



New occurrences of *Holospira* (*Bostrichocentrum*) *goldmani* Bartsch, 1906 (Gastropoda, Urocoptidae) in northwestern Oaxaca, southern Mexico

Rosalía Guerrero-Arenas,¹ Eduardo Jiménez-Hidalgo,¹ Celestino Sandoval-García²

1 Laboratorio de Paleobiología, campus Puerto Escondido, Universidad del Mar, C.P. 71980, San Pedro Mixtepec, Oaxaca, Mexico. **2** Instituto de Industrias, campus Puerto Escondido, Universidad del Mar, C.P. 71980, San Pedro Mixtepec, Oaxaca, Mexico.

Corresponding author: Rosalía Guerrero-Arