

TWO NEW SPECIES OF *SONORELLA* (GASTROPODA: PULMONATA: HELMINTHOGLYPTIDAE) FROM THE PINALENO MOUNTAINS, ARIZONA

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Abstract.—*Sonorella christenseni* and *S. macrophallus*, new species of pulmonate land snails, are described from the Pinaleno Mountains of southeastern Arizona. The relationships of these new *Sonorella* to each other and to other members of the genus are discussed.

Introduction

The Pinaleno Mountains, a rugged range dominated by 10,713 foot Mt. Graham, are located in Graham County, Arizona. The range contains the largest continuous area above 9,000 feet elevation of any mountain range in southeastern Arizona. There are three peaks above 10,000 feet in elevation with several additional peaks in excess of 9,000 feet. The Pinalenos lie directly north of the Dos Cabezas and Chiricahua ranges.

Prior to 1950, malacological collecting in the Pinaleno Mts. was rare. The earliest trip was made by J. H. Ferriss in 1913, and *Sonorella grahamensis* was described from the material he collected (Pilsbry and Ferriss, 1919). Beginning in 1954, collecting in the Pinalenos increased. In that year, M. L. Walton and W. O. Gregg collected material from the Mt. Graham area, and from that material *S. imitator* was described (Gregg and Miller, 1974). W. B. Miller began collecting in the Pinaleno Mts. in 1965, and since that time he and others have collected in many areas of the range. This paper describes two new species of *Sonorella* found in the course of several collecting trips to the Pinalenos from 1965 through 1978.

Sonorella christenseni, new species Figs. 1A, 2B

Description of holotype.—Shell depressed, heliciform, convex above and below, thin, glossy, tan in color, with one chestnut-brown spiral band just above midline of rounded shoulder of body whorl; umbilicate, umbilicus contained approximately 7 times in diameter. Embryonic shell of approximately 1½ whorls, first ½ whorl, including apex, with radial striae only, remainder of embryonic shell having a reticulate pattern of fine lines that break up into a granular pattern in the last ¼ whorl. Post-embryonic whorls with granular surface superimposed upon the radial growth striae; faint spi-

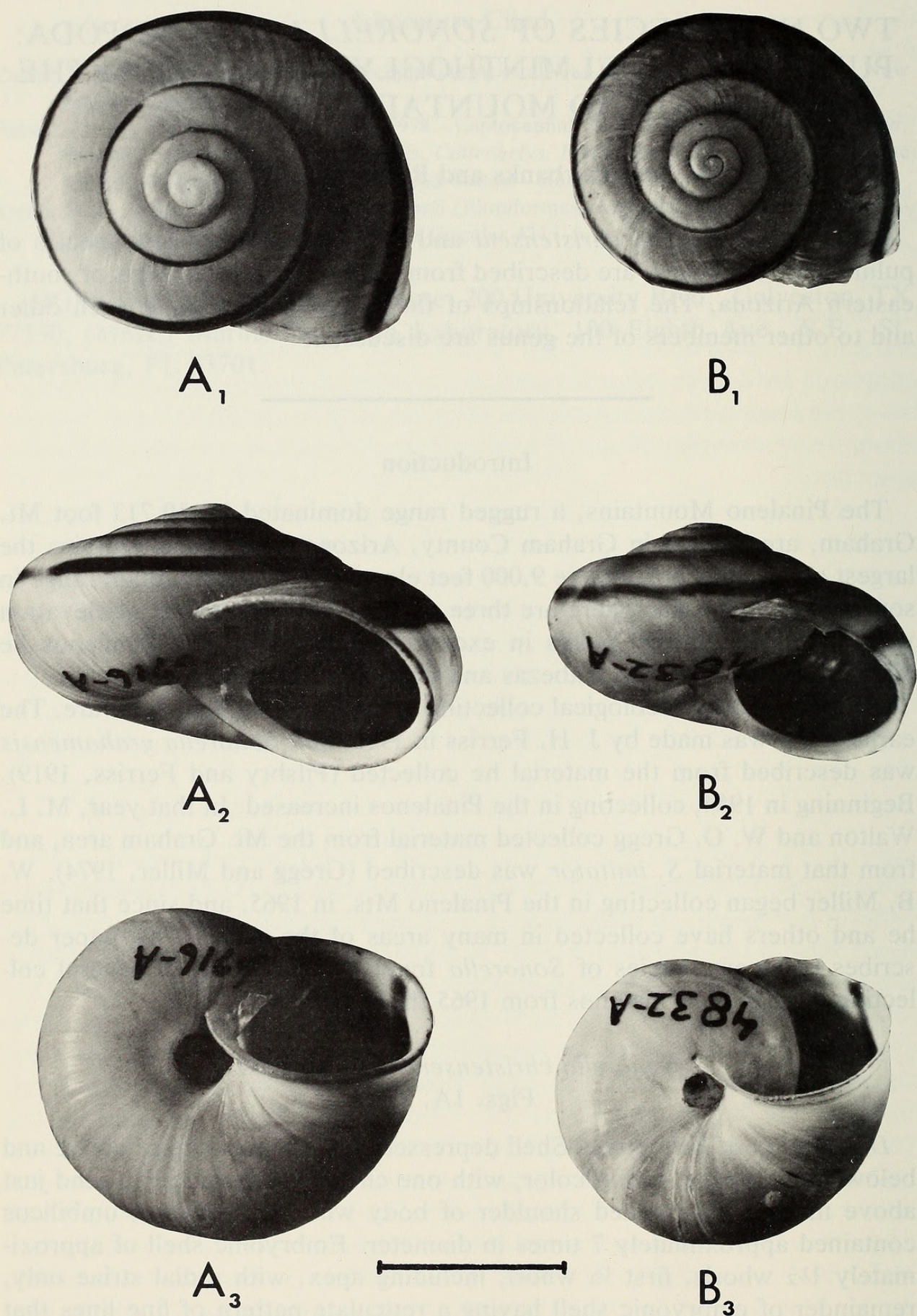


Fig. 1. Dorsal, ventral and side views of holotypes of *Sonorella christenseni* (A₁, A₂, A₃) and *S. macrophallus* (B₁, B₂, B₃). Scale bar equals 10 mm.

ral lines appearing, granular surface fading, just prior to beginning of body whorl; body whorl with radial growth striae plus spiral striae, the latter strongest near slightly recurved lip of aperture; spiral striae visible on dorsal surface of body whorl only near mid-line of shoulder; suture descends moderately to peristome. Aperture oblique, oval, slightly wider than high; parietal callus thin.

Measurements of holotype: Diameter—20.6 mm; height—11.0 mm; umbilicus diameter—2.9 mm; whorls— $4\frac{2}{3}$; embryonic whorls— $1\frac{1}{2}$.

Genitalia of holotype (Fig. 2B): Penis moderately long, gradually increasing in diameter to junction with vagina and containing a smooth cylindrical verge that nearly fills penial chamber. Verge approximately 64% length of penis, tapering gradually to a rounded point; seminal duct opens terminally. Penial sheath moderate in length, approximately 56% that of penis. Epiphallus slightly longer than penis, with large epiphallic caecum. Vas deferens same thickness as epiphallus. Length of vagina approximately 77% that of penis; free oviduct length 62% that of vagina.

Measurements of holotype genitalia: Penis—11.1 mm; verge—7.1 mm; penial sheath—6.2 mm; epiphallus—12.3 mm; epiphallic caecum—2.0 mm; vagina—8.6 mm; free oviduct—5.3 mm.

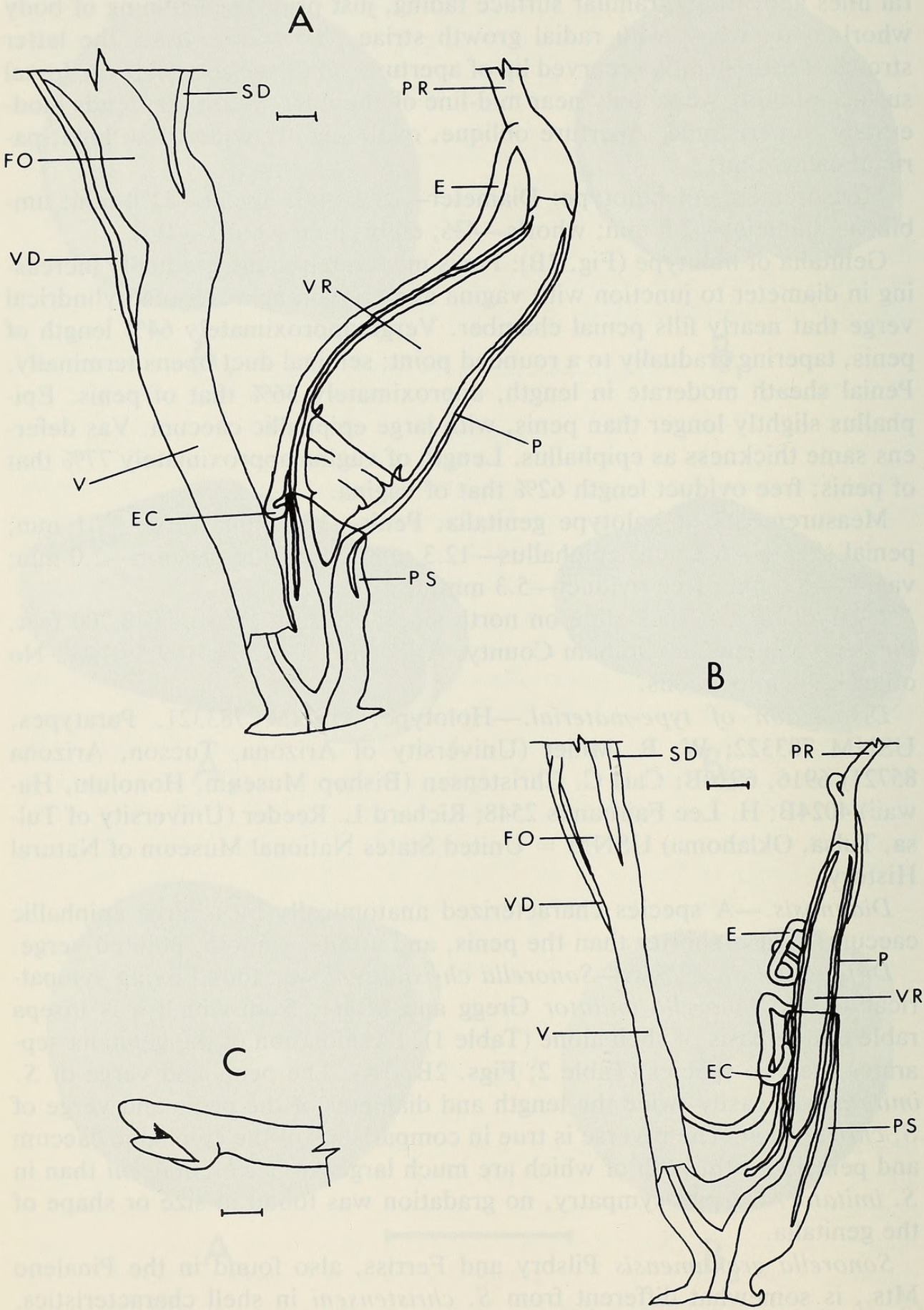
Type-locality.—Rock-slide on north slope of Clark Peak, ca. 8,700 feet, Pinaleno Mountains, Graham County, Arizona, $32^{\circ}43.5'N$; $109^{\circ}59.1'W$. No other known locations.

Disposition of type-material.—Holotype, USNM 783321, Paratypes, USNM 783322; W. B. Miller (University of Arizona, Tucson, Arizona 85721) 6916, 6916B; Carl C. Christensen (Bishop Museum, Honolulu, Hawaii) 4024B; H. Lee Fairbanks 2548; Richard L. Reeder (University of Tulsa, Tulsa, Oklahoma) USNM = United States National Museum of Natural History.

Diagnosis.—A species characterized anatomically by a large epiphallic caecum, vagina shorter than the penis, and a long, smooth, pointed verge.

Differential diagnosis.—*Sonorella christenseni* was found living sympatrically with *Sonorella imitator* Gregg and Miller, from which it is inseparable on the basis of shell alone (Table 1). Examination of the genitalia separates the two species (Table 2; Figs. 2B, 3A). The penis and verge of *S. imitator* are easily twice the length and diameter of the penis and verge of *S. christenseni*. The reverse is true in comparisons of the epiphallic caecum and penial sheath, both of which are much larger in *S. christenseni* than in *S. imitator*. Despite sympatry, no gradation was found in size or shape of the genitalia.

Sonorella grahamensis Pilsbry and Ferriss, also found in the Pinaleno Mts., is somewhat different from *S. christenseni* in shell characteristics. However, the two are still difficult to separate with casual examination



(Table 1). Comparisons of the genitalia of these two species will separate them easily (Table 2; Figs. 2B, 3B).

In the genus *Sonorella*, there are many species that have a long slender verge; however, few are smooth as in *Sonorella christenseni*. No other species of *Sonorella* has a verge of the same size and shape as that of *S. christenseni*. In addition, the ratios of genitalia measurements in other members of the genus do not coincide with those of *S. christenseni*.

Sonorella macrophallus, new species

Figs. 1B, 2A

Description of holotype.—Shell depressed, heliciform, convex above and below, thin, light brown in color, with chestnut-brown band just above midline of rounded shoulder of body whorl; umbilicate, umbilicus contained approximately 7 times in diameter. Embryonic shell of approximately $1\frac{1}{3}$ whorls, first $\frac{1}{4}$ whorl, including apex, with regularly spaced hyphen-like papillae superimposed upon radial striae; over remaining embryonic whorls, radial striae broken forming a granular surface with regularly spaced papillae superimposed upon it. Post-embryonic whorls radially striate with papillae present except for last $1\frac{1}{2}$ whorls, which have only faint spiral lines appearing near suture; spiral lines visible on ventral surface of body whorl, suture descends moderately to a slightly expanded peristome. Aperture oblique, oval, slightly wider than high.

Measurements of holotype: Diameter—17.7 mm; height—10.6 mm; umbilicus diameter—2.5 mm; whorls— $4\frac{1}{2}$; embryonic whorls— $1\frac{1}{3}$.

Genitalia of holotype (Fig. 2A): Penis long and of large diameter, containing a verge that is large, expanded just distal of the midpoint of its length, and nearly fills the penial chamber. Distal end of verge modified to form a retractable tip that when fully extended comprises approximately $\frac{1}{3}$ of total length of verge. Length of verge approximately 66% that of penis; seminal duct opens terminally. Penial sheath short, approximately 22% as long as penis. Epiphallus shorter than penis; epiphallic caecum small. Vas deferens about as thick as epiphallus. Length of vagina approximately 60% that of penis; free oviduct length 82% that of vagina.

Measurements of holotype genitalia: Penis—16.1 mm; verge—10.7 mm; penial sheath—3.5 mm; epiphallus—8.7 mm; epiphallic caecum—1.5 mm; vagina—9.7 mm; free oviduct—8.0 mm.

