

Proof Only

NUMBER 1 OF 1

AUTHOR QUERIES

DATE 14/05/2012

JOB NAME AMB

ARTICLE 30204

QUERIES FOR AUTHORS Hoffman et al.

PLEASE ANSWER THE AUTHOR QUERIES WHERE THEY APPEAR IN THE TEXT.

THERE ARE NO QUERIES

Proof Only

Synonymy of *Sonorella rosemontensis* Pilsbry 1939 with *Sonorella walkeri walkeri* Pilsbry and Ferriss, 1915 (Pulmonata: Helminthoglyptidae) from the Santa Rita Mountains, Arizona, U.S.A.

James E. Hoffman¹, Lance H. Gilbertson², and Robert S. Fritz³

¹ 12450 S. Saladom Road, Tucson, Arizona 85736, U.S.A.

² Museum Associate, Natural History Museum of Los Angeles County, Malacology Section, 900 Exposition Boulevard, Los Angeles, California 90007, U.S.A.

³ WestLand Resources, Inc., 4001 East Paradise Falls Drive, Tucson, Arizona 85712, U.S.A.

Correspondence, Robert S. Fritz: rfritz@westlandresources.com

Abstract: In the northern Santa Rita Mountains, Pima County, Arizona, there are three named species of the helminthoglyptid landsnail *Sonorella* Pilsbry, 1900: *Sonorella magdalenensis* (Stearns, 1890), *S. walkeri walkeri* Pilsbry and Ferriss, 1915, and *S. rosemontensis* Pilsbry, 1939. Of these taxa, Pilsbry (1939) originally named *S. rosemontensis* based on shell characters alone. Later, he dissected and described the reproductive organs from a specimen preserved in alcohol that was collected at a location different from the type locality. Subsequently, Walter B. Miller collected two snails, calling them *S. rosemontensis*, because they were collected at Pilsbry's *S. rosemontensis* locality. He noted that their male genitalia did not resemble those described by Pilsbry; rather, they closely resembled those of *S. w. walkeri*. Our examination of shell and reproductive anatomies of snails from the *S. rosemontensis* type locality near the north end of the Santa Rita Mountains, as well as specimens in the Santa Barbara Museum of Natural History collection lead us to conclude that snails previously referred to as *S. rosemontensis* are synonymous with *S. w. walkeri*, and that in his original description of the reproductive anatomy of *S. rosemontensis*, Pilsbry mistakenly dissected a specimen of *S. magdalenensis*.

Key words: talus snails, land snail, Santa Rita Mountains, verge, anatomy

Sonorella rosemontensis H. A. Pilsbry, 1939 was described in error. The reproductive anatomy, as drawn by Pilsbry (1939), does not match the anatomy of snails subsequently collected from the type locality and no other collections of snails that we are aware of contain specimens resembling Pilsbry's description. The correct depiction of the reproductive tract of a snail collected from the *S. rosemontensis* type locality appears on page 260 of Walter B. Miller's doctoral dissertation (Miller 1967). Miller's drawing of the reproductive tract of *S. rosemontensis* does not appear to differ in any significant way from that of *S. walkeri walkeri* Pilsbry and Ferriss, 1915 (Miller 1967: 260).

Pilsbry (1939) named *Sonorella rosemontensis* based on a shell that he originally described as a range extension of *S. hesterna* Pilsbry and Ferriss, 1923 (Pilsbry and Ferriss 1923, Bequaert and Miller 1973). The internal anatomy was disregarded as an identifying characteristic since *S. hesterna* was known only from shells at its original locality. Shell size and embryonic sculpture seemed the same as those of *S. hesterna* in the nearby Rincon Mountains.

Later, Pilsbry (1939) seems to have mistakenly dissected the genitalia from a different species of *Sonorella*, which he describes as being, "very closely related to *S. arida* Pilsbry and Ferriss, 1939, the genitalia being of the same general

character...". *Sonorella arida*, *S. tumamocensis* Pilsbry and Ferriss, 1915, and *S. linearis* Pilsbry and Ferriss, 1923 were synonymized with *Sonorella magdalenensis* (Stearns, 1890) by Miller (1967). Pilsbry apparently confused the shell of the specimen he dissected with that of *S. hesterna*, which are very similar to the shells of *S. walkeri*, as they are in the same *Sonorella* complex (*S. hachitana* Dall, 1985) (Bequaert and Miller 1973). Furthermore, Pilsbry (1939: 349) went on to say, "It [*Sonorella rosemontensis*] 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*." Thus, Pilsbry was well aware of the distinct features of the animal he dissected, which resembled two different known species.

This disparity in reproductive structures of the specimens that Walter B. Miller collected at the type locality of *Sonorella rosemontensis*, compared to the description and drawings in Pilsbry (1939) was first noted by Miller (Miller 1967: 70). He states: "The genitalia ... are not at all those of the [*Sonorella*] *tumamocensis* group [i.e., *Sonorella magdalenensis*]. Instead, they resemble those of *S. walkeri*. The penis is very short and thin as is [*Sonorella*] *walkeri*...". Miller goes on to say that: "It is probable that he [Pilsbry] dissected a

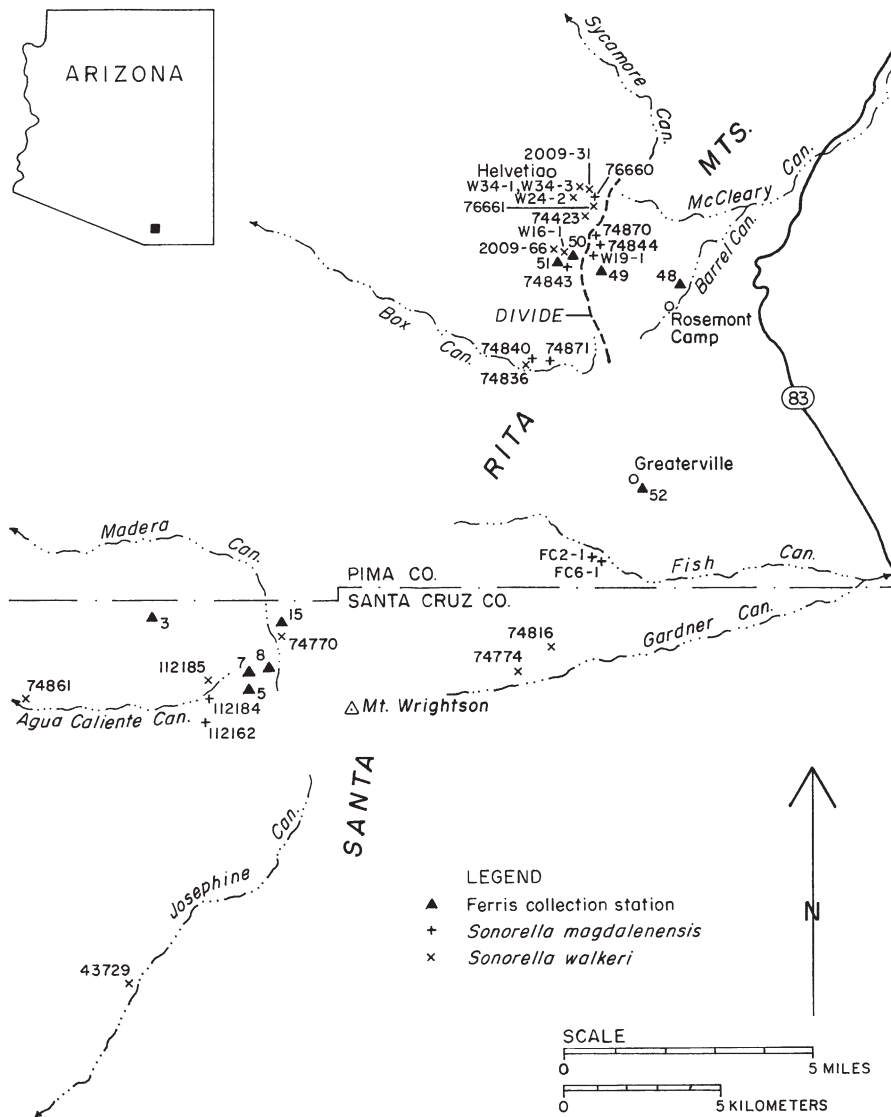


Figure 1. Map of collection sites of *Sonorella walkeri* (= *S. rosemontensis*) and *S. magdalenensis* in the Santa Rita Mountains. Numbers beside symbols indicate museum numbers, WestLand collection numbers, or Ferriss' stations.

specimen of *S. tumamocensis linearis* by mistake. I have dissected an adult specimen of [*S.*] *rosemontensis* and find the genitalia to be as described above... *S. rosemontensis* is closely related in all respects to *S. walkeri*."

Pilsbry (1939) did not describe the collection locality of *Sonorella rosemontensis* in any greater detail than: "Northern end of the Santa Rita Mountains near Rosemont." However, examination of the collection localities for *S. hesterna* in the Santa Rita Mountains, show that snails were collected from "above ... Rosemont Camp" (Ferriss' Station 48), at a saddle overlooking Helvetia (Station 50), and on a talus slope south

of Greaterville, Arizona (Station 52; Ferriss' Collection Notes 1917-18; Pilsbry and Ferriss, 1923). Examination of collections at The Academy of Natural Sciences of Philadelphia (ANSP) showed that the holotype of *S. rosemontensis* was collected at Ferriss' station 49, on the east side of the divide, and consists of a single shell (ANSP166642). Pilsbry then dissected a snail from station 50, on the west side of the divide, calling it the paratype (ANSP118058). This paratype contains a dried up alcoholic specimen, and station 50 is the only station in the north end of the Santa Rita Mountains where Ferriss collected live snails (Ferriss' collection notes 1917-18). This evidence strongly suggests that Pilsbry used the shell collected at one location and the reproductive anatomy from another to describe *S. rosemontensis*.

In Miller (1967) and Bequaert and Miller (1973) *Sonorella walkeri* and *S. rosemontensis* are listed as separate species, though they are described as being very similar. In a later report to the U. S. Fish and Wildlife Service on invertebrates of the Rosemont area, Miller (1978) wrote: "Careful examination of shells and reproductive anatomies revealed no significant difference [of *S. rosemontensis*] from *S. walkeri* Pilsbry and Ferriss, which is common further south..." He went on to say "It is the opinion of the author that *S. rosemontensis* is at least conspecific with *S. walkeri* and may possibly be a synonym."

The purpose of this paper is to present the results of an analysis of specimens from Miller's collection of the reproductive anatomies of *Sonorella*

species collected in the type location of *Sonorella rosemontensis* and to present an analysis of the reproductive anatomies of specimens recently collected at the same location. Together, these analyses provide evidence that *S. rosemontensis* was named in error and is synonymous with *Sonorella walkeri*.

MATERIALS AND METHODS

Species considered in this study are: *Sonorella magdalenensis* (Stearns, 1890); *S. walkeri walkeri* Pilsbry and Ferriss,

Table 1. Lengths of measurements of the genital organs of *Sonorella rosemontensis*, *S. walkeri*, and *S. magdalenensis* (= *S. tumamocensis*), Walter B. Miller Collection, Santa Barbara Museum of Natural History and results of measurements taken on slides of reproductive tracts of *Sonorella* spp. we collected at the north end of the Santa Rita Mountains to the nearest 0.1 mm.

