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Report on the Terrestrial Mollusks of the Sierra de la Madera (Oposura), Sonora, Mexico – The Caracoleros

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Abstract. The Madrean Archipelago Biological Assessment (MABA) “bioblitz” expedition to Sierra de la Madera (Oposura) near Moctezuma, Sonora, Mexico from 29 July–7 August 2010 included a land snail inventory. Five people searched for both macro- and microsnails in five sites in foothills thornscrub, oak woodland, and pine-oak forest (1225–2080 m elevation) and found 347 individuals of 18 species or forms. Macroscopic snails included a *Sonorella* Pilsbry, 1900 species ($N = 5$) found at four sites, a succineid species ($N = 3$) from two sites, and one philomycid slug. Micromollusks (< 6 mm) included representatives of seven families. The vertiginid genus *Gastrocopta* Wollaston, 1878 included eight species/forms. *Vallonia perspectiva* Sterki, 1892 was the most abundant species ($N = 123$). This collection adds four species to the 59 previously reported for the state. Seven forms from this southern “sky island”, including the *Gastrocopta ashmuni* group (= *Immersidens ashmuni* Pilsbry and Vanatta, 1900) and *Sonorella*, are characteristic of the Southwestern Mollusk Province (SWMP). Collecting land snails in Sonora has been sporadic because of the difficult terrain and remote locations. Additional efforts and locations should add many more species and clarify biogeographical affinities of this rugged area.

Resumen. El programa de la Evaluación de la Biodiversidad del Archipiélago Madreño organizó una expedición a la Sierra de la Madera (Oposura) cerca de Moctezuma, Sonora, México, para realizar un muestreo biológico intensivo (bioblitz) del 29 julio hasta el 7 agosto 2010, el cual incluyó un inventario de caracoles terrestres. Cinco personas buscaron tanto macro como micromoluscos en cinco sitios en matorrales espinosos, bosques de encino y de pino-encino (1225–2080 m de elevación) y encontraron 347 individuos de 18 especies o formas. Los macromoluscos incluyen una especie de *Sonorella* Pilsbry, 1900 ($N = 5$) encontrada en cuatro sitios, una especie de *Succinea* Draparnaud, 1801 ($N = 3$) de dos sitios, y una babosa de la familia Philomycidae. Los micromoluscos (< 6 mm) incluyen representantes de siete familias. El género *Gastrocopta* Wollaston, 1878 de la familia Vertiginidae incluye ocho especies/formas. *Vallonia perspectiva* Sterki, 1892 fue la especie más abundante ($N = 123$). Esta colecta añade cuatro especies a las 59 previamente reportadas para el estado. Siete formas de esta “isla serrana” del sur entre ellas el grupo *Gastrocopta ashmuni* Sterki, 1896 y *Sonorella* Pilsbry, 1900, son características de la Provincia Malacológica del Suroeste. La recolección de caracoles terrestres en Sonora ha sido esporádica debido a las dificultades del terreno y lugares remotos. El trabajo de campo en áreas nuevas añadirá muchas más especies y aclarará las afinidades biogeográficas de esta zona escarpada.

Key words: Mexican land snails, sky islands, MABA, biodiversity

The third Madrean Archipelago Biological Assessment (MABA) expedition into northeastern Sonora in July and August 2010 was a “bioblitz” sponsored by the Sky Island Alliance as part of its mission to survey, protect and restore unique habitats of the mountain islands and desert seas of the United States/Mexico borderlands. Participants included nearly 30 science professionals and students from both Mexico and the United States with a wide range of expertise. Five people, “los caracoleros”, worked on land snails. The target of the bioblitz was the Sierra de la Madera (Oposura), an isolated granitic-batholithic mountain range covering about 800 km² in the greater Río Yaquí drainage in northeastern Sonora near the town of Moctezuma. The mountain included

foothills thornscrub vegetation around its base as well as more mesic habitats grading into pine–oak forest above 1700 m. Some higher elevations of the Sierra de la Madera are part of the Reserva Forestal Nacional y Refugio de Fauna Silvestre Ajos-Bavispe in the Comisión Nacional de Áreas Protegidas (CONANP) system (T. R. Van Devender pers. comm. 2010).

MATERIALS AND METHODS

Land snails were sampled at five sites in the Sierra de la Madera (within the municipios or “counties” of Cumpas and Moctezuma) in northwestern Sonora, Mexico (Figure 1).

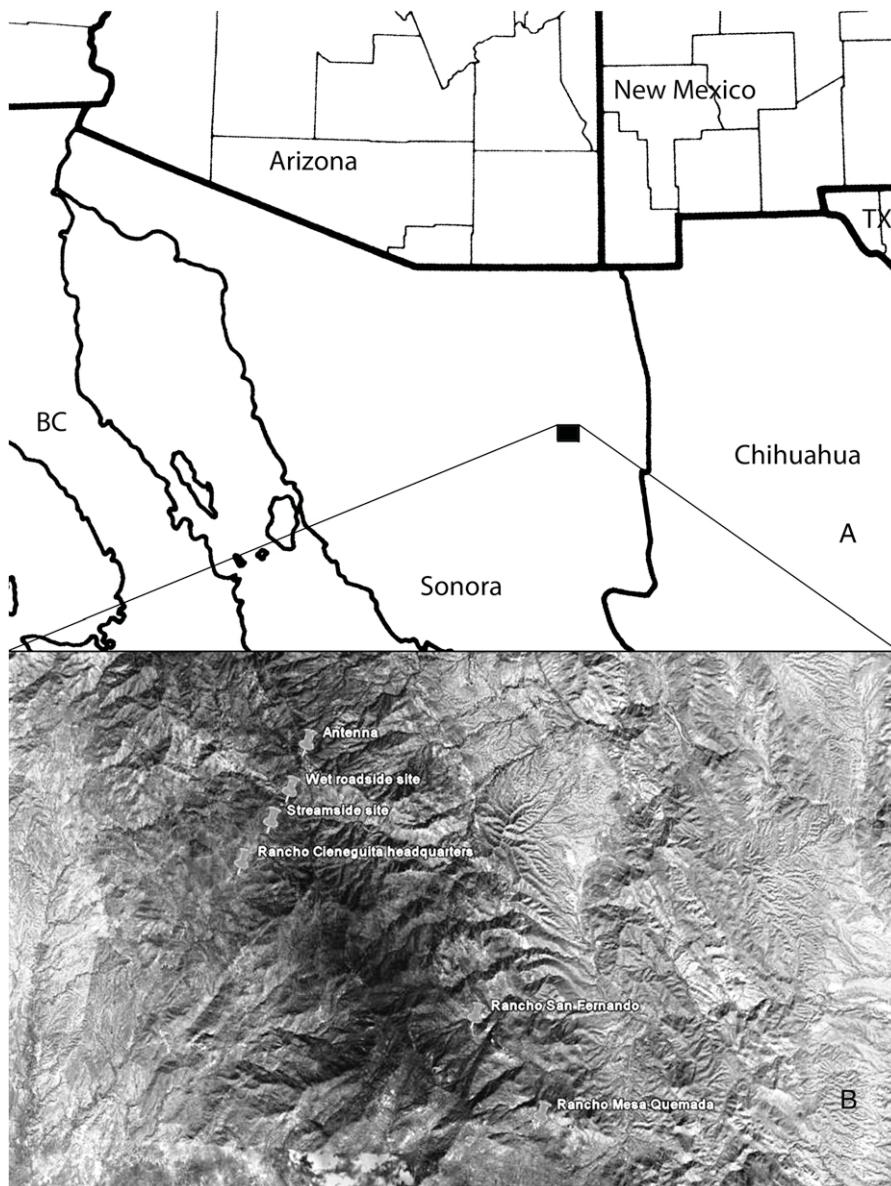


Figure 1. Collection locations. **A.** Northern Mexico and southwestern United States with location of Sierra de la Madera. **B.** Location of sites visited (Google Earth projection July 2011).

Elevation, orientation and descriptions were recorded at each site. Likely microhabitats under rocks, downed wood, and leaf litter were searched visually. Samples of leaf litter, humus and soil were collected at four sites, sundried, sifted through sieves (0.855–3.35 mm mesh) and searched using hand lenses. Live snails were drowned in tap water laced with menthol crystals and preserved in 70% EtOH. Most specimens were brought back to the U.S. under SEMARNAT permit #055 to Dr. Edna Naranjo-García, but one slug and two succineids were transported to Mexico City. Most specimens will be deposited into the Colección Nacional de Moluscos in the Instituto

de Biología, Universidad Nacional Autónoma de México in Mexico City. Specimens were cleaned and imaged using cameras, microscopes, and scanning electron microscopes (SEM). Data recorded for most intact specimens were number of whorls (WH), diameter (D) and height (H) as measured to ± 0.01 mm from micrographs using analysis in Adobe Photoshop™. Width of umbilical opening (U) was measured for many specimens. Samples were compared using the conservative two-tailed T-tests with unequal variance (Steele and Torrie 1980) using Microsoft Excel™.

Specimens were identified using figures, keys, and descriptions in Pilsbry (1940, 1946, 1948), Bequaert and Miller (1973), Naranjo-García and Fahy (2010), and Nekola and Coles (2010). Fred Thompson (University of Florida), Jeff Nekola (University of New Mexico), Barry Roth (San Francisco, California), and Harry G. Lee (Jacksonville, Florida) were consulted for opinions on problematic specimens. Taxonomy of Bouchet and Rocroi (2005) was used. Information on the biogeography, botany, and geology of the region was obtained from T. R. Van Devender.

RESULTS

Sites

Three sites were on the north or northwest part of the mountain range in Municipio de Cumpas, Sonora (Figure 1). Collection site 1 was a steep, north facing, mesic canyon at 1584 m elevation above Rancho Cieneguitas, (29.9948°N, 109.5593°W). Four people searched this site for approximately four hours (16 person-hours). Most snails were in litter collected on the steep slope above the canyon floor. Site 2 was in pine-oak woodland near a microwave antenna at 2080 m elevation (30.0196°N, 109.5457°W). Snails were found under bark on logs, in talus slides, and in leaf litter during about two hours of searching (8 person-hours). Site 3 was a steep north-facing road cut at 1832 m elevation (30.0029°N, 109.5538°W). Water seeping from crevices and ferns among the rocks indicated a particularly moist area. The site was searched for about 3

person-hours. Remaining sites were on the southeastern flank of the range in Municipio de Moctezuma, Sonora (Fig. 1). Site 4 included roadside rocks, a small arroyo, and part of a wooded canyon at about 1225 m elevation on Rancho Mesa Quemada (29.8952°N, 109.4573°W). About 10 person-hours were spent searching this site. Site 5 included edges of a large meadow and a semi-permanent stream in a steep canyon at Rancho San Fernando (29.8952°N, 109.4826°W) near 1490 m elevation. Snails were found in litter under logs, under bark on dead trees, on wet rock walls and in the riparian zone. Searches at this site involved more than 20 person-hours of effort. Additional images and maps are available in the MABA database <<http://www.madreaan.org/maba/symbfauna/imagelib/index.php>>.

Snails collected

A total of 347 live animals or identifiable shells were collected. Only nine individuals of two snail and one slug species were larger than 5 mm. Nearly all other snails were extracted from soil/litter samples. Snails represented 10 families, 11 genera and 18 species or forms listed below and in Table 1. Identification of most species was hampered by lack of comparative material and high quality illustrations of whole animals, shells, or aperture lamellae for similar taxa. We provide these illustrations for most taxa encoun-

tered. Snails were distributed heterogeneously among sites. Eleven species were found at only one site, and five more species were found at only two sites. The remaining two species were found at three or four sites. No species was found at all sites. The only "invasive" species was *Zonitoides arboreus* (Say, 1816), which was fairly rare at a disturbed site. Snail diversity varied considerably among sites at Sierra de la Madera; but only site one had sufficient numbers to provide a reliable estimate of diversity (Cameron and Pokrysko 2005). Both the 13 species and Shannon-Wiener diversity estimate ($h' = 1.674$) were much lower at this site than we would expect in similar sized samples from eastern U.S.A.

Family Gastrodontiidae

One perfect shell with the distinctive ribbing of *Striatura meridionalis* (Pilsbry and Ferriss, 1906) (Fig. 2D–F) was found at Rancho San Fernando (Site 5). It has 3 whorls, D = 1.53 mm, H = 0.49 mm, and U = 0.32D. The first 1.25 whorls have conspicuous incised lines but no riblets. Ten major riblets are equally spaced in 0.49 mm of the last whorl. This shell is the first record of the species from Sonora. *S. meridionalis* is widespread in eastern U. S. and ranges to Texas, New Mexico, and Arizona (Bequaert and Miller 1973, Hubricht 1985, Metcalf and Smartt 1997). *Striatura meridionalis* also occurs

Table 1. Snails collected at each site at Sierra de la Madera, Sonora, Mexico.

Family	Species	Sites					All
		1	2	3	4	5	
Gastrodontiidae	<i>Striatura meridionalis</i>					1	1
Gastrodontiidae	<i>Zonitoides arboreus</i>		3				3
Helicarionidae	<i>Habroconus trochulinus</i>					12	12
Helminthoglyptidae	<i>Sonorella</i> species	1	1	1		2	5
Philomycidae	<i>Pallifera arizonensis</i>	1					1
Punctidae	<i>Punctum</i> species	32					32
Vertiginidae	<i>Gastrocopta ashmuni</i>	16				8	24
Vertiginidae	<i>Gastrocopta cochisensis</i>	4					4
Vertiginidae	<i>Gastrocopta dalliana</i>				6		6
Vertiginidae	<i>Gastrocopta</i> cf. <i>dalliana</i>	38				8	46
Vertiginidae	<i>Gastrocopta pellucida</i>	4					4
Vertiginidae	<i>Gastrocopta perversa</i>	3					3
Vertiginidae	<i>Gastrocopta perversa</i> form <i>sana</i>				9	9	
Vertiginidae	<i>Gastrocopta pilsbryana</i>	2					2
Succineidae	<i>Succinea</i> species	1				2	3
Thysanophoridae	<i>Thysanophora horni</i>	6			17	1	24
Valloniidae	<i>Vallonia perspectiva</i>	120			3	123	
Zonitidae	<i>Glyphyalinia</i> cf. <i>umbilicata</i>	23	1		2	19	53
	Total	251	5	1	37	53	347
	Total species	13	3	1	5	8	18
	Unique species	6	1	0	2	2	

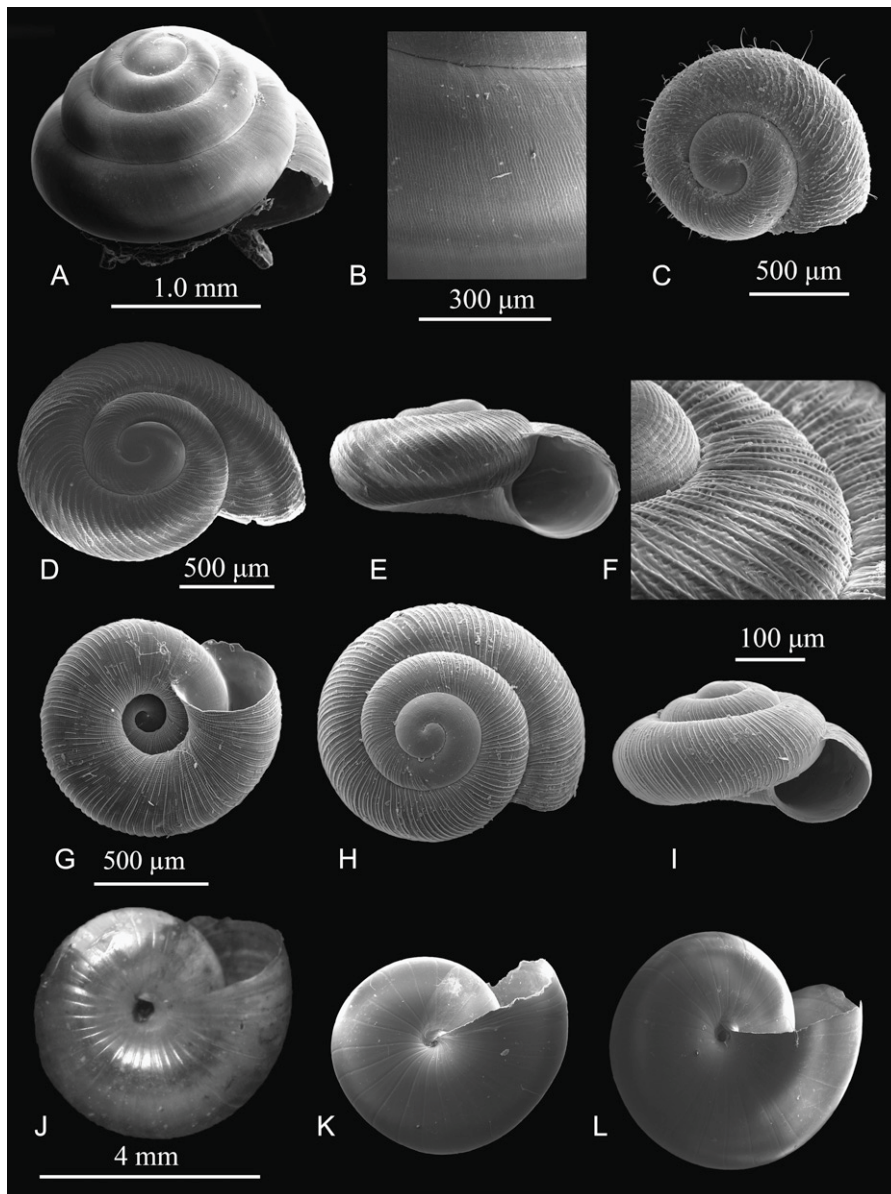


Figure 2. Microsnails with low spires from Sierra de la Madera. **A–B**, *Habroconus trochulinus* (Morelet, 1851) from Rancho San Fernando (site 5). **C**, *Thysanophora hornii* (Gabb, 1866) from Rancho Cieneguita (site 1). **D–F**, *Striatura meridionalis* from Rancho San Fernando (site 5). **G–I**, *Punctum* species from Rancho Cieneguita (site 1). **J**, *Glyphyalinia* cf. *umbilicata* from Rancho Cieneguita (site 1). **K**, *Glyphyalinia indentata* from Gastonia, Gaston County, North Carolina, USA. **L**, *Glyphyalinia umbilicata* from Austin, Travis County, Texas, USA. (Scale bars are as indicated except for bars shared by D and E, and separate bars for rows three and four.)

in the Mexican states of Chihuahua, Nuevo León, Puebla and Veracruz (Bequaert and Miller 1973, Thompson, 2011).

Three *Zonitoides arboreus* (T. Say, 1817 as *Helix*) shells were found in its usual habitat of rotting logs at the micro-

wave antenna (Site 2). These shells have 3–4 whorls, D between 2.67 and 4.59 mm, indistinct growth wrinkles, and minute incised lines along the axis of the whorls. This is the first record of *Z. arboreus* from Sonora; but the species is common over much of North America from Canada to Central America and the Caribbean, and has been introduced into agricultural areas worldwide (Pilsbry 1946). *Zonitoides arboreus* is widespread in Arizona and New Mexico (Bequaert and Miller 1973, Metcalf and Smartt 1997) and occurs in the Mexican states of Chihuahua, Nuevo León, Puebla and San Luis Potosí (Naranjo-García and Fahy 2010).

Family Helicarionidae

Twelve *Habroconus trochulinus* (Morelet, 1851) (Fig. 2A–B) were found alive under leaves in rock crevices along a permanent stream at the base of an east-facing ridge at Rancho San Fernando (Site 5). The single specimen imaged has 4 whorls, D = 2.03 mm, H = 1.64 mm and is similar to all others. This species resembles *Euconulus fulvus* (Müller, 1774) in size and shape but has distinctive microstructure of densely packed, radial striae spaced evenly at intervals of 5 µm and traces of spiral striae near sutures of whorls and on the first whorl. Initial 0.2 whorls are nearly smooth. These specimens extend the range of this species in Mexico from Chiapas, Michoacán, Puebla, and Veracruz (Thompson 2011).

Family Helminthoglyptidae

Five shells of a *Sonorella* Pilsbry, 1900 species were found in talus or piles of rocky debris at four sites. Shells average D = 13.48 mm (range = 13.4–14.3 mm) and have about 4 whorls. Two were immature at death. *Sonorella* has many species distinguishable only by anatomy of the genital complex (W. B.

Miller 1967, Bequaert and Miller 1973). Mead *et al.* (2010) list 15 *Sonorella* species from Sonora. The Sierra de la Madera is near the southernmost limit of *Sonorella* and includes the type locality for *Sonorella perhirsuta* (W. B. Miller, 1967).

Identification of Sierra de la Madera *Sonorella* must await collection and dissection of live adults.

Family Philomycidae

The only slug found was a 10–15 mm specimen of *Pallifera arizonensis arizonensis* (Pilsbry, 1917 as *Philomycus* Rafinesque, 1820) in leaf litter at Site 1. The type locality for *P. a. arizonensis* is in the Santa Rita Mountains in Santa Cruz County, Arizona. The subspecies is known from a few localities in Arizona and Sierra Purica in northern Sonora (Bequaert and Miller 1973).

Family Punctidae

Thirty two specimens of a *Punctum* Morse, 1864 species were found in litter in oak woodland at Site 1 (Fig. 2G–I). These snails have D from 0.85–1.32 mm (mean = 1.101, $N = 30$), 2.2–3.5 whorls (mean = 2.94, $N = 30$), and $U = 0.200\text{--}0.333D$ (mean = 0.284, $N = 29$) and are the first record of *Punctum* in Sonora. The species name to be applied to these shells is questionable. They most closely resemble figures and descriptions of shells from the Dragoon Mountains of Arizona tentatively called *Punctum californicum* H. A. Pilsbry, 1897 (Pilsbry 1948: 648) but differ from that species in smaller size and more depressed shell (Barry Roth pers. comm. 2011). They are similar to *P. minutissimum* (Lea 1841) in size and closely-spaced major riblets but are more depressed and lack the downturned aperture of that species. They differ from *P. vitreum* H. B. Baker, 1930 in having only 3–4 minor riblets between major riblets. Another widespread species in the American Southwest similar to *P. vitreum* is probably undescribed (Jeff Nekola pers. comm. 2011); but it may be the same as our species and Pilsbry's specimens from the Dragoon Mountains. Further studies of anatomy and DNA will be necessary to provide a final species identification.

Family Succineidae

A broken succineid shell found under a rock at site 1 was $H = 6.92$ mm, $D = 3.91$ mm, and $WH = 3$ with deeply-indented sutures. A badly broken shell was seen and discarded at site 3. Two live specimens with shells about 5 mm long were found in the flood plain of the stream at site 5. These shells had distinctly tapering shells with deeply-incised sutures like some species of *Catinella* Pease, 1871. Dissection found these to be immature and not assignable to species or genus (E. Naranjo-García, pers. comm. 2010). *Succinea luteola luteola* Gould, 1848 and *Succinea luteola sonorensis* Fischer and Crosse, 1878 are known from Sonora.

Family Thysanophoridae

A total of 22 individuals of *Thysanophora horni* (W. M. Gabb, 1866 as *Helix*) were found in litter at four sites. The largest seven individuals average 3.46 whorls (range 2.4–3.8)

and $D = 3.02$ mm (range = 1.6–3.45 mm). Umbilicus diameter averages $0.227D$ (range = 0.185–0.267D). The species is widespread in Sonora and Mexico (Bequaert and Miller 1973, Hubricht 1985, Naranjo-García and Fahy 2010, Thompson 2011).

