygyrella* also from the Miocene of Oregon.

Classification.—By the anatomy the genera may be grouped as follows:

1. Flagellum reduced to a minute vestige; lung with distinct secondary veins.
 - Glyptostoma*
 - Flagellum moderately developed though short; lung without visible secondary veins.....2
2. Penis continued beyond the insertion of the epiphallus; pharyngeal and left eye retractor muscles independent; hermaphrodite duct conspicuously convoluted.
 - Polygyroidea*
 - Epiphallus terminal on the penis; pharyngeal and left eye retractors extensively united; hermaphrodite duct appearing not convoluted.....3
3. Lung plain, transparent.....*Polygyrella*
Lung spotted with black.....*Ammonitella*

Key to Genera and Species by Shell Characters

1. Shell large, the diameter more than 20 mm., dark colored, the lip thin; parietal wall engraved with spiral lines.....2
Shell smaller, diameter less than 15 mm., pale colored, the lip thickened within....4
2. Diameter of shell from about 34 to 40 mm. or more....*Glyptostoma newberryanum*
Diameter of shell about 25 to 30 mm.....3
3. Ensenada, Lower California.....*Glyptostoma n. depressum*
San Gabriel Mountains to Dominguez Hills*Glyptostoma gabrielse*
4. Spire concave; the aperture narrowly crescentic, toothless.....*Ammonitella yatesi*
Spire flat or convex; aperture moderately wide, a parietal tooth present.....5
5. Radial series of teeth within the last whorl but no lip teeth; spire costulate.
 - Polygyrella polygyrella*
 - No internal teeth, two lip teeth; spire striate.....*Polygyroidea harfordiana*

POLYGYRELLA W. G. Binney

Polygyrella W. G. Binney, Dec. 9, 1863, Smiths. Misc. Coll. 000, p. 5, monotype
Helix polygyrella Bland.

Polygyrella "Bland," Binney and Bland, 1869, L. & Fr. W. Sh. N. A., Pt. 1, p. 112, in Smiths. Misc. Coll. No. 194.

Polygyrella Binney, Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 307; 1932, 84: 15.

Adelodonta Aney, 1880, Le Naturaliste, 1: 334, type *Helix polygyrella*.

The shell is widely umbilicate, discoidal with convex to nearly flat spire of narrow, closely coiled costulate whorls; base smooth, translucent. Aper-

ture lunate-triangular, the unexpanded peristome somewhat thickened within, the ends connected by an erect, triangular parietal tooth. Within the last whorl there are one or two radial series of three teeth each. Jaw with flat plaits and fine vertical striae. Soft anatomy otherwise about as in *Ammonitella*.

Distribution.—Northern Idaho, the adjacent part of Montana, southeastern Washington and northeastern Oregon; Miocene of Oregon.

Polygyrella has a character unique in its family, the development of radial series of teeth within the last whorl of the shell, such as are found in *Helicodiscus* and various zonitid genera. They appear very early; in a shell of $2\frac{1}{2}$ whorls, diameter 2.1 mm., there are two sets of well developed and one of rudimentary teeth. As new sets are formed with growth, the earlier ones are absorbed. Immature shells often show three sets of teeth but adults usually one or two. The presence of this peculiar structure, together with the quite different arrangement of the free retractor muscles, appear to be sufficient reasons for separating *Polygyrella* generically from *Polygyroidea*. *Ammonitella* is more like *Polygyrella* anatomically, but I consider the difference in the shells of generic significance.

The anatomy of *P. polygyrella* is drawn in Figure 369. The very long lung has no secondary veins and is not spotted. The short kidney (6 mm. long) is as figured for *Polygyroidea harfordiana*. The genitalia (Fig. 369: 1, 4, 5), are much as in *Ammonitella yatesi*, but the organs are more lengthened. The ovo-testis is disposed in a few bundles of long follicles. The hermaphrodite duct has a thick envelope. The talon is slender and from two-thirds to about as long as the albumen gland. The uterus and prostate gland are extremely long, 24 mm., in large individuals. Spermathecal duct long, arising at the same point as the accessory sac. The flagellum is larger than in *Ammonitella*. Lumen of penis ribbed, somewhat enlarged distally, with beaded or subinterrupted ribs (Fig. 369: 5 a). Penial retractor short, arising some distance from end of penis, and inserted on the diaphragm.

In a specimen from Mission Creek, Idaho, the penis was fully extruded, as in the outline sketch (Fig. 369: 7). It is cylindric, somewhat larger towards the end, the rugae of the internal wall projecting weakly. It is 13 mm. long.

The free muscles are essentially as in *Ammonitella*, but the whole system is longer. The left ocular and pharyngeal retractors are united. The right ocular and tail or columellar retractor unite, forming a band independent to the columellar insertion, where the suturo-pallial muscle is inserted close

Fig. 369. 1, *Polygyrella polygyrella*. 1, genitalia of 13 mm. specimen from Cataldo, Idaho. a.s., accessory sac of the vagina. epi, epiphallus. fl, flagellum. i.s., indication of the point of insertion of the spermathecal duct, which is not visible in the figure. sp, spermatheca. t, talon. 2, Jaw of same individual. 3, 3a, Jaw of specimen from North Lapwai, Idaho, with more enlarged detail of lower margin. 4, Genitalia of specimen from Stites, Idaho; diam. of shell, 9.3 mm. 5, 5a, Genitalia of specimen from North Lapwai, Idaho, with detail of upper curve of penis opened; diam. of shell 10 mm. 6, Free muscles of specimen from Cataldo, Idaho (diagrammatic). 7, Head with everted penis of specimen from Mission Creek, Idaho. The scale at bottom refers to figures 1, 4 and 5.

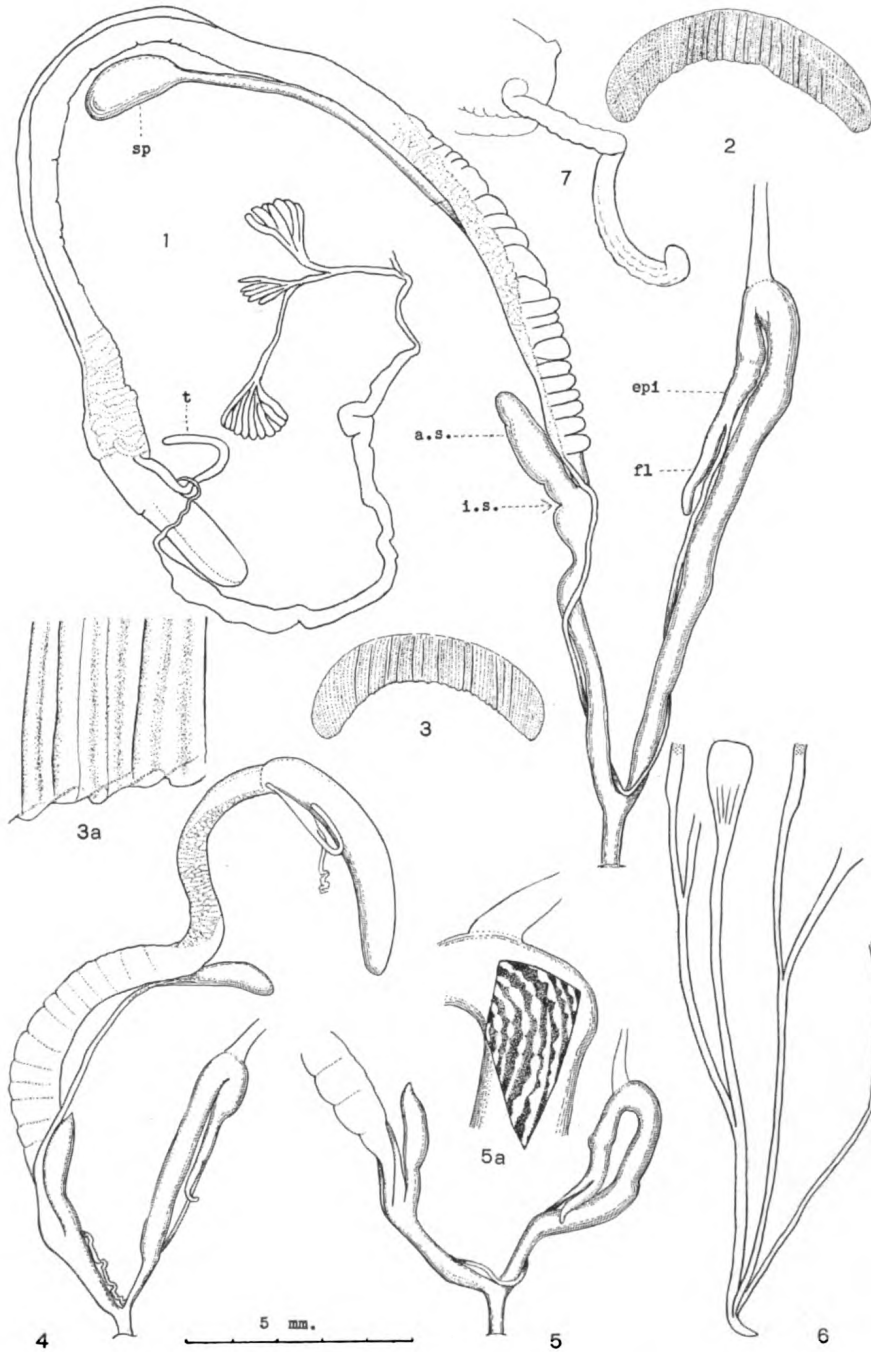


Fig. 369. See bottom of p. 556 for legend.

to it. The right ocular retractor passes between penis and vagina (Fig. 369: 6, diagrammatic).

The jaw (Fig. 369: 2, 3, 3a) is 0.75 mm. wide, crescentic with blunt, narrow ends, thin, the flat anterior face showing edges of about a dozen flat plaits, so fully united that only part of their edges are visible, and close, irregular, vertical striation, rather ill-defined in places. The distinction between plaits and striae is rather indistinct except in the median part of the jaw. At 3a is an enlarged view of part of the cutting edge of the jaw.

The specimens from North Lapwai, Idaho, dissected (Fig. 369: 5, 5a, diameter of shell 10 mm.) are entirely like those from Stites (Fig. 369: 4). The large (13 mm.) specimens have the penis and vagina relatively longer, as in Figure 369: 1.

The jaw might be thought odontognathous from W. G. Binney's figure (Terr. Moll., vol. 5, p. 289), which was in outline, but it is of the flat, plaited type, which is common to all Ammonitellinae.

	Stites, Idaho	Cataldo, Idaho
Diameter of shell	9.3 mm.	13.0 mm.
Length of penis	7.5 "	14.0 "
Epiphallus	1.3 "	1.5 "
Flagellum	1.5 "	2.5 "
Vagina	3.0 "	7.3 "
Accessory sac of same	2.5 "	...
Spermatheca and duct	10.0 "	16.5 "
Length of lung .....	...	30.0 "
Illustration	Fig. 369: 4	Fig. 369: 1

Polygyrella polygyrella (Bland & Cooper)

Fig. 370.

Helix polygyrella Bland and Cooper, 1861, Ann. Lyc. Nat. Hist. N. Y., 7: 365, pl. 4, figs. 13-15.

Helix (Polygyrella) polygyrella B. & C., Binney and Bland, 1869, L. & Fr. W. Sh. N. A., 1: 112.

Polygyrella polygyrella B. & C., Tryon, 1867, Amer. Journ. Conch., 3: 160.—Binney, 1878, Terr. Moll., 5: 289, fig. 186; 1885, Man. Amer. L. Sh., p. 172; 1886, Bull. Mus. Comp. Zool., 13: 36, pl. 1, figs. 12, 14; pl. 3, fig. 8 (genitalia).—Hanna, 1920, Univ. Ore. Pub., 1: 3, (Oregon, Miocene).—Henderson, 1924, Univ. Colo. Stud., 13: 109; 1929, 17: 86, fig. 43.—Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 307; 1932, 84: 15 (anatomy).

[*Polygyrella polygyrella* var.] *montanensis* Ancey, 1887, Conch. Exch., 2: 80.

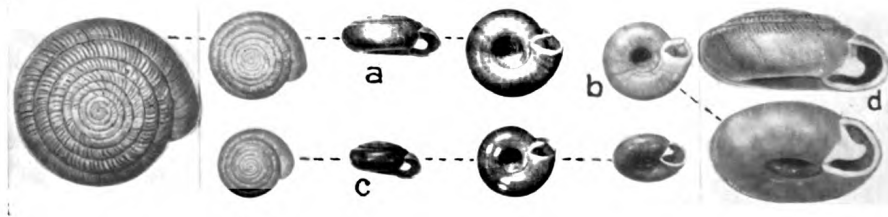


Fig. 370. *Polygyrella polygyrella*. a, Cataldo; b, Coeur d'Alene Mts.; c, d, North Lapwai. End figures enlarged.

The shell is discoidal, with wide umbilicus about one-third of the diameter; of a pale greenish yellow tint, somewhat translucent, glossy. Spire varying from nearly flat to convex, of very closely coiled whorls.

Initial 2 to 3 whorls smooth, the rest with rather strong radial ribs which become obsolete near the aperture, the rounded periphery and the base with faint growth ripples only. Suture impressed, descending a little to the aperture. Umbilicus well-like, enlarging in the last half whorl. Aperture lunate-triangular, the peristome thickened within; parietal wall with an erect, triangular tooth connected with the ends of the lip. Within the last whorl there are one or two radial rows of three teeth each, visible through the shell.

Height 5 mm., diameter 11 mm.; 7-8 whorls. (Bland.)

Height 5.1-6 mm., diameter 12.5 mm.; $8\frac{1}{2}$ whorls. Cataldo.

Height 3.7 mm., diameter 9.3 mm.; $6\frac{1}{2}$ whorls. Cataldo.

MONTANA: Eastern slope of the Coeur d'Alene Mountains, in moss and decaying wood in the dampest parts of the spruce forest (Cooper), type locality. Prospect Creek, 3-6 miles west of Thompson Falls, Sanders County (H. B. Baker).

IDAHO: Coeur d'Alene (H. E. Dore); Cataldo, Kootenai County, in slides of schist (H. B. Baker); "Old Mission" (near Cataldo), Kootenai County (Hemphill); Mission Creek, 7-8 miles above Jacques Spur, and half a mile west of North Lapwai, Nez Perce County, in lava slides facing north; 1 to 2 miles south of Stites, and 3-4 miles south of Harpster, Clearwater River, Idaho County (H. B. Baker).

WASHINGTON: 15 miles east of Walla Walla (J. Henderson).

OREGON: East of Milton (Henderson); 2-3 miles up north fork of Walla Walla River, Umatilla County, on lava slides facing south (H. B. Baker).

Most of the shells taken on lava by H. B. Baker are light dresden brown colored, with the lip-callus thin and the parietal tooth small. The typical form is "yellowish horn-colored" with a large tooth. The figures repeated in Binney's three monographic works, copied from Bland's originals, represent the umbilicus incorrectly.

The usual variation is not great. In 26 measured from the North Lapwai lot, the extremes of diameter are 8.6 and 10.5 mm., with about as symmetrical a curve for intermediate forms as could be expected in a small series, thus:

1	1	2	1	4	4	3	2	3	3	1	1
8.6	9	9.2	9.4	9.5	9.6	9.7	9.8	9.9	10	10.2	10.5 mm.

The average elevation of this lot is greater than usual, but there are also a few quite depressed individuals, the extremes of height being 41 to 51 per cent of the diameter.

At Cataldo it was found in schist rock slides near base of slopes facing east, on the right side of the Coeur d'Alene River. Here the largest specimen occurred, 11 to 13 mm. diameter with $7\frac{1}{2}$ to $8\frac{1}{2}$ whorls. In the same place, 300 or 400 feet higher, the shells were smaller, 9.5 to 11 mm., with

6½ to 7½ whorls. Local conditions of humidity and food supply probably control the size. On lava rock, as at Stites, Idaho, it buries itself in the black, coarsely granular soil beneath the rock slides, according to H. B. Baker.

The variety *montanensis* Ancey is said to be "distinguished from the type in having a large and more developed parietal tooth, more triangular aperture, the basal margin of it being more thickened and horizontal, and also the ribs of the upper surface more distant and coarser. It has been figured by W. G. Binney [2d Sup., Bull. Mus. Comp., 13: 36, pl. 1, figs. 12, 14] from a specimen collected by Mr. Hemphill in Deer Lodge Valley, Montana."

AMMONITELLA J. G. Cooper

Ammonitella Cooper, 1868, Amer. Journ. Conch., 4: 211, for *A. yatesii*.

Gonostoma W. G. Binney, 1878, Terr. Moll., 5: 261. Not *Gonostoma* Held.

The shell is umbilicate, planorboid, the concave spire of closely coiled whorls, the last coil shortly tangential, descending, broadly rounded peripherally. Aperture narrow, lunate, without teeth, the peristome unexpanded, thickened within.

Distribution.—Limestone region of eastern Calaveras County, California, and the Miocene of Oregon.

In the reproductive organs, free muscles, jaw and teeth this genus scarcely differs from *Polygyrella*, but the planorboid shell with narrow, toothless aperture suffices to give it generic rank. Both genera are of great antiquity. The peculiar shell of *Ammonitella* was fully developed as long ago as the Lower Miocene, in the John Day beds of central Oregon, where *A. lunata* (Conr.),¹ was found in the same rock containing the remains of *Oreodon superbus* Leidy.

The lung (Fig. 371: 3) is rather long (11 mm.) and narrow, spotted with black below the pulmonary vein, plain between that and the hindgut; without secondary veins. The kidney is short (2 mm.), but little longer than the heart; at the base it widens, extending nearly to the hindgut. The secondary ureter appears to be open throughout.

Genitalia (Fig. 371: 2) are long and rather slender. The hermaphrodite duct is remarkable for being nearly smooth, not convoluted as is usually the case. The talon is slender, very long, about 2.4 mm., or 2 mm. beyond the point where the hermaphrodite duct is given off. The prostate gland is equal in length to the sacculate part of the oviduct. The penis is rather long (5.7 mm.) and slender, thick-walled, its cavity star-shaped in section, the interior being ribbed longitudinally. There is no verge or "papilla." It

¹ Originally described as a *Planorbis*, this species was first recognized as an *Ammonitella* by H. Edson in 1911. References follow:

P.[lanorbis] lunatus Conrad, 1871, Amer. Journ. Conch., 6: 305, pl. 13, fig. 8 (Bridge Creek).

Ammonitella yatesii praecursor Stearns, 1900, Proc. Wash. Acad. Sci., 2: 656, pl. 35, figs. 8, 12.

Ammonitella lunata Conr., Edson, 1911, Nautilus 24: 132. — Hanna, 1920, Univ. Oregon Pub., Bull. Dept. Geol., 1: 20 (see for further references and figures).

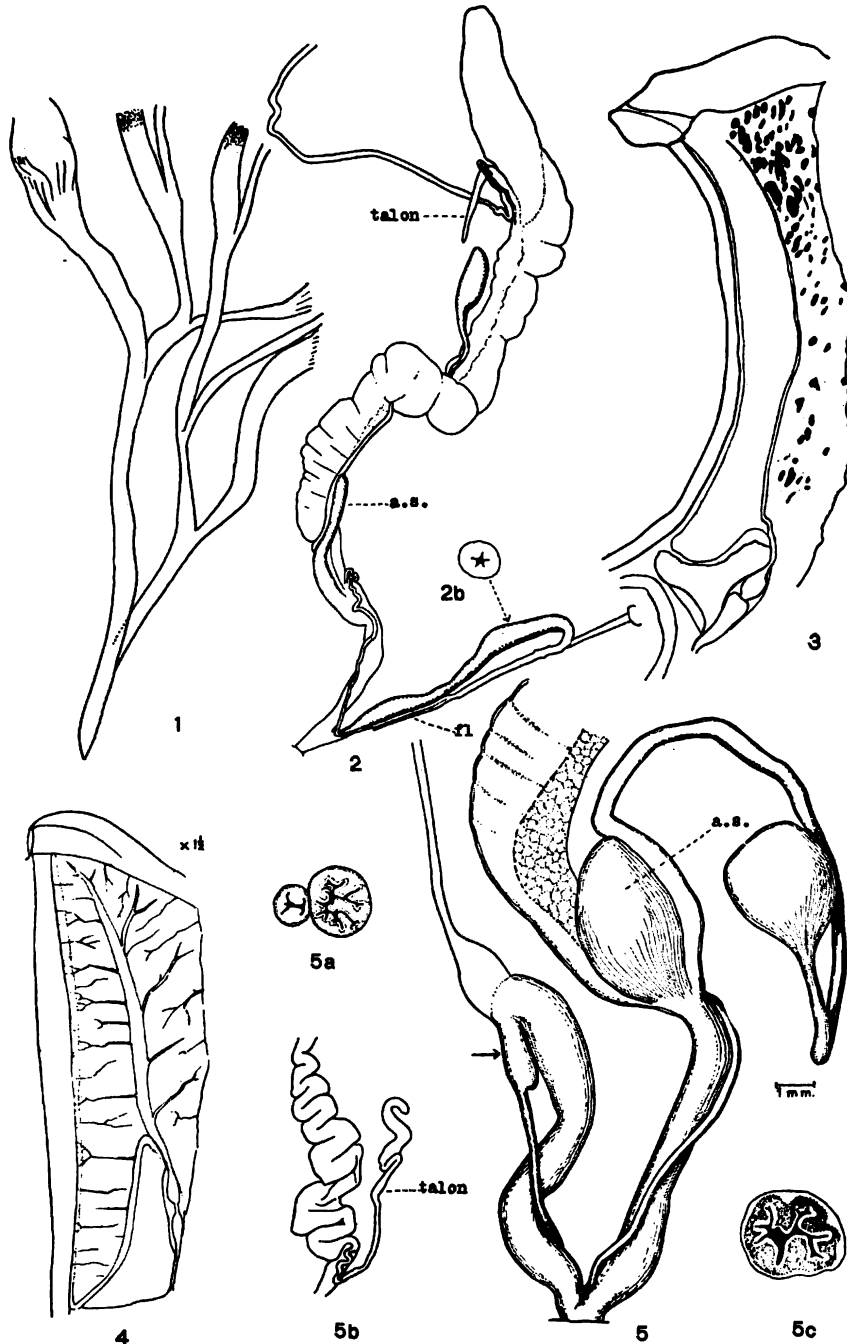


Fig. 371. 1, *Ammonitella yatesi*. Free retractor muscles. 2, Genitalia. a.s., accessory sac. fl, flagellum. t, talon. 2b, section of the penis. 3, Pallial organs. 4, *Glyptostoma gabrielense*, pallial organs. 5, Anterior part of genitalia. 5a, section of penis and epiphallus at the point marked with an arrow. 5b, part of the hermaphrodite duct and the talon. 5c, section of the accessory sac.

passes into a slender epiphallus 3 mm. long, which terminates in the vas deferens and a short flagellum 1.7 mm. long, which adheres to the vas deferens, and is thus easy to overlook. The penial retractor is short, about 1.5 mm., and attached to the lung floor.

The uterus or sacculate part of the oviduct is very long. The vagina about 3 mm. long, bears a long muscular accessory sac (Fig. 371: 2, a.s.). The cavity of this sac has longitudinally ridged walls, and was empty in several specimens opened. It is about 4 mm. long and is more slender than that of *Polygyroidea harfordiana*. The spermatheca is oblong, lodged about as far back as the heart, and has a long, thin duct entering the vagina immediately above the insertion of the accessory sac. The albumen gland does not have the distinctly cellular appearance of that *Polygyroidea*.

Free retractor muscles (Fig. 371: 1). The right ocular retractor passes between penis and vagina; for about one-third of its length it is united with the columellar muscle. Both ocular bands give off pedal retractors in the form of single slender bands which are inserted at the sides of the visceral cavity near the insertion of the columellar muscle. The left ocular band is as usual in Helicidae united in two-thirds of its length with the pharyngeal retractor, thereby differing from *Polygyroidea*.

(*Ammonitella*, diminutive of *Ammonites*.)

***Ammonitella yatesi* J. G. Cooper**

Fig. 372: 1.

Ammonitella yatesi J. G. Cooper, 1868, Amer. Journ. Conch., 4: 209, pl. 18, figs. 1-3; 1869, Amer. Journ. Conch., 5: 202.—Hanna and Rixford, 1923, Proc. Cal. Acad. Sci., 12: 44, pl. 4, figs. 4-7.—Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 304, pl. 24, figs. 1-3.

Helix ammonitella J. G. Cooper, 1875, Proc. Cal. Acad. Sci., 6: 22, footnote (substitute for *A. yatesi*).

Gonostoma yatesi J. G. C., Binney, 1878, Terr. Moll., 5: 262, pl. v, fig. q, teeth.

Helix yatesi Coop., Hemphill, 1892, Zoc, 3: 45.

The shell is discoidal, biconcave, isabella color shading into cream-buff behind the lip; glossy, marked with faint wrinkles of growth. Whorls convex, very narrow and closely coiled, the last third of a turn diverging

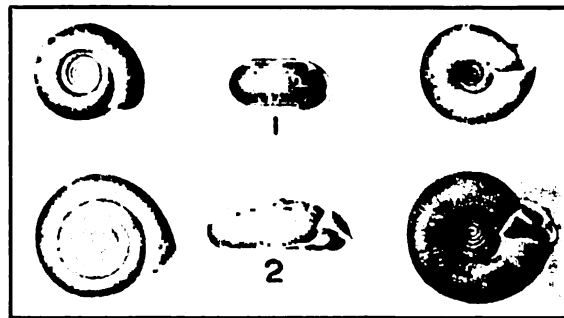


Fig. 372. 1, *Ammonitella yatesi*, near Murphy's, California. ($\times 1.75$.)
2, *Polygyroidca harfordiana*, Mariposa Big Trees, California. ($\times 1.75$.)

tangentially and descending to the aperture. Last whorl wide, rounded at periphery, the base convex. Umbilicus deeper than the spire, contained about $2\frac{1}{2}$ times in the diameter, showing all the whorls. Aperture oblique,

narrowly lunar, the lip thickened within except near the upper insertion; parietal callus thin.

Height 4 mm., diameter 8.8 mm.; 7 whorls.

Height 3.2 mm., diameter 7.3 mm.; 6½ whorls.

CALIFORNIA: Calaveras County, near and in the cave at Cave City (L. G. Yates, Hemphill, Hanna and Rixford). Near Murphy's aestivating under stones on north hillsides (Hemphill). About 1 to 2 miles north of Murphy's (H. B. Baker).

Hanna and Rixford write that the living animal is "externally pale, translucent-gray with dark bands dorsally where the optic retractor muscles show through. The skin has a delicate reticulation; pedal grooves are absent. The tail is acutely pointed and keeled in the median line above; no caudal mucous pore could be found. If the species were a cave dweller the eyes would be expected to be functionless or absent, but they appear to be normal in every respect. The animal is very timid and retracts within its shell upon slight provocation."

The smallest shell seen has a diameter of 6.6 mm. Rarely a buff streak a half turn back shows a growth-rest with formation of a lip callus.

The original lot of five shells was found within the cave at Cave City, now an abandoned mining camp. Hanna and Rixford found it immediately outside the entrance under moss-laden stones at not more than a foot depth. Buckeye trees cast a dense shade over the place. They agree with Hemphill that it is not normally a cave dweller. H. Burrington Baker collected it in Calaveras County near Mercer's Cave. The place is between Murphy's and Cave City, "about one to two miles north of Murphy's. It occurred in clean talus around limestone ledges, at about 2300 to 3000 feet. They were aestivating from six inches to a foot below the surface, but rare or absent in accumulated humus under shrubs. Also in damper talus of non-calcareous rocks below the ridges in the valley of Santo Domingo Creek. Digger pine (*Pinus sabiniana*) and buckeye were prominent in the vicinity. Living snails were quite abundant." This appears to be within the upper limit of the Upper Sonoran zone.

POLYGYROIDEA Pilsbry

Polygyroidea Pilsbry, *Nautilus*, 37: 134, for *D. harfordiana*; 1930, *Proc. Acad. Nat. Sci. Phila.*, 82: 305 (anatomy).

The shell is widely umbilicate, discoidal with nearly flat spire of closely coiled striate whorls, the periphery and base smooth. Aperture subtriangular, the unexpanded peristome thickened within, toothed in the outer and basal margins; parietal callus bearing an oblique, shortly entering tooth. Anatomy about as in *Ammonitella* except that the penis is prolonged beyond the insertion of the epiphallus, and the left ocular and pharyngeal retractors are free throughout.

Distribution.—Fresno and Mariposa Counties, California. It is a Transition Zone genus.

Polygyroidea differs from *Polygyrella* chiefly by lacking radial series of teeth within the last whorl of the shell, and by the free retractor muscles. It differs from both *Polygyrella* and *Ammonitella* by having the penis continued in a blind sac beyond the entrance of the epiphallus.

Anatomy.—The animal of *P. harfordiana* is rather long and narrow, buff or slightly brownish in the alcoholic specimens, with rather coarse reticulation. The tail is rounded above.

The jaw (Fig. 373: 3) is low and wide, its face delicately striate vertically throughout. The radula has 16.6.1.6.16 teeth (Fig. 373: 2, central, first lateral, twelfth and thirteenth marginals). The central tooth has well developed side cusps and a middle cusp projecting beyond the basal plate. It is asymmetrical in the radula figured, doubtless an individual peculiarity. The laterals have strong ectocones and an overhang, sometimes notched, on the inner side of the mesocone. The marginal teeth are bicuspid throughout, except that the minute outer one has no cusp.

The long (19 mm.) and narrow lung (Fig. 373: 5) is not pigmented and shows no secondary veins. The kidney is irregularly oblong, short (4.5 mm. long), being very little longer than the heart. The secondary ureter is represented by a thickened band along the hindgut, apparently open throughout. The heart is nearly as long as the kidney. Pulmonary vein is rather wide and conspicuous; only a narrow band of the lung lies between it and the hindgut.

Genitalia (Fig. 373: 1-1g). The ovotestis consists of several (about 5) groups of elongate follicles, imbedded in the liver as usual. The long hermaphrodite duct is strongly convoluted. The talon (Fig. 373: 1a) is nearly as long (2.5 mm.) as the albumen gland, rather slender with club shaped end, glandular on both sides in the basal half. The prostate gland is as long as the sacculate part of the oviduct. The penis, 6 mm. long, has a terminal retractor inserted on the diaphragm. Its cavity has closely ridged walls, there being 9 or 10 ridges in the upper part, about 15 in the middle (Fig. 373: 1e, 1f), all of the ridges being granulose. The epiphallus is short and stout, about 1.5 mm. long; entering the penial cavity by a small aperture (Fig. 373: 1g), on right side, which is some distance below the apex of the penis. It terminates in a short flagellum (Fig. 373: 1c, fl.) 2 mm., and the vas deferens, all being closely applied to the penis. The vas deferens is adnate to the oviduct for a short distance before entering the prostate gland. The vagina is moderately long, about 3.5 mm., and just below the entrance of the spermatheca it receives a stout, banana-shaped accessory organ (Fig. 373: 1, 1c, at a.s.) nearly 4 mm. long, which in section shows a very strong muscular outer layer and a large cavity with longitudinally ridged walls (Fig. 1d).

The spermatheca is oblong, lodged slightly farther in than the heart, on a long, slender duct.

Fig. 373. *Polygyroidea harfordiana*. 1, Genitalia. 1e, section of penis above epiphallus. 1f, section of penis and epiphallus. 1b, apical part of vaginal accessory sac, opened. 1c, lower duct of genitalia, showing epiphallus, flagellum and anterior ends of oviduct and spermatheca. 1d, section of vaginal accessory sac at point marked with arrow. 1g, part of the wall of the cavity of penis, showing entrance of the epiphallus near the right side. (This fig. is below fig. 1). 2, central, lateral and marginal teeth. 3, jaw. 4, free retractor muscles. 5, pallial organs.

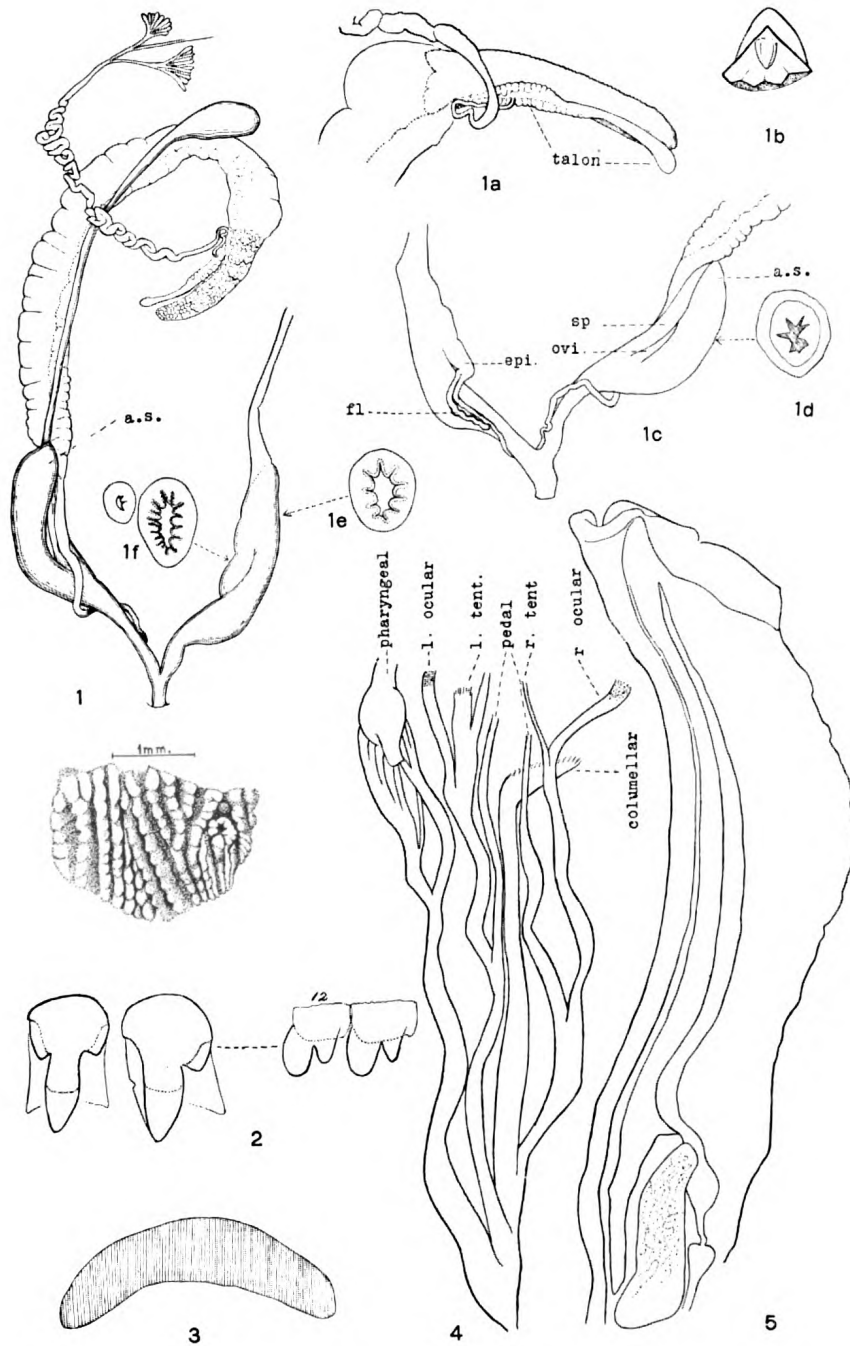


Fig. 373. See bottom of p. 564 for legend.

The free retractor muscles (Fig. 373: 4) are of unusual length. The left ocular and the pharyngeal bands are free to their basal insertions, an unusual condition. The union of the right ocular and columellar retractors is farther back than in *Ammonitella*. Each ocular band gives off a single slender pedal retractor. The penial retractor passes between the penis and vagina.

Polygyroidea harfordiana (J. G. Cooper)

Fig. 372: 2.

Daedalochila harfordiana J. G. Cooper, 1870, Amer. Journ. Conch., 5: 196, pl. 17, fig. 8.

Polygyra harfordiana, J. G. C., W. G. Binney, 1885, Man. Amer. L. Sh., p. 114, fig. 81, not the description.

Helix harfordiana J. G. C., Tryon, 1887, Man. Conch., 3: 130, pl. 27, figs. 55-57.

Helix (Polygyrella) harfordiana Cooper, Pilsbry, 1890, Proc. Acad. Nat. Sci. Phila., p. 200, pl. 5, figs. 12, 13, 14; reprinted in Nautilus, 1891, 5: 40.

Polygyrella harfordiana (J. C. Cooper), Pilsbry, 1894, Man. Conch., 9: 80.

Polygyrella (Polygyroidca) harfordiana (J. G. C.) Pilsbry, 1924, Nautilus, 37: 124.

Polygyroidea harfordiana (J. G. Cooper) Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 306, pl. 23 (anatomy).—Allyn G. Smith, 1931, Nautilus, 44: 101.

The shell is discoidal, openly umbilicate, pale yellow. Spire flat or very slightly convex, of narrow whorls, the last about double the width of the preceding, a little dilated near the aperture. Surface glossy, with weak growth ripples only except near the suture and on the spire where it is closely striate. Umbilicus conic, showing all the whorls. The aperture is subtriangular; peristome thickened within, two-toothed, a tubercular tooth within the outer lip above the periphery, a wider tooth in the middle of the basal margin. Parietal callus moderately thick, bearing a compressed, obliquely entering tooth.

Height 4.1 mm., diameter 10.5 mm., umbilicus 3.4 mm. Type.

Height 4.2 mm., diameter 11.5 mm., umbilicus 4 mm.; 6 whorls. Wawona Point.

Height 4.1 mm., diameter 10.2 mm.; 5½ whorls. Wawona Point.

Height 4.0 mm., diameter 9.4 mm.; 6 whorls. Merced River.

Height 3.5 mm., diameter 8.3 mm.; 5½ whorls. Merced River.

CALIFORNIA: Fresno County, Big Trees, 6500 feet (W. G. W. Harford),¹ Type 11451 A.N.S.P. Mariposa County, Big Trees west of Wawona Point, 6-7000 feet (H. B. Baker). Quarter mile above junction of Alder Creek with the South Fork Merced River, 4000 feet (Allyn G. Smith).

Dr. Cooper described the living animal as white, the back and eye-bearing tentacles black, foot long, posteriorly wedge-shaped.

This rare snail had been known by only one adult shell collected 60 years before, when early in July, 1929, Dr. Baker rediscovered it "in a steep limestone rock slide just west of Wawona Point, at about 150 feet below the crest of the saddle above the slide, at an elevation of about 6800 feet. Living snails were quite rare, and were found acstivating about two feet below the surface under sprawling (probably snow-crushed) scrub oaks near the main roots, where considerable soil had accumulated. Between

¹ Nautilus, 1911, 25: 8.

the trees the rock slide was almost barren of snails. In places on this slope with north exposure, sugar pine and Douglas fir (*Pseudotsuga*) were prominent; *Sequoia* grew on the gentle southern slope beyond the saddle."

Allyn G. Smith found it in a new locality, on the South Fork of Merced River. "These shells all run smaller (diameter 8.2 to 9.4 mm.) than those Baker found in the Big Trees Grove at Wawona Point, where I was fortunately able to find a few also. I venture to predict that it will be found scattered through the Sierra in localities where conditions of moisture, shade, rock slide, and leaf mold are just right. At this new locality it was possible to lift off the dried and matted leaf mold in slabs of a square foot or two at a time, and down to moisture among the rather small angular rocks of the well-shaded slide to find the *harfordiana* rather common, as land snails of the Sierra generally come."

GLYPTOSTOMA Bland & Binney

Glyptostoma Bland and Binney, 1873, Proc. Acad. Nat. Sci. Phila., p. 244, for *Helix newberryanum* W. G. B.—W. G. Binney, 1878, Terr. Moll., 5: 373.—Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 309.—Berry, 1938, Journ. Ent. & Zool. Pomona Coll., 30: 55.

The shell is broadly umbilicate, depressed, with low, convex spire of $5\frac{1}{2}$ to 6 whorls, rounded peripherally and below; dark colored, glossy and nearly smooth. Aperture broadly lunate, the lip thin and sharp, parietal wall engraved with fine spirals. The flagellum is minute or wanting. Lung with distinct secondary veins. Kidney about twice the length of the pericardium.

Distribution.—Rocky hills and mountains from the San Gabriel Range, California, to Ensenada de Todos Santos, Lower California. It inhabits humid spots in a semiarid country, at relatively low elevations.

The position of *Glyptostoma* in the helicoid series was problematic until its relationship to *Polygyrella* and *Ammonitella* was demonstrated in 1930. A single species has been recognized, but there are certainly two, with two other races of uncertain status.

Anatomy.—Free retractor muscles: The left ocular band unites with the pharyngeal band, and the right ocular with the columellar muscle, as in *Ammonitella*; but these connections are far back, near the posterior insertion.

The kidney is twice as long as the heart, triangular. The secondary ureter is wholly open throughout. Secondary venation is developed, but the veins of the lung are quite inconspicuous with the exception of the principal one (Fig. 371: 4).

The penis is continued beyond the entrance of the epiphallus in *newberryanum* but not in *gabrielense*. The thick penial wall is very strongly folded within, there being one large and several smaller folds of different sizes, as in fig. 5a. The epiphallus is short, the vas deferens entering it at one side, the other side of the end being abrupt or a little swollen in *newberryanum*, more tapering in *gabrielense*, and there is a very short flagellum in *G. newberryanum mimus* (Fig. 374d). The epiphallus and vas deferens are closely bound to the penis throughout.

In *G. newberryanum* the vagina is about half as long as the penis. Immediately above the entrance of the spermathecal duct a slender, club-shaped sac with strongly plicate inner walls is inserted. It is about as long as the vagina. The spermathecal duct is closely bound to the uterus. The talon is convoluted and about 9 mm. long. Three specimens examined, one from Mission Gorge figured.

In *G. n. mimus* the accessory sac of the oviduct is broader, not club-shaped, and the blind sac at apex of penis is shorter. The flagellum is closely bound to the vas deferens.

G. gabrielse has no blind sac at apex of the penis, which is about as long as the vagina. The accessory sac of the oviduct is oval or egg-shaped, only about half as long as the vagina (the longitudinal folds in Fig. 374c are owing to rapid dehydration). Four specimens from 3 localities examined.

Measurements in mm. of the specimens figured follow, the first column *newberryanum*, the second *mimus*, the third to fifth *gabrielse*.

	San Diego County	Riverside	Pasadena	Mt. Lowe	Dominguez
Length of penis	18.5	20	10	8	9
Length of epiphallus....	3.0	4	2	2.5	2.2
Length of flagellum	0	2	0	0	0
Length of vagina	9.0	9	9	10.5	13
Length of acc. sac	11.5	8	4.5	5	3.5
Diameter of shell .....	...	34	31	26.5	25
Figure	374a	374d	371: 5	374c	374b

The radula (Fig. 274 g, *G. newberryanum*) has ectocones on all of the teeth. The transition from laterals to marginals is very gradual. The rows curve forward at the sides. In *G. newberryanum* from Jamul, San Diego County, there are 44.1.44 teeth; Binney found 47.1.47 teeth in a specimen probably from San Diego. *G. n. mimus* has 41.1.41, and *G. gabrielse* 38.1.38 teeth (Fig. 374f).

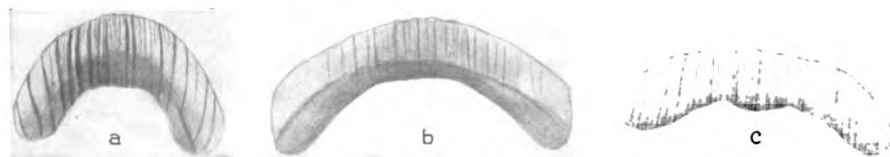
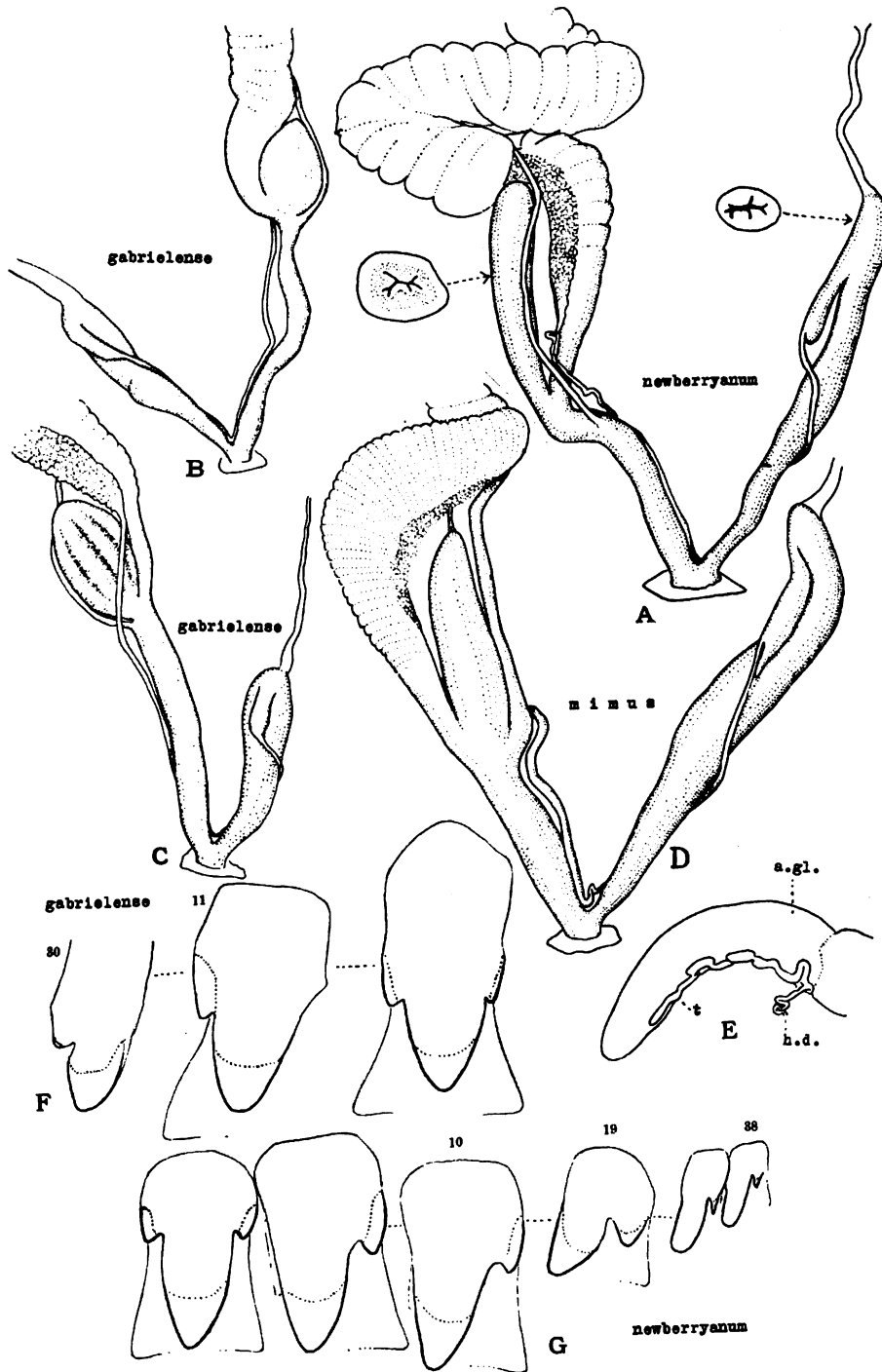


Fig. 375. Jaws of: a, *Glyptostoma newberryanum*; b, *G. newberryanum mimus*; c, *G. gabrielse*.

The jaw is short and wide, with numerous low, narrow ribs, or rather, rib-like plaits some of them linear, and part notching the lower margin. I count about 21 "ribs" in a specimen of *G. newberryanum* from Jamul

Fig. 374. Genitalia of: A, *Glyptostoma newberryanum*, with sections of accessory sac and blind end of penis. B, *G. gabrielse*, Dominguez Hills; c, Mt. Lowe. d, *G. newberryanum mimus*. e, albumen gland and talon of *G. gabrielse*. Dentition of: f, *G. gabrielse*. g, *G. newberryanum*. a.g., albumen gland; h.d., end of hermaphrodite duct; t, talon. See p. 569.



(Fig. 375a). Binney found 16 ribs, but mentioned large variation in several he examined. There is no median projection. In *G. n. mimus* the plaits are extremely weak, in places hardly noticeable (Fig. 375b). In *G. gabrielense* there is a well-marked median projection and quite weak, very unequal and unevenly spaced plaits (Fig. 375c).

(Γλυπτός, engraved, στόμα, mouth, in allusion to the sculpture of the parietal wall.)

*Key to Species*¹

1. Penis about as long as vagina and not continued in a blind sac beyond entrance of epiphallus; accessory sac of oviduct egg-shaped, half as long as vagina or less.

G. gabrielense

Penis about twice the length of vagina and continued in a blind sac beyond entrance of the epiphallus; accessory sac of oviduct narrow, nearly as long as vagina. 2

2. Flagellum represented only by the convex end of epiphallus; accessory sac of oviduct slender, club-shaped. *G. newberryanum*

Flagellum slender, about 2 mm. long; accessory sac stouter, cylindrical. *G. n. mimus*

Glyptostoma newberryanum (W. G. Binney)

Fig. 376 a.

Helix newberryana W. G. Binney, 1858, Proc. Acad. Nat. Sci. Phila., p. 115; 1859, Terr. Moll., 4: 20, pl. 76, fig. 7.—Bland & Binney, 1871, Amer. Journ. Conch., 7: 190; 1873, Proc. Acad. Nat. Sci. Phila., p. 244.

Zonites newberryana Binney & Bland, 1869, L. & Fr. W. Sh. N. A., 1: 282, fig. 504.

Glyptostoma newberryana W. G. B., Cooper, 1875, Proc. Cal. Acad. Sci., 6: 20.

Glyptostoma newberryanum Binney, 1878, Terr. Moll., 5: 374, pl. xiv, fig. d (anatomy); Bull. Mus. Comp. Zool., 11: 159, pl. 4, fig. v.—Williamson, 1900, Nautilus, 14: 214 (aestivation).—Gude, 1905, Proc. Malac. Soc. Lond., 6: 283.—Ivan Johnson, 1918, Journ. Ent. & Zool. Pomona Coll., 10: 14.—Berry, 1928, Journ. Ent. & Zool. Pomona Coll., 20: 75; 1938, 30: 55.—Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 310.

The shell is broadly umbilicate, depressed, with low, convex spire; carob brown to black. Surface glossy, the first 2 whorls smooth, the rest nearly smooth, with weak wrinkles of growth and faint traces of spiral striae. The moderately convex whorls increase rather slowly to the last, which is about twice the width of the preceding, rounded peripherally. The aperture is



Fig. 376. a, *Glyptostoma newberryanum*, San Diego. b, *G. gabrielense*, Mt. Lowe; c, *G. newberryanum depressum*. d, *G. newberryanum depressum*.

¹ For key by shell characters see page 555.

lunate, wider than high, the lip thin and sharp, dilated very little near the columellar insertion. Parietal callus thin, transparent, closely engraved with fine spirally entering lines, which sometimes become subobsolete in old individuals.

Height 13 mm., diameter 37 mm.; 6 whorls. (Binney, type.)

Height 18.5 mm., diameter 39.3 mm. San Diego.

Height 20.4 mm., diameter 38.5 mm., umbilicus 10 mm.; 6 whorls. San Diego.

Height 18 mm., diameter 36.7 mm. San Diego.

CALIFORNIA: Around San Diego, type locality; Mussey Grade (F. W. Kelsey). Jamul, about 25 miles east of San Diego, west bank Penasquitos River below the Alvarado Falls, and Ramona and Mission Gorge, about 6 miles northeast of San Diego (J. L. Baily). Claremont (I. Johnson). El Cajon, Foster, Lakeside, San Diego County (Nat. Hist. Mus. San Diego).¹

The large typical form (Fig. 376a), diameter 36 to 40 mm., appears to be confined to southwestern San Diego County. Binney states that the largest he had seen had a diameter of 47 mm. It lives among igneous rocks. Hemphill's label says "among granite rocks, elevation 500 feet." According to Mrs. Williamson it aestivates buried in the soil, the shell almost hidden from sight.