Number	Species name	Verge (mm)	Vagina (mm)	Penis (mm)
A. Walter B. Miller Collection				
74923A	<i>S. rosemontensis</i>	1.3	5.1	2.7
76661	<i>S. rosemontensis</i>	2.9	9.4	3.9
	Mean (<i>N</i>)	2.1 (2)	7.2 (2)	3.3 (2)
	Range	1.3–2.9	1.5–9.4	2.7–3.9
B. Walter B. Miller Collection				
74770	<i>S. walkeri</i>	1.2	8.3	3.3
74774B	<i>S. walkeri</i>	3.3	1.2	4.4
74795B	<i>S. walkeri</i>	2.0	5.3	3.1
74795C	<i>S. walkeri</i>	-	-	4.0
4795D	<i>S. walkeri</i>	2.4	9.9	3.9
74876C	<i>S. walkeri</i>	-	-	4.0
77219	<i>S. walkeri</i>	2.8	9.9	3.4
74876D	<i>S. walkeri</i>	2.0	-	3.4
74876E	<i>S. walkeri</i>	2.0	4.5	4.5
74876F	<i>S. walkeri</i>	2.3	-	4.3
	Mean (<i>N</i>)	2.2 (8)	8.3 (6)	3.8 (10)
	Range	1.2–3.3	1.2–9.9	3.1–4.5
C. WestLand Collection				
W34-1	<i>S. walkeri</i>	1.2	5.8	3.2
W24-2	<i>S. walkeri</i>	1.5	7.5	3.2
W23-4	<i>S. walkeri</i>	1.3	9.5	2.0
W34-3	<i>S. walkeri</i>	1.5	-	2.8
FC2-1	<i>S. walkeri</i>	1.2	-	-
	Mean (<i>N</i>)	1.3 (5)	7.6 (3)	2.8 (4)
	Range	1.2–1.5	5.8–9.5	2.0–3.2
D. Walter B. Miller Collection				
74739	<i>S. tumamocensis</i>	4.1	9.3	10.2
74742(3)	<i>S. tumamocensis</i>	4.3	3.5	10.4
74742 (2)	<i>S. tumamocensis</i>	4.4	-	10.2
74742	<i>S. tumamocensis</i>	4.7	15.3	9.8
77453H	<i>S. magdalenensis</i>	6.4	17.9	14.7
	Mean (<i>N</i>)	4.8 (5)	11.5 (4)	11.1 (5)
	Range	4.1–6.4	3.5–17.9	9.8–14.7
E. WestLand Collection				
E12-1	<i>S. magdalenensis</i>	10.5	7.5	19.0

1915; and *S. rosemontensis* Pilsbry, 1939 (Pulmonata: Helminthoglyptidae) from the Santa Rita Mountains, Arizona.

Material for this investigation came from two sources. First, *Sonorella* spp. were collected in 2008, 2009, and 2011. The habitat for *Sonorella* in this locality consists of talus slopes that occur on both the east and west sides of the north-south oriented divide of the Santa Rita Mountains just east of

Helvetia, Arizona. Specimens in 2008 and 2009 were collected from the northern Santa Rita Mountains in the vicinity of Helvetia (Figure 1), the locality of the *Sonorella rosemontensis* type specimen. Additionally, eight snails were collected in 2011; four from the west side of the divide and one from the east side of the divide and three from the mountains near Fish Creek (Figure 1). Second, we studied material that was part of Miller's mounted reproductive tracts and shells of *S. rosemontensis*, *S. walkeri*, and *S. magdalenensis*; part of the Walter B. Miller Collection at the Santa Barbara Museum of Natural History (SBMNH), Santa Barbara, California.

Eight living snails were drowned and their bodies were removed from their shells. Reproductive organs were dissected free of the other organs, stained with Delafield Hematoxylin and Eosin B and mounted on slides in the manner described by Gregg (1959) and later revised by Naranjo-García (1989). Reproductive tracts from snails were measured using an ocular micrometer under a dissecting microscope at 40X and scaled to millimeters.

We dissected several specimens of *Sonorella walkeri* and *S. magdalenensis* collected by personnel from WestLand in 2008 and 2009 that were preserved in 70% ethyl alcohol. These specimens were mounted and examined to provide a comparison of their shape to other specimens.

Preservation in alcohol prior to dissection results in dehydration, which causes substantial shrinkage in length of tissues (5–40 %: Fowler and Smith 1983, Radtke 1989, Jennings 1991), thus we did not use these specimens for tissue measurements.

All of the slide-mounted reproductive tracts of *Sonorella* species collected from the Santa Rita Mountains in the Walter B. Miller Collection at the SBMNH were scanned adjacent to

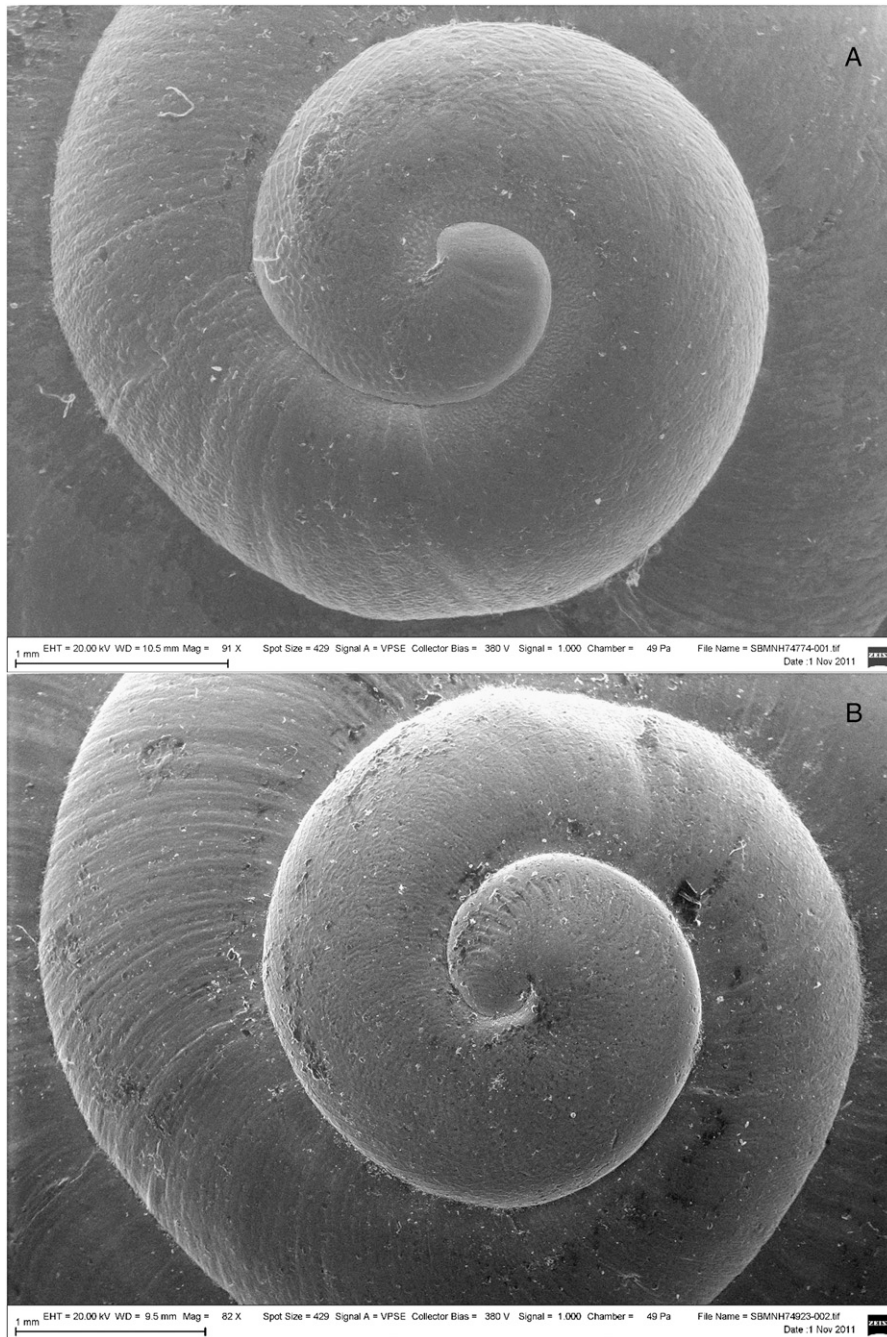


Figure 2. Scanning electron micrograph images of the shells of: **A)** *Sonorella walkerii* (SBMNH 74774) and **B)** *S. rosemontensis* (SBMNH 74923) showing the sculpturing of the embryonic shell.

a millimeter scale. The digital images of the reproductive tracts were examined at the maximum size in which both the reproductive tract and the millimeter scale could be measured from the screen image and lengths of the reproductive structures were scaled to determine actual length in

millimeters. At the same time, numerous shells were photographed, including those of the scanned specimens. In addition, scanning electron micrographs (SEMs), using a Zeiss EVO40 XVP SEM, were taken of the embryonic whorls of a specimen of *Sonorella rosemontensis* and a *S. walkerii* from Miller's collection (SBMNH).

RESULTS

Identification of snails

Two species of *Sonorella* were identified from our mounted specimens: *Sonorella walkerii* and *S. magdalenensis*. The specimens of *S. walkerii* (five mature fresh dissected, two immature fresh dissected, and two alcohol-preserved specimens) had thin verges that narrowed towards the tip with a sub-terminal pore. Three specimens (one mature fresh dissected and two alcohol preserved) were identified as *S. magdalenensis* based on the larger, spirally plicate and cone-tipped verge (for an illustration of the genitalia of *S. walkerii*, see Pilsbry 1939: 287, Fig 157; for *S. magdalenensis* (as *S. arida*) see pp. 343, Fig 211).

Range

The collection locations of *Sonorella walkerii* and *S. rosemontensis* are overlapping and continuous throughout the Santa Rita Mountains (Fig. 1). Pilsbry's and Miller's collections of *S. walkerii* are located in the Santa Rita Mountains as far north as Greaterville, Arizona. Ferris collected snails, identified from shells by Pilsbry as *S. rosemontensis*, in Greaterville (ANSP 166642, 118058, 166641, 166639). Snails we collected and identified as *S. walkerii* were found located on both sides of the divide near Helvetia and Rosemont

and from Fish Creek near Greaterville. There is no evidence of allopatric ranges of these two species. The range of *S. magdalenensis* is also widespread through the Santa Rita Mountains and is sympatric with the range of *S. walkerii* (Figure 1).

Genitalia

The shape of the verge of *Sonorella walkeri* as illustrated by Pilsbry (1915), Miller (1967), and seen in our specimens is identical to the shape of the verge of the *S. rosemontensis* specimens collected by Miller (1967) and as seen in the examination of his preserved specimens.

The verge of all of these specimens is thin with a pointed tip and possesses a subterminal pore. The verge of these specimens is entirely different from the robust verge described by Pilsbry (1939) for *S. rosemontensis*, which is spirally plicate with a cone-shaped tip, a trait of *S. magdalenensis*. We are not aware of any specimens collected since Pilsbry (1939) named *S. rosemontensis* that have a verge of the shape described therein.

The measurements of the reproductive tracts of *Sonorella walkeri* and *S. rosemontensis* collected and mounted by Miller and those we collected and mounted have completely overlapping ranges of sizes (Table 1). The verges of Miller's *S. walkeri* range in size from 1.2–3.3 mm (nearly a 3-fold difference between the smallest and the largest specimens) and those of *S. rosemontensis* range from 1.3–2.9 mm. The lengths of the verge of the five specimens we collected range in size from 1.2–1.5 mm, within the range of Miller's *S. walkeri* specimens. The penis lengths are variable but not as variable as the verge (Table 1). The vagina lengths are much more variable with a nearly six-fold difference (Table 1). There are notable differences in the size of the verge, penis, and vagina and in shell size in the two specimens of *S. rosemontensis* (SBMNH 74923 and 76661) collected by W. B. Miller in very similar, nearby locations about 10 years apart (Table 1).

Sonorella magdalenensis has a male anatomy distinctly different from *S. walkeri* and *S. rosemontensis* in Miller's collection and in our specimens. Its verge is more than twice as long on average (Table 1D, 1E), has a cone-shaped tip, and is spirally plicate along its length. We collected three specimens of *S. magdalenensis*. Of the three, one (E12-1), was relaxed and counterstained. It had a verge length of 10.5 mm (Table 1E).

Embryonic shell sculpturing

Comparison of the scanning electron micrographs of the embryonic whorls of a *Sonorella walkeri* (Fig. 2a) and *S. rosemontensis* (Fig. 2b) show the same features – punctations and spiral lines. Thus, there is no indication that the morphology of the embryonic whorls indicates that these individuals belong to different species.