Family Valloniidae

Vallonia perspectiva (Sterki, 1893) was the most common snail ($N = 123$) found during the study. These were found at sites 1 and 5. Three adult shells with reflected lips had 2.7–3.2 whorls and D from 1.83–1.97 mm. One specimen has 41 major riblets on the last whorl. *Vallonia perspectiva* is known in Mexico from a few records in Sonora and one in Chihuahua (Bequaert and Miller 1973, Hubricht 1985, Naranjo-García and Fahy 2010). This species is easily distinguished by its size, open umbilicus, and complex shell sculpture.

Family Vertiginidae

Gastrocopta Wollaston, 1878 occurred at most sites. Five of seven species had the transverse basal lamella, deeply placed palatal lamellae, and the complexly-fused angular and parietal lamellae of Subgenus *Immersidens* Pilsbry and Ferriss, 1900.

Gastrocopta (Immersidens) ashmuni (Sterki, 1896) (Fig. 3A) was found at sites 1 ($N = 12$) and 5 ($N = 4$). Shells have 4–4.5 (mean = 4.14) whorls, shell lengths from 1.63–2.19 (mean = 1.85) mm, and shell width of 0.94–1.07 (mean = 1.003) mm. These shells have huge, united angulo-parietal lamellae forming a reversed “y” shape and a distinctive columella that extends onto the parietal wall and appears as an infraparietal. Most of the shells resemble *G. ashmuni* form *minor* (Sterki, 1898) in size, number of whorls, and length of aperture free from shell; but the largest shell is much too large for *G. ashmuni* form *minor*. This species is known from several sites to the north and west in Sonora and in Arizona and New Mexico.

Gastrocopta (Immersidens) cochisensis (Pilsbry and Ferriss, 1910 as *Bifidaria* Sterki, in Pilsbry, 1891) was found in litter at Rancho Cieneguita (site 1) (Fig. 3E). The two intact shells differ from *G. ashmuni* in having smaller lamellae in the aperture and a columella extending only to the junction of the columellar and parietal walls. These shells have 4 whorls, length of 1.90–2.06 mm, and width of 1.05 mm. This species is known in Sonora only from “arroyo 8 km S. Guaymas” (Pilsbry, 1953.) The Guaymas site was listed by Bequaert and Miller (1973) and Thompson (2011) but not by Mead *et al.* (2010).

Snails assignable to *Gastrocopta (Immersidens) dalliana* (Sterki, 1898) from sites 1, 4, and 5 varied considerably among sites and indicated presence of more than one closely-related species in this limited area. Shells from site 4 (Rancho Mesa Quemada) are quite variable. Five intact shells are similar to most written accounts of this species in their small size