G. K. Gude found that several septa are formed partitioning off the early whorls, the first at $1\frac{1}{2}$ whorls, and two more at intervals of $\frac{3}{4}$ of a whorl. In two from San Diego opened I found the first septum at end of the first whorl, another near beginning of third whorl. In one *G. n. mimus* from mountains west of Riverside there is a partition in the third whorl. These partitions are long, pocketlike, with the convex end toward apex. In specimens from Ensenada (*depressum*) and those from the San Gabriel Range (*gabrielense*) I found no septa.

***Glyptostoma newberryanum depressum* Bryant**

Fig. 376 d.

G. newberryanum var. *depressum* F. W. Bryant, 1902, Nautilus, 16: 70.

The shell is smaller and more depressed than *newberryanum*, without internal septa. Bryant's type measured: height 11 mm., diameter 27 mm.; a paratype height 11.4 mm., diameter 28 mm., umbilicus 7.5 mm., $5\frac{1}{2}$ whorls.

LOWER CALIFORNIA: Bluffs north of Ensenada de Todos Santos (Bryant; Ingles; Nat. Hist Mus. San Diego).

One of Bryant's original lot is figured. I have seen only bleached "bones". Dr. Berry has expressed doubts as to the validity of this race; its status can hardly be settled without an anatomical examination. That there are no records of *Glyptostoma* between Ensenada and the San Diego district may be owing to deficient collecting. The specimens reported by Bryant from Riverside, Los Angeles County, from Hemphill, were doubtless the small form of *G. gabrielense*.

¹ Localities supplied by Dr. Clinton G. Abbott, Director.

Glyptostoma newberryanum mimus new subspecies

Fig. 377.

The shell is similar to *newberryanum* or of slightly lighter color, and a little smaller size. Anatomically it differs by the broader shape of the accessory sac of the oviduct and by possessing a short (2 mm.) slender flagellum at summit of the epiphallus (Fig. 374 d).

Height 17.3 mm., diameter 34 mm.; $5\frac{1}{2}$ whorls.

Height 16.2 mm., diameter 34.3 mm.; $5\frac{1}{2}$ whorls.



Fig. 377. *Glyptostoma newberryanum mimus*.¹

CALIFORNIA: Mountains west of Riverside (S. N. Rhoads), Type 97745 A.N.S.P.²

I hesitate to describe this race, as the shell alone does not seem distinguishable from the typical San Diego form. The diameter in the type lot runs from 33.7 to 35 mm. But the possession of a tapering flagellum in place of a mere convexity alongside the vas deferens, such as *newberryanum* has, should be significant. Further dissections from other lots will show whether there are intermediate stages. The flagellum is inclosed in the intimate sheath of the vas deferens, and the structure does not become clear until this is dissected away.

(*Mimus*, a mimic.)

Glyptostoma gabrielense Pilsbry

Fig. 376 b.

Glyptostoma newberryanum W. G. Binney, Vanatta, 1898, Proc. Acad. Nat. Sci. Phila., p. 67, pl. 1, fig. 1.—Pilsbry, 1930, Proc. Acad. Nat. Sci. Phila., 82: 310, in part, pl. 24, figs. 4-5c.

Glyptostoma gabrielense Pilsbry, 1938 (June 7), Proc. Acad. Nat. Sci. Phila., 90: 25.

Glyptostoma pilsbryanum Berry, 1938 (June 20), Journ. Ent. & Zool. Pomona Coll., 30: 55 (Monrovia Canyon, Winter Creek, and neighboring portions of San Gabriel Mountains).³

¹ In Proc. Acad. Nat. Sci. Phila. 1930. 82: 309, these figures were erroneously labelled "Pasadena". The shells figured are from mountains west of Riverside.

² Probably the form reported from Claremont by Ivan Johnson belongs here. Also those from Box Springs Grade, near Riverside, in the Natural History Museum, San Diego, reported by Dr. Clinton G. Abbott, Director.

³ Dr. Berry had my manuscript of this account of *Glyptostoma* (containing the description of *G. gabrielense*), in his possession for about five months before publishing *G. pilsbryanum*. In returning the manuscript he gave me no information, and did not mention that he was about to publish a paper on the subject. This is mentioned to explain why two names for the same species were published in the same month.

Glyptostoma [*pilsbryanum*] *binneyanum* S. S. Berry, 1938 (June 20), Journ. Ent. & Zool. Pomona Coll., 30: 56.

Shell smaller than *newberryanum*, bay or chestnut colored, the surface highly polished, with scarcely any trace of spiral sculpture. The periphery, while not to be called subangular, is less equably rounded than in typical *newberryanum*. In a half dozen opened there were no internal septa.

Height 13.7 mm., diameter 30 mm.; 5½ whorls. Millard Canyon.

Height 14.1 mm., diameter 29.3 mm.; 5½ whorls. Mt. Lowe.

Height 14.2 mm., diameter 30.7 mm.; 5½ whorls. Mt. Lowe.

Penis and accessory sac of oviduct relatively much shorter than in *G. newberryanum*.

CALIFORNIA: San Gabriel Range in canyons back of Pasadena; Millard Canyon (Pilsbry); Mt. Lowe (S. N. Rhoads), Type 97748 A.N.S.P. A smaller form in the Dominguez Hills (H. N. Lowe, E. P. Chace).

The shell differs from *G. newberryanum* chiefly by its smaller size, somewhat greater depression and more brilliant gloss. The chief differences are anatomic, as noted on an earlier page.

There is considerable variation in size. In a lot from Millard Canyon above Pasadena, 22 which seem to be adult measure from 26.2 to 30.1 mm. diameter, 11 of them being from 27.2 to 28.7 mm. The rest are rather evenly spread; two are 30 mm., one 30.1.

The form from the Dominguez Hills (Fig. 376 c) falls 2 or 3 mm. short of the diameter of typical *G. gabrielse*, but the sizes intergrade, and after comparison of long series, no other difference could be found. The elevation of the spire varies in all of the localities; it is not higher in Dominguez Hills than in many San Gabriel range shells. The Dominguez shell appears to be merely an ecologic form of *gabrielse* from a decidedly dryer locality. This form was described as *G. pilsbryanum binneyanum* Berry, as follows:

"Shell usually smaller, more elevated [than *G. pilsbryanum*, the size of which was not given]; suture quite deep, aperture relatively small and quite definitely elliptic; periostracum strongly polished. Vaginal sac rounded-pyriform, swollen; proximal portion of penis only moderately inflated. Dominguez Hills." (Berry.) Type in collection of S. S. Berry.

Adult specimens of this form measure:

Height 13.3 mm., diameter 27.3 mm. Paratype of *binneyanum*.

Height 13. mm., diameter 28.3 mm. Elysian Park.

Height 13.5 mm., diameter 28.5 mm. Dominguez Hills.

Height 12.2 mm., diameter 25.7 mm. Dominguez Hills.

The Dominguez Hills, about 6 miles northward from Wilmington and Long Beach, Los Angeles County, are a small hill group rising to 195 feet. H. N. Lowe and E. P. Chace found *Glyptostoma* there "under dead cacti on the east side of hill near San Pedro electric lines." In Elysian Park, Los Angeles, Mr. G. Grant found them "quite common but rather local, on the surface and under vegetable debris." In the series of over 100 specimens sent, the largest are 28 mm. in diameter.

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