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Fig. 2. Cutaway camera lucida drawings of genitalia of *Sonorella macrophallus* (A), *S. christenseni* (B), and distal end of verge of *S. binneyi* (C). Scale bars equal 1 mm. E, epiphallus; EC, epiphallic caecum; FO, free oviduct; P, penis; PR, penial retractor; PS, penial sheath; SD, spermathecal duct; V, vagina; VD, vas deferens; VR, verge.

Table 1.—Shell measurements of holotypes and paratypes of *Sonorella christenseni* and *S. macrophallus*, with shell measurements of some specimens of *S. imitator* and *S. grahamensis* for comparison. Upper numbers are means and ranges (in parentheses); lower numbers are standard deviations. Measurements are in mm, measured with vernier caliper.

	<i>S. christenseni</i>		<i>S. macrophallus</i>		<i>S. imitator</i>	<i>S. grahamensis</i>
	Holotype	Paratypes	Holotype	Paratypes		
No. of specimens	1	5	1	17	12	3
Diameter	20.6	20.4 (19.7–20.9) .5167	17.7	17.8 (16.4–19.5) .8455	19.7 (18.8–21.2) .8301	18.8 (18.2–19.5) .6658
Height	11.0	11.1 (10.5–12.0) .6285	10.6	10.6 (9.6–11.6) .6020	11.3 (9.9–12.8) .8433	10.9 (10.2–11.4) .6429
Umbilicus diameter	2.9	3.0 (2.6–3.4) .3194	2.5	2.5 (2.0–2.8) .2205	3.1 (2.7–3.5) .2290	2.7 (2.5–2.8) .1732
Whorls	4.67	4.5 (4.5–4.67) .0760	4.5	4.5 (4.25–4.75) .1598	4.4 (4.0–4.67) .1795	4.5 (—) .0000
Embryonic whorls	1.5	1.4 (1.33–1.5) .0760	1.33	1.5 (1.33–1.75) .1201	1.4 (1.25–1.5) .0786	1.4 (1.33–1.5) .0981

Type-locality.—Wet Canyon, Pinaleno Mountains, Graham County, Arizona, under rocks on the south side of the canyon ca. 300 feet from Highway 366 (Swift Trail) at ca. 6050 feet elevation; 32°39.1'N; 109°48.8'W.

Other localities.—Wet Canyon, Pinaleno Mountains, Graham County, Arizona, in rockslide approximately $\frac{1}{3}$ mile up canyon from Highway 366 at ca. 6,400 feet elevation; also ca. 1.0 miles up Wet Canyon at ca. 6,900 feet elevation (C. C. Christensen, W. B. Miller, N. Babrakzai, P. Turk).

Disposition of type-material.—Holotype USNM 783324 Paratypes, USNM 783325; W. B. Miller (University of Arizona, Tucson, Arizona 85721) 4832, 14 paratypes.

Diagnosis.—A species of moderate size, having a shell with hyphen-like papillae on the dorsal surface, and a verge which is long, large in diameter, and with a retractable tip.

Differential diagnosis.—This species has been found only in Wet Canyon in the Pinaleno Mts. of southeastern Arizona. It is found there in sympatry with *S. imitator*. A previous report (Gregg and Miller, 1974) of *S. grahamensis* in Wet Canyon was found to be in error.

The shell of *Sonorella macrophallus* is somewhat smaller than that of the other 3 species of *Sonorella* found in the Pinaleno Mts. (Table 1). In addition, the papillae on the surface of the shells of *S. macrophallus* do not occur on the shells of the other species. However, erosion of the papillae can occur and thus this character may not be helpful in the identification of some specimens. Gregg and Miller (1974) reported that *S. imitator* had "suggestions of papillae" on the shell, but examination of 12 specimens of this species detected no papillae. Examination of 18 specimens of *S. macrophallus* found 16 with easily detectable papillae. The remaining 2 shells were old and worn. Neither *S. christenseni* nor *S. grahamensis* has papillae on the shell.

The genitalia of *Sonorella macrophallus*, in particular the verge, will immediately identify this species. The verge of *S. macrophallus* has a protrusible tip, a characteristic known in only one other species of *Sonorella*, *S. binneyi* from the Chiricahua Mts. The senior author has examined 6 stained and slide-mounted reproductive systems of *S. macrophallus* and has noted various stages of protrusion. The tip of the verge of the type-specimen (Fig. 2A) is nearly fully extended. There can be no confusion between *S. macrophallus* and *S. binneyi*, because in the former species the protrusible tip is terminal, whereas in the latter species it is subterminal (Fig. 2C).

Etymologies.—*Sonorella christenseni* is named in recognition of Dr. Carl C. Christensen, Bishop Museum, Honolulu, Hawaii, a friend and colleague of many field trips, and the person responsible for locating the site at which this species was found.

The name *macrophallus* (Greek, makros + phallos) refers to the large, distended verge found in this species.

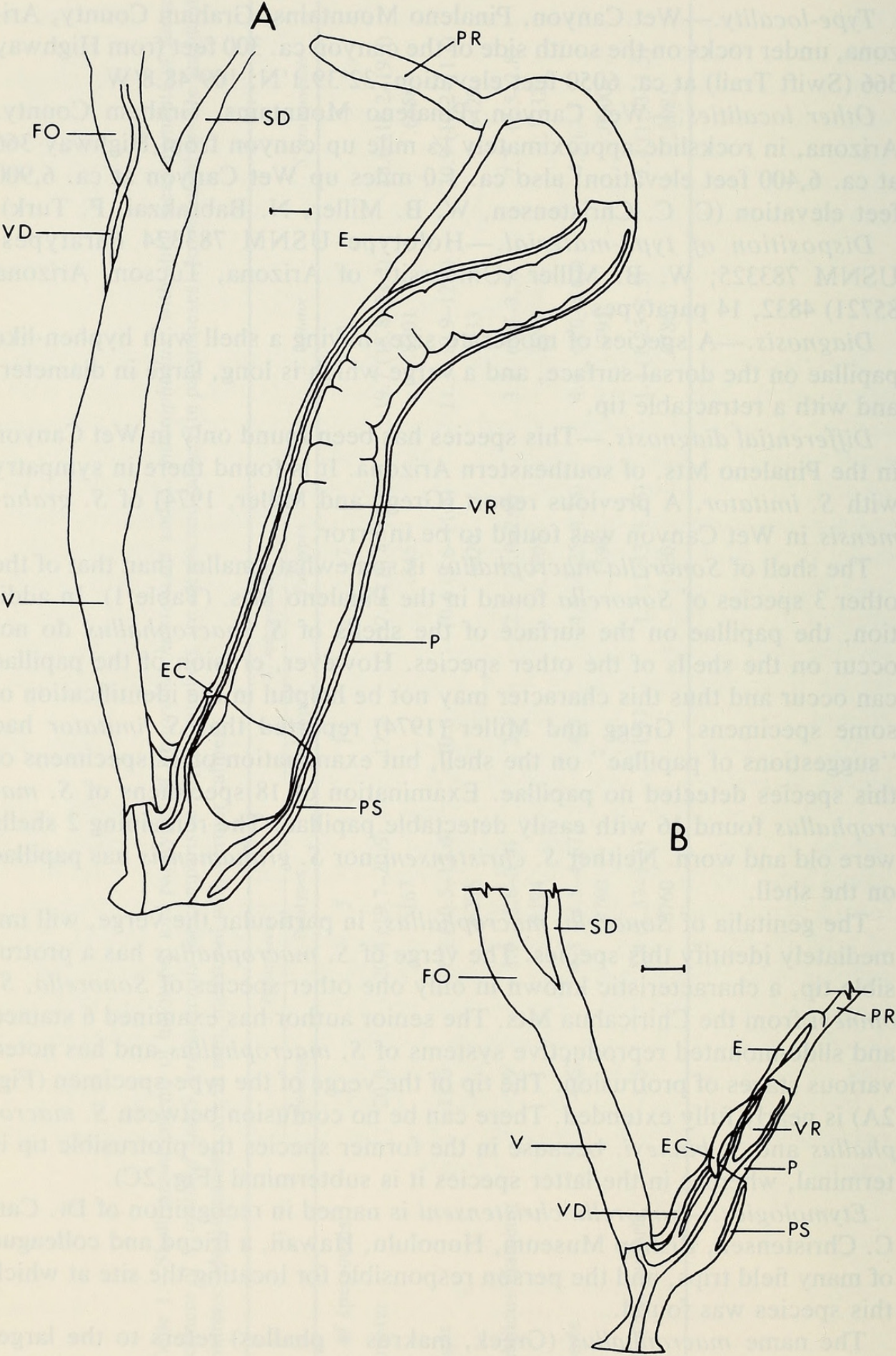


Fig. 3. Cutaway camera lucida drawings of genitalia of *Sonorella imitator* (A), and *S. grahamensis* (B). Scale bars equal 1 mm. Labeling as in Fig. 2.

Table 2.—Genitalia measurements of holotypes and paratypes of *Sonorella christenseni* and *S. macrophallus* with genitalia measurements of some specimens of *S. imitator* and *S. grahamensis* for comparison. Upper numbers are means and ranges (in parentheses), lower numbers are standard deviations. Measurements are in mm, made with ocular micrometer.

	<i>S. christenseni</i>		<i>S. macrophallus</i>		<i>S. imitator</i>	<i>S. grahamensis</i>