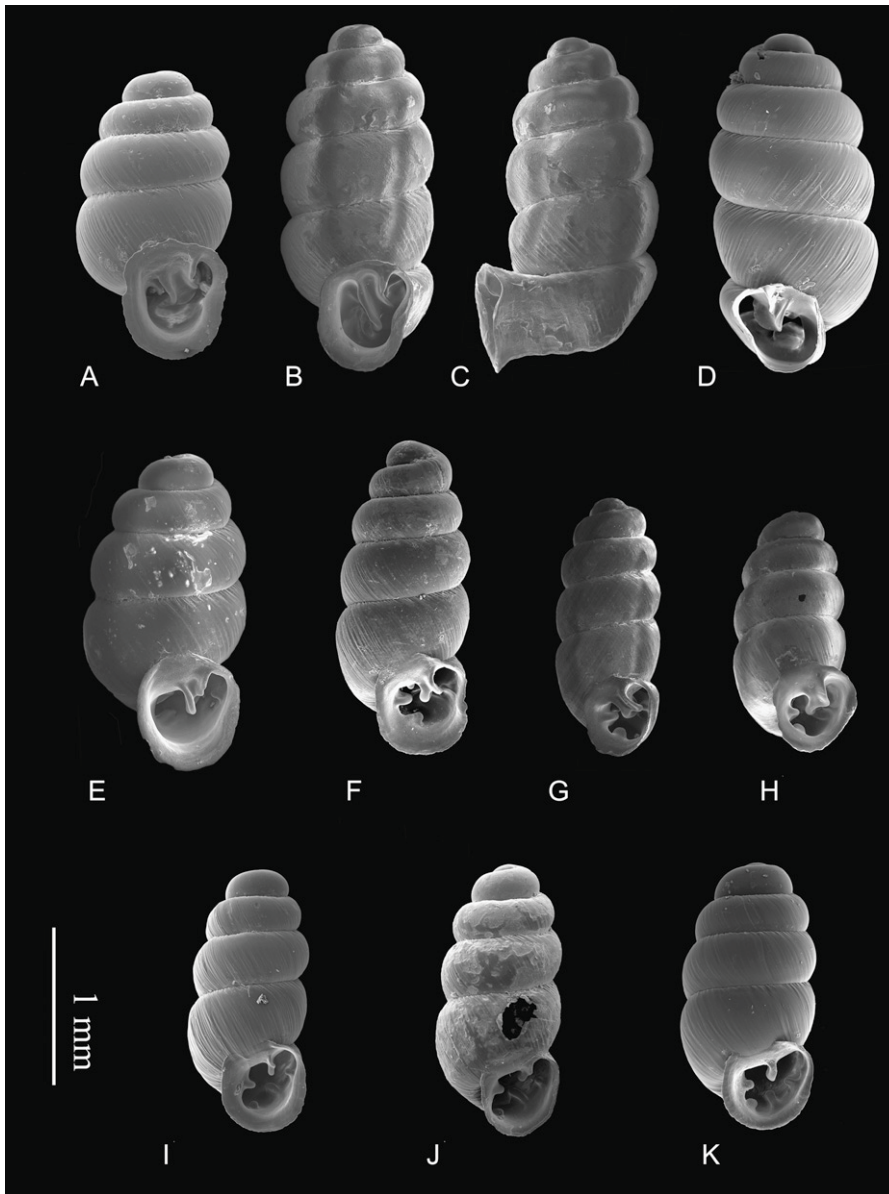


Figure 3. *Gastrocopta* of Sierra de la Madera. **A**, *Gastrocopta ashmuni* from Rancho Cieneguita (site 1). **B–C**, *Gastrocopta perversa* form *sana* from Rancho Mesa Quemada (site 4). **D**, *Gastrocopta perversa* Sterki from Rancho Cieneguita (site 1). **E**, *Gastrocopta cochisensis* from Rancho Cieneguita (site 1). **F**, *Gastrocopta* cf. *dalliana* with infraparietal from Rancho Cieneguita (site 1). **G–H**, *Gastrocopta dalliana* without infraparietal from Rancho Mesa Quemada (site 4). **I–J**, *Gastrocopta pellucida* from Rancho Cieneguita (site 1). **K**, *Gastrocopta pilsbryana* from Rancho Cieneguita (site 1).

(1.64–1.74 mm in length, mean = 1.69 mm, and 0.70–0.79 mm in width, mean = 0.75 mm), aperture shape, and placement of lamellae. Two of these shells (Fig. 3G) are like *G. dalliana dalliana* of Pilsbry (1948: 902, Figure 488) in all respects. Three shells (Fig. 3H) have more complete apertures and a columellar

lamella bending downward like Pilsbry's (1948: 902, figure 489) illustration of *G. d. bilamellata* (Sterki and Clapp, 1909); which is the larger, western form found over much of Arizona, Sonora, northern Chihuahua and Baja California (Bequaert and Miller 1973). All shells at Rancho Mesa Quemada are smaller than *G. d. bilamellata* and are included in *G. d. dalliana* (Jeff Nekola pers. comm. 2011).

Specimens from higher elevations at site 1 (Rancho Cieneguita) and site 5 (Rancho San Fernando) resemble *Gastrocopta dalliana* with the infraparietal fold as described by Sterki (1898) and ignored by all subsequent authors. These 21 specimens are significantly larger in shell length (1.60–2.06 mm, mean 1.905) and diameter (0.78–0.88 mm, mean 0.832) than *G. dalliana* at Rancho Mesa Quemada (two sample T-test assuming unequal variance). The two species of *G. dalliana*-like snails at Sierra de la Madera seem to represent both the form described by Sterki (1898) and the widely distributed form called *G. dalliana* by all others since 1900. Examination of the type specimens and further studies using DNA and anatomy will be necessary to determine which of these represents a new species.

Three shells of *Gastrocopta perversa* (Sterki, 1898) (Fig. 3D) were found at Rancho Cieneguita (site 1). These sinistral animals are larger than sympatric *G. ashmuni* and have more extended aperture necks. Nine *Gastrocopta perversa* form *sana* (Pilsbry, 1916) (Fig. 3B–C) were found at Rancho Mesa Quemada (site 4). The *G. p. sana* shells are similar in size and shape to *G. perversa* at site 1 and noticeably larger than *G. ashmuni* from all sites. Recognition of the larger *G. perversa* is consistent with the presence of two species at each

of two sites. Both forms of *G. perversa* are known from other sites in Sonora (Pilsbry 1948, Bequaert and Miller 1973) as *G. ashmuni*.