DISCUSSION

In 1939, Pilsbry stated of the genus *Sonorella*: “The male genitalia have been much more modified [as opposed to the shells], and the classification of the genus is therefore based

upon these organs.” Pilsbry 1939: 270). In this paper, we have examined the reproductive tracts of *Sonorella walkeri* and *S. rosemontensis* collected by W. B. Miller and the reproductive tracts that we collected and mounted. There are no discernible differences in the shapes or sizes of the male or female reproductive organs among these specimens. We also examined the embryonic whorls of *S. walkeri* and *S. rosemontensis* and found no discernible differences in the microscopic sculpturing of these shells. Based on these morphological data and the sympatric range of *S. walkeri* and *S. rosemontensis*, we conclude that the names of these species are synonymous. Because *S. walkeri* Pilsbry and Ferris, 1915 has precedence, this name is valid and the name *S. rosemontensis* is a junior objective synonym and therefore is a *nomen nudum* (Mayr 1969).

ACKNOWLEDGMENTS

We dedicate this paper to Walter B. Miller who was the mentor of JEH and LHG and whose work on *Sonorella* in the southwestern United States has greatly expanded our understanding of the taxonomy and range of these interesting snails. We are very grateful to Paul Valentich-Scott, Curator of Malacology at the Santa Barbara Museum of Natural History, for the invitation to visit the museum and for providing generous assistance to us during our stay. We thank the Editor and two anonymous reviewers for numerous helpful suggestions. Funding for this work was provided by Rosemont Copper Company by contract to WestLand Resources, Inc.

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.
- Ferriss, J. H. 1917/1918. Collecting Notes, Stations 1917-18, P2. Unpublished notes in the Academy of Natural Sciences of Philadelphia.
- Fowler, G. M. and S. J. Smith. 1983. Length changes in silver hake (*Merluccius bilinearis*) larvae: Effects of formalin, ethanol, and freezing. *Canadian Journal of Fisheries and Aquatic Sciences* **40**: 866–870.
- Gregg, W. O. 1959. A technique for preparing *in-toto* mounts of molluscan anatomical dissections. *Annual Report of the American Malacological Union* **1958**: 25–39.
- Jennings, S. 1991. The effects of capture, net retention and preservation upon lengths of larval and juvenile bass, *Dicentrarchus labrax* (L.). *Journal of Fish Biology* **38**: 349–357.
- Mayr, E. 1969. *Principles of Systematic Zoology*. McGraw-Hill, New York.

- Miller, W. B. 1967. *Anatomical revision of the genus Sonorella (Pulmonata: Helminthoglyptidae)*. Ph.D. Dissertation, Department of General Biology, University of Arizona, Tucson.
- Miller, W. B. 1978. Invertebrates (other than insects) of the Rosemont area. In: R. Davis and J. R. Callahan, eds., *An Environmental Inventory of the Rosemont Area in Southern Arizona*. Unpublished report in the University of Arizona Library. Pp. 110–115.
- Naranjo-García, E. 1989. Four additional species of *Sonorella* (Gastropoda: Pulmonata: Helminthoglyptidae) from Sonora, Mexico. *The Veliger* 32: 84–90.
- Pilsbry, H. A. 1939. Land Mollusca of North America (north of Mexico). *Monographs of the Academy of Natural Sciences of Philadelphia* 3: 1–573.
- Pilsbry, H. A. and J. H. Ferriss. 1915. Mollusca of the Southwestern States, VII—The Dragoon, Mule, Santa Rita, Baboquivari, and Tucson Ranges, Arizona. *Proceedings of the Academy of Natural Sciences of Philadelphia* 67: 363–350, Plates VIII—XV.
- Pilsbry, H. A. and J. H. Ferriss, 1923. Mollusca of the Southwestern States, XI—From the Tucson Range to Ajo and Mountain Ranges between the San Pedro and Santa Cruz Rivers, Arizona. *Proceedings of the Academy of Natural Sciences of Philadelphia* 75: 47–104.
- Radtke, R. L. 1989. Larval fish age, growth, and body shrinkage: Information available from otoliths. *Canadian Journal of Fisheries and Aquatic Sciences* 46: 1884–1894.

Submitted: 22 December 2011; **accepted:** 10 March 2012;
final revisions received: 1 May 2012