	Holotype	Paratypes	Holotype	Paratypes		
No. of specimens	1	5	1	8	5	3
Penis	11.1	10.7 (10.0–12.0) .8198	16.1	16.6 (14.2–18.5) 1.3815	23.7 (21.3–26.0) 1.7726	7.5 (7.1–8.4) .7506
Verge	7.1	6.2 (5.7–7.0) .5030	10.7	10.9 (9.3–12.9) 1.2992	17.1 (15.0–18.8) 1.6592	2.2 (2.0–2.4) .2082
Penial sheath	6.2	6.2 (5.0–8.3) 1.2390	3.5	4.1 (3.1–5.0) .6781	3.6 (3.0–4.8) .7348	2.9 (2.4–3.2) .4359
Epiphallus	12.3	9.2 (8.3–11.7) 1.4342	8.7	9.6 (7.2–12.2) 2.0345	14.0 (13.4–15.6) 1.0308	4.8 (4.3–5.3) .5033
Epiphallic caecum	2.0	1.8 (1.5–2.3) .3594	1.5	1.2 (0.9–2.0) .3732	0.3 (0.2–0.4) .1155	0.3 (—) .0000
Vagina	8.6	6.1 (5.4–8.2) 1.1832	9.7	10.1 (7.2–12.5) 2.0188	14.9 (14.4–15.8) .7155	5.4 (5.3–5.5) .0999
Free oviduct	5.3	4.5 (4.0–5.1) .4147	8.0	7.2 (5.6–9.9) 1.2456	4.2 (3.5–4.8) .4669	5.0 (5.0–5.1) .0577

Discussion

The difference in genitalia among the 4 species of *Sonorella* found in the Pinalenos appears to be too great to support the hypothesis that all evolved from a single ancestral population. A more probable hypothesis is that the ancestors of the current species arrived at the Pinalenos from other areas at different periods during the Pleistocene.

W. B. Miller (1967) in his revision of *Sonorella* recognized 2 subgenera. The subgenus *Sonorella* s.s., was subdivided into 3 complexes: the *hachitana* complex, the *binneyi* complex, and the *granulatissima* complex. Miller hypothesized that each of these complexes had a different center and time period of dispersal.

All 3 of Miller's complexes are represented among the species of *Sonorella* found in the Pinalenos, adding support to the hypothesis of emigration from different areas at different times.

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