The subgenus *Gastrocopta* Wollaston 1878 is represented by *Gastrocopta* (*Gastrocopta*) *pellucida* (Pfeiffer, 1841 as *Pupa*

Say, 1821) found at Rancho Cieneguita (site 1). Three of these are very small and narrow with the last two whorls similar in diameter (Fig. 3I), but a larger one (Fig. 3J) is more tapered, and has a less reflected aperture. The three intact shells averaged WH = 4.2, H = 1.76 mm, and D = 0.817 mm. The species is known from Sonora (Naranjo-García 1991, Mead *et al.* 2010).

The subgenus *Vertigopsis* Sterki 1893 is represented by two *Gastrocopta* (*Vertigopsis*) *pilsbryana* (Sterki, 1890 as *Pupa*) found at site 1. The best specimen had 4.5 whorls, H = 1.81 mm, and D = 0.89 mm (Fig. 3K). This species is known from Sonora (Thompson 2011).

Family Zonitidae

A *Glyphyalinia* Von Martens, 1892 species ranked second in abundance with 53 specimens from four sites (Table 1). Many specimens are small and broken, but a sample of 6 large, intact shells average D = 4.12 mm (range = 2.44–5.26 mm) with 3.66 whorls (range = 2.7–4.2). Umbilicus averages 6.2% of diameter but ranges from 3.7–9.3% in three adult shells from Rancho Cieneguita. One specimen from Rancho Cieneguita (Fig. 2J) has about 33 incised lines in the last whorl and largest umbilicus in the sample. Two other adults have 29 and 33 incised lines in the final whorl. Shells resemble *G. umbilicata* (Singly in Cockerell, 1893 as *Zonites* Montfort, 1810) from Texas (Fig. 2L) more closely than typical *G. indentata* (T. Say, 1821 as *Helix*) from Gaston County, North Carolina (Fig. 2K) and are assigned to that species. *Glyphyalinia indentata* ranges from southeastern Canada, over much of the U.S. and Mexico south to Guatemala (Metcalf and Smartt 1997). It is reported in Sonora, Nuevo León, Tamaulipas, and San Luis Potosí as *Glyphyalinia indentata indentata* (Naranjo-García and Fahy 2010) and in Puebla and Mexico near Teotihuacan as *G. indentata paucilirata* (Morelet, 1851). *Glyphyalinia indentata* probably comprises a complex of several anatomically-distinct species (Hubricht 1985). Snails in the Sierra de la Madera are certainly not *Glyphyalinia indentata* of the eastern U.S. (Fig. 2K) and probably do not represent *G. indentata paucilirata* (Bequaert and Miller 1973, Metcalf and Smartt 1997). The wider umbilicus of our specimens suggests affinity with *Glyphyalinia umbilicata* from Texas (Fig. 2L), which is currently recognized for many U. S. populations previously referred to as *G. paucilirata* (Turgeon *et al.* 1998). Further anatomical and DNA work on this group will undoubtedly reorganize this genus dramatically.

DISCUSSION

Sierra de la Madera is a “sky island” (Heald 1951, Warshall 1995) of mesic environment surrounded by xeric lowlands and has many microhabitats within a relatively small area. The fauna of the Sierra de la Madera is derived from diverse

sources. Seven species (*Striatura meridionalis*, *Zonitoides arboreus*, *Glyphyalinia umbilicata*, *Gastrocopta pilsbryana*, *Punctum* species, *Succinea* species, and *Vallonia perspectiva*) represent widespread Nearctic lineages, while four species (*Habroconus trochulinus*, *Pallifera arizonensis*, *Thysanophora horni*, and *Gastrocopta pellucida*) are clearly Neotropical. The six forms in *Gastrocopta* (*Immersidens*) are members of autochthonous radiations in the region but are derived from a Neotropical lineage. The *Sonorella* species is also autochthonous but cannot easily be assigned to any biogeographical source as the family is widespread in the New World. The snail fauna is similar to several floras (McLaughlin 1955) in having both northern and southern biogeographic affinities, but seems to include more local and regional endemic species. Very little is known about biogeography, habitat requirements, species’ anatomy or fossil record of land snail faunas worldwide (Metcalf and Smartt 1997). This situation seems especially true for Sonora (Naranjo-García 1991, Mead *et al.* 2010). Snails from the Sierra de la Madera are consistent with the Southwestern Molluscan Province discussed by Bequaert and Miller (1973); but analyses of additional faunas in this region will be necessary to elucidate its biogeographical history. While Mead *et al.* (2010) listed 59 species, 27 genera, and 17 families from Sonora, there are few reports of actual faunal assemblages for the state. The diversity of this fauna is rather meager compared to Mexican states with better-studied faunas (Thompson 2011) or the somewhat larger Arizona (Bequaert and Miller 1973). Our collection of 18 total species (about 1/3 of the total known for the state) and 4 taxa new for the state in a relatively short time and limited area suggests that many more species remain unrecorded. We expect the list of Sonoran snail species to grow considerably with additional sampling.

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