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THREE NEW SPECIES OF *SONORELLA* (GASTROPODA: PULMONATA: HELMINTHOGLYPTIDAE) FROM ARIZONA

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Abstract.—*Sonorella reederi, S. russelli,* and *S. bradshaveana* are described from Arizona. Relationships within the genus are discussed.

Although the genus *Sonorella* has been intensively studied in Arizona since the beginning of the century, new populations have continued to be discovered in remote, isolated areas. In many instances, however, the procurement of scarce, live specimens for positive identification has entailed repeated expeditions over a period of many years. This was the case for the following three new species, described below. The following abbreviations for repositories of specimens are employed: ANSP—Academy of Natural Sciences of Philadelphia; CAS—California Academy of Sciences; FMNH—Field Museum of Natural History; RLR—personal collection of Richard L. Reeder; USNM—National Museum of Natural History; UTEP—University of Texas at El Paso; WBM—personal collection of Walter B. Miller.

Sonorella reederi, new species
Figs. 1A–C, 2

Description of holotype.—Shell depressed-globose, heliciform, light tan, with chestnut-colored spiral band on rounded shoulder; widely umbilicate, umbilicus contained 7½ times in diameter of shell, only about 1/10th covered by reflected columellar lip. Embryonic shell of 1½ whorls, lustrous, with surface microscopically roughened by radial wrinkles and numerous papillae. Post-embryonic whorls also lustrous, marked with light growth wrinkles, with fewer and smaller papillae gradually replaced on penultimate whorl by shallow, spirally-arranged pits. Body whorl silky-lustrous above, becoming glossy underneath, marked with light growth wrinkles and, above shoulder, with closely-spaced, parallel, shallow, spiral grooves. Peristome thickened and slightly expanding. Aperture oblique, rounded, with margins converging; parietal callus thin. Shell measurements in mm: diameter 19.4, height 11.0, umbilicus 2.7; 4½ whorls.

Reproductive anatomy of holotype.—Ovotestis and distal structures as in other *Sonorella.* Proximal structures show diagnostic characters. Penis 5.0 mm long, containing stout verge, 2.5 mm long; verge with smooth sides and rounded conical tip. Thin penial sheath encases lower 2.0 mm of penis. Epiphallic caecum miniscule, 0.25 mm in length. Short spermathecal diverticulum, 1.0 mm in length, present; common spermathecal duct below diverticulum highly convoluted internally. 30 mm long spermathecal duct leads to typical, spherical spermatheca, 2.0 mm in diameter.

Variations in paratypes.—A total of 23 adult paratype shells were collected in two separate visits to the type-locality. The largest paratype measures 20.8 mm in diameter, the smallest 18.4 mm. All show remarkably similar sculpture, shape,

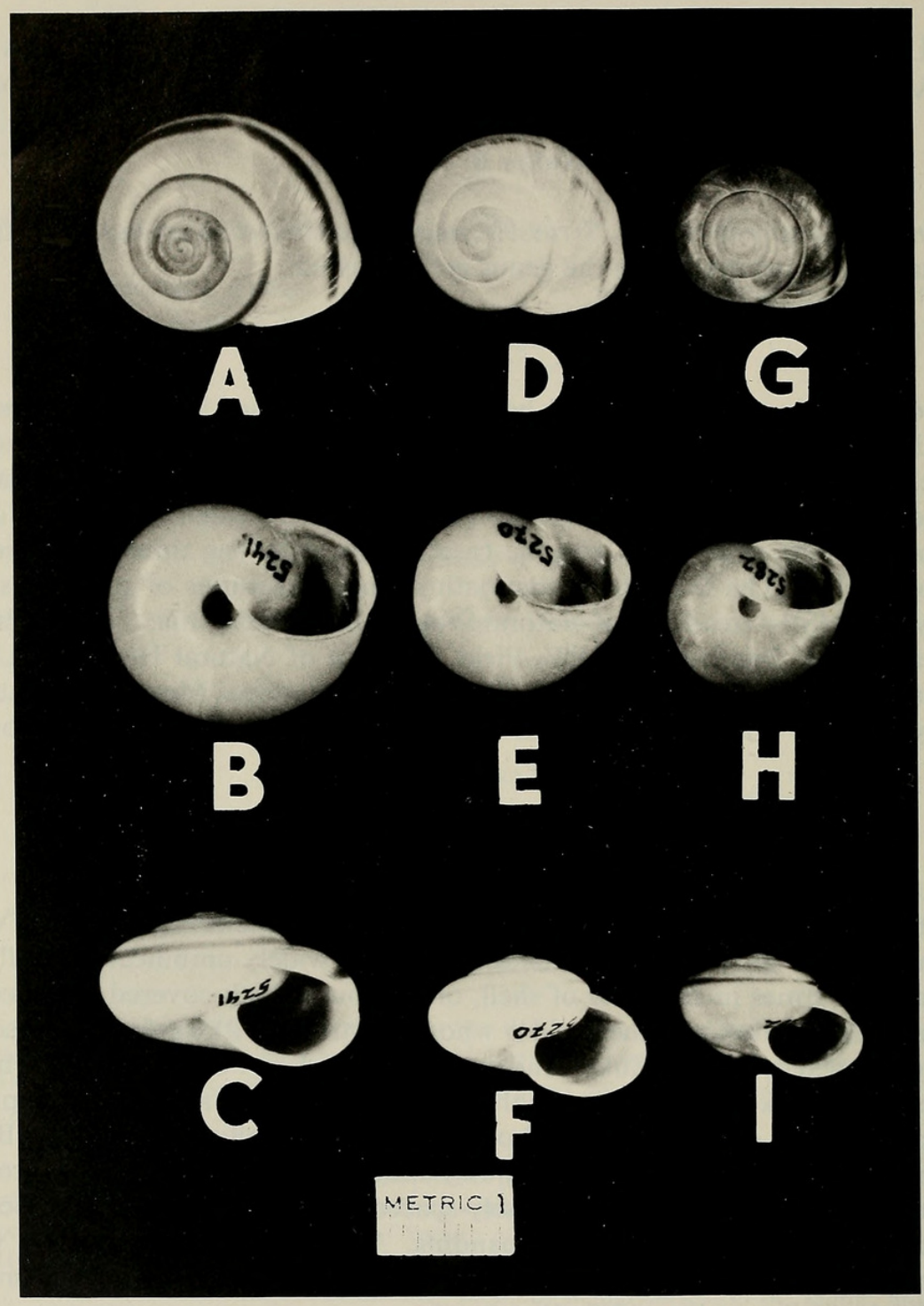

Fig. 1. A, B, C, Shell of a paratype of *Sonorella reederi*; D, E, F, Shell of a paratype of *Sonorella russelli*; G, H, I, Shell of a paratype of *Sonorella bradshaveana*.

and color. Five live adults were dissected. All show a short spermathecal diverticulum, varying from 1.0 to 2.3 mm in length.

Disposition of types.—Holotype: USNM 792406. Paratypes: ANSP 356004; CAS 033405; FMNH 206235; UTEP 9051; RLR 298; WBM 5241 & 6307.

Type-locality.—Mohave Co., Arizona. Lower Granite Gorge of the Colorado River, in limestone rockslide just west and below Rampart Cave; elevation ca. 1700 ft., 36°06′N, 113°56′W.

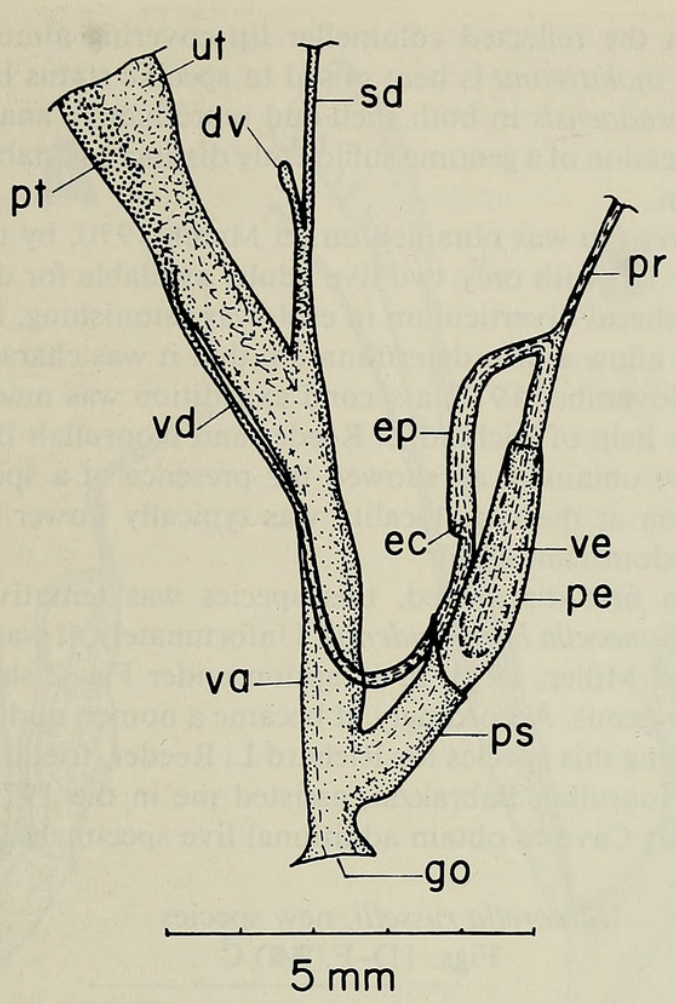

Fig. 2. Lower accessory structures of reproductive system of *Sonorella reederi*; drawing prepared from projection of stained whole mount WBM 6307. dv, spermathecal diverticulum; ec, epiphallic caecum; ep, epiphallus; go, genital orifice; pe, penis; pr, penial retractor muscle; ps, penial sheath; pt, prostate; sd, spermathecal duct; ut, uterus; va, vagina; vd, vas deferens; ve, verge.

Remarks.—The most outstanding distinguishing characteristic of this species is the presence of a spermathecal diverticulum, which is a structure not normally found in any other species of *Sonorella.* It is probably vestigial and too short to function in storing exogenous sperm. Its presence nevertheless may be of significance to students of evolutionary processes, in that the gene, or genes, for this structure have apparently not been eliminated from the ancestral helminthoglyptid genome but rather they have only been masked, or prevented from being expressed, by whatever mutations or chromosomal re-arrangements occurred when the founder *Sonorella* was formed.

This species appears to be genetically most closely related to its two geographical neighbors, *S. coloradoensis* (Stearns, 1890) to the east and *S. mohaveana* (W. B. Miller, 1968), to the southwest, as revealed by the similar type of short, cylindrical verge. In *S. coloradoensis,* however, the verge is widely corrugated instead of smooth-sided; furthermore, as stated above, only *S. reederi* is equipped with a distinct, short, spermathecal diverticulum. In shell characters, *S. coloradoensis* is a much smaller shell, whose average diameter is approximately half the size of *S. reederi* and *S. mohaveana. Sonorella mohaveana* is more narrowly umbilicate

than *S. reederi,* with the reflected columellar lip covering almost half of the umbilicus. *Sonorella mohaveana* is here raised to specific status because its differences from *S. coloradoensis* in both shell and reproductive anatomy are considered to be the expression of a genome sufficiently distinct to establish effectively reproductive isolation.

The first lot of *S. reederi* was obtained on 25 March 1970, by the author and his son, W. B. Miller III, with only two live adults available for dissection. The presence of a spermathecal diverticulum in each was astonishing, but the sample size was too small to allow a firm determination that it was characteristic of the population. On 23 November 1973, a second expedition was made to the type-locality, and with the help of Richard L. Reeder and Noorullah Babrakzai, four more live adults were obtained; all showed the presence of a spermathecal diverticulum. Vegetation at the type locality was typically Lower Sonoran, with *Acacia greggi* the predominant shrub.

Etymology.—When first discovered, this species was tentatively given the manuscript name of *Sonorella boreoccidentis.* Unfortunately, it was inadvertently listed in Bequaert and Miller, 1973, in a caption under Fig. 2 showing the distribution limits of the genus. Accordingly, it became a nomen nudum. I now take great pleasure in naming this species for Richard L. Reeder, friend and colleague, who, together with Noorullah Babrakzai, assisted me in the 1973 backpacking expedition to Rampart Cave to obtain additional live specimens.

Sonorella russelli, new species
Figs. 1D–F, 3A

Description of holotype.—Shell depressed-globose, heliciform, very light tan, with pale-chestnut, spiral band on well-rounded shoulder; umbilicate, umbilicus contained 9 times in diameter and slightly covered by reflected columellar lip. Embryonic shell of 1½ whorls, dull, with surface microscopically roughened by radial ripples and papillae. Post-embryonic whorls marked with light growth-wrinkles. Body whorl glossy underneath, descending only slightly to peristome. Aperture oblique, rounded, with margins converging; parietal callus thin. Shell measurements in mm: diameter 15.8, height 10.2, umbilicus 1.8; 4½ whorls.

Reproductive anatomy.—Ovotestis and distal accessory structures as in other *Sonorella.* Proximal structures show diagnostic characters. Penis short, containing short, stout, rhomboid, obtusely pointed verge about ⅓ length of penis; penial sheath embraces proximal ½ of penis. Epiphallus about equal in length to penis, proximally stout as far as attachment of penial retractor muscle, then thin; epiphallic caecum miniscule and buried in connective tissue of epiphallus. Vagina short, about ⅔ length of penis. Lengths in mm: penis 4.5, penial sheath 2.5, verge 1.5, epiphallus 5.0, epiphallic caecum 0.3, vagina 3.0.

Variations in paratypes.—Approximately 30 dead, adult shells were collected during five separate expeditions over a period of four years, from 6 September 1966 to 6 September 1970. The largest shell measures 18.1 mm in diameter and the smallest measures 14.7 mm. All show similar sculpture and shape; many are all glossy white with no trace of the chestnut spiral band.

Disposition of types.—Holotype: USNM 792407. Paratypes: ANSP 356002; CAS 033406; FMNH 206236; UTEP 9050; WBM 4916, 4967, 5200, 5230, 5270.

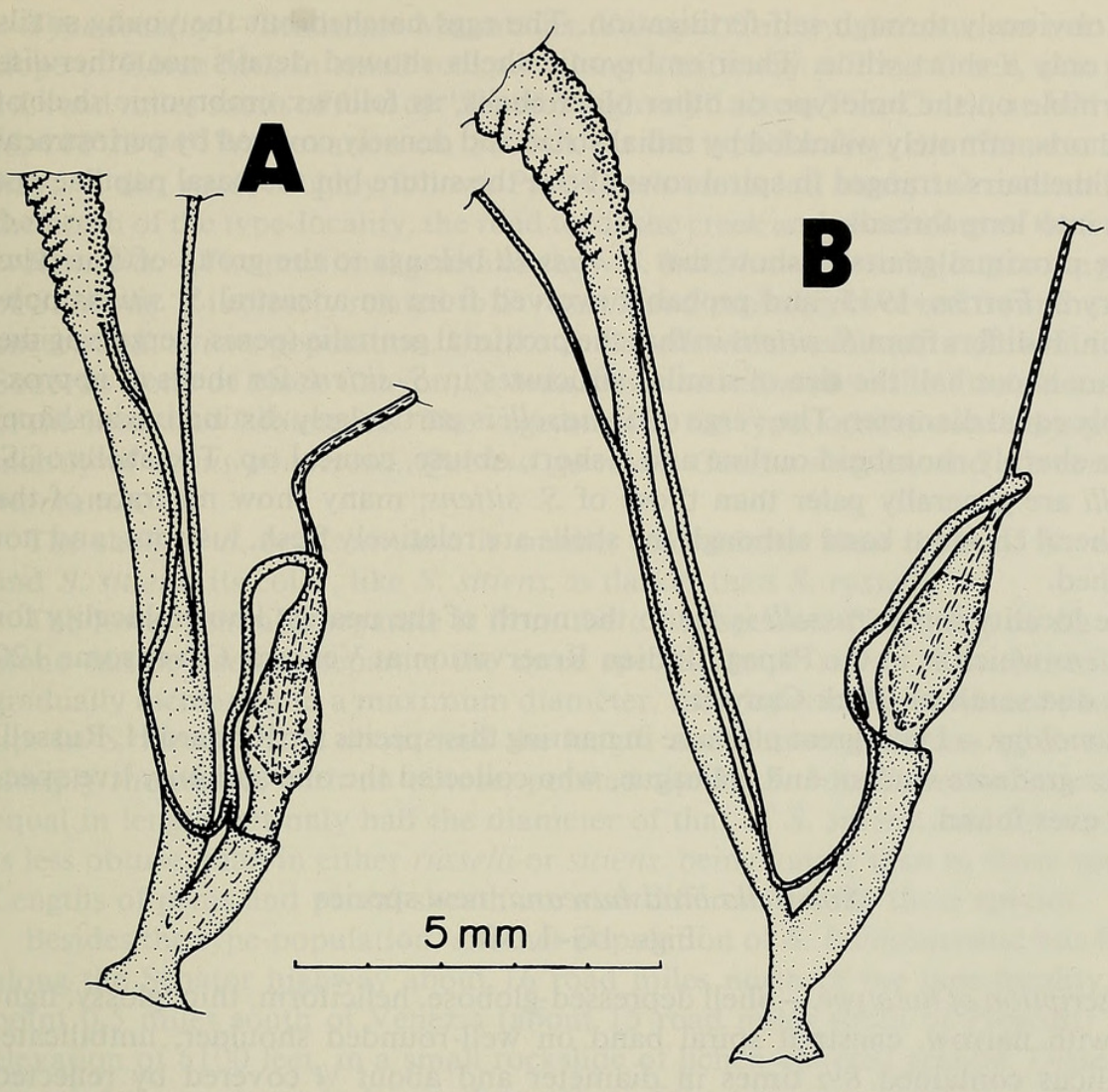

Fig. 3. A, Lower accessory structures of reproductive system of *Sonorella russelli*; drawing prepared from projection of stained whole mount, WBM 5200; B, Lower accessory structures of reproductive system of *Sonorella bradshaveana*; drawing prepared from projection of stained whole mount, WBM 5282. Both drawings to same scale.

Type-locality.—Black Canyon, Yavapai County, Arizona, on west flank of Black Mesa, east of Arrastre Creek (a tributary to Black Canyon Creek), in Sec. 10, T9N, R2E, at 34°08′05″ N, 112°08′42″ W; elevation ca. 2850 ft. This locality is presently about 0.1 mile east of Interstate highway 17, northbound lane, at a point 6.3 road miles north of the town of Rock Springs.

Remarks.—*Sonorella russelli* is known only from the type-locality. The locality is a very arid lava rockslide in the Lower Sonoran Zone. It is probable that the type population speciated by rapid genetic drift after ecological isolation in post-pluvial times within the past ten thousand years. The scarcity of live animals, as well as of dead shells, indicates that the population may be on the verge of extinction. In spite of repeated, diligent efforts to find live animals, only 1 live immature specimen was ever obtained. Although this immature specimen was reared carefully for a period of two years, its shell was deformed and could not be used as a holotype; accordingly, a more typical holotype was selected from other shells. The live animal not only yielded a good anatomy, but also laid two

eggs, obviously through self-fertilization. The eggs hatched but the young snails lived only a short while. Their embryonic shells showed details not otherwise discernible on the holotype or other older shells, as follows: embryonic shell of 1½ whorls, minutely wrinkled by radial striae and densely covered by periostracal hairs, the hairs arranged in spiral rows above the suture but the basal papillae not fused into long threads.

The proximal genitalia show that *S. russelli* belongs to the group of *S. sitiens* Pilsbry & Ferriss, 1915, and probably evolved from an ancestral *S. sitiens* population. It differs from *S. sitiens* in that the proximal genitalia (penis, verge, vagina, etc.) are about half the size of similar structures in *S. sitiens* for shells of approximately equal diameter. The verge of *S. russelli* is particularly distinctive in shape, with a sharply rhomboid outline and a short, obtuse, conical tip. The shells of *S. russelli* are generally paler than those of *S. sitiens*; many show no trace of the peripheral chestnut band although the shells are relatively fresh, lustrous, and not bleached.

The locality for *S. russelli* is far to the north of the nearest known locality for *S. sitiens* which is in the Papago Indian Reservation at Ventana Cave, some 120 miles due south of Black Canyon.

Etymology.—I take great pleasure in naming this species for Richard H. Russell, former graduate student and colleague, who collected the one and only live specimen ever found.

Sonorella bradshaveana, new species
Figs. 1G–I, 3B

Description of holotype.—Shell depressed-globose, heliciform, thin, glossy, light tan, with narrow, chestnut spiral band on well-rounded shoulder; umbilicate, umbilicus contained 8½ times in diameter and about ¼ covered by reflected columellar lip. Embryonic shell of 1¼ whorls, with surface microscopically roughened by radial wrinkles and minute papillae. Post-embryonic whorls marked with light growth wrinkles and pits of worn-off periostracal hairs, pits fewer on later whorls. Last whorl descends abruptly to slightly expanded peristome. Aperture oblique, rounded, slightly wider than high, with margins converging; parietal callus thin. Shell measurements, in mm: diameter 14.7, height 9.3, umbilicus 1.7; 4¼ whorls.

Reproductive anatomy.—Ovotestis and distal accessory structures as in other *Sonorella.* Proximal structures show diagnostic characters. The penis contains a short, stout, acutely pointed verge which is about ⅓ the length of the penis; a penial sheath embraces the proximal ⅔ of the penis. Epiphallus about as long as the penis, proximally thick as far as attachment of penial retractor muscle, then thin; epiphallic caecum miniscule, buried in connective tissue of epiphallus. The vagina is short, about ⅘ the length of the penis. Lengths, in mm: penis 6.0, penial sheath 4.0, verge 2.0, epiphallus 6.0, epiphallic caecum 0.2, vagina 4.7.

Variations in paratypes.—A total of 18 adult shells was collected from the type-locality. The largest measures 14.8 mm and the smallest 13.5 mm. All have similar sculpture, shape, and color.

Disposition of types.—Holotype: USNM 792408. Paratypes: ANSP 356003; CAS 033404; FMNH 206237; UTEP 9052; WBM 5282.

Type-locality.—Bradshaw Mountains, Yavapai County, Arizona, on northeast slope of Horse Mt., in small rockpile along a tributary to Pine Creek, at a point 1.2 road miles south of ford of "Senator highway" across Pine Creek, at 34°14′40″ N, 112°23′04″ W; elevation ca. 5800 ft. At the type-locality, the "Senator highway," a dirt road, roughly follows Pine Creek on its left bank; 1.2 road miles to the north of the type-locality, the road fords the creek and climbs out of the valley.

Remarks.—The proximal genitalia show *S. bradshaveana* to belong to the group of *S. sitiens.* It is closely related to *S. russelli* and probably evolved from the same ancestral *S. sitiens* population. Unlike *S. russelli* which evolved in the arid Lower Sonoran Zone of Black Canyon, *S. bradshaveana* radiated to the Transition Zone of the Bradshaw Mountains. The vegetation at the type-locality consists predominantly of *Pinus ponderosa, Quercus gambeli, Garrya wrighti,* and *Cercocarpus montanus.*

The shell of *S. bradshaveana* is smaller and thinner than those of *S. russelli* and *S. sitiens*; its color, like *S. sitiens,* is darker than *S. russelli.*

The lower genitalia separate it from the other species. The shape of the verge alone can be used to separate the three species. In *S. sitiens,* it is short, stout, gradually increasing to a maximum diameter, then tapering to an obtuse rounded tip. In *S. russelli,* it is about half the length and diameter of that of *S. sitiens,* sharply rhomboid, with an obtuse, pointed tip. In *S. bradshaveana,* it is about equal in length but only half the diameter of that of *S. sitiens,* and the tip cone is less obtuse, than in either *russelli* or *sitiens,* being longer than in those species. Lengths of penis and penial sheath are also different for the three species.

Besides the type-population, another population of *S. bradshaveana* was found along the Senator highway about 16 road miles north of the type-locality, at a point 0.5 miles south of Venezia (about 15 road miles south of Prescott) at an elevation of 6100 feet, in a small rockslide of lichen-covered granite. Dissection revealed the anatomy to be similar to that of the type specimens.

Etymology.—The species is named for the Bradshaw Mountains which it inhabits.

Literature Cited

Bequaert, J. C., and W. B. Miller. 1973. The mollusks of the arid Southwest with an Arizona check list.—University of Arizona Press, Tucson, Arizona, i–xvi + 271 pp.; 7 figs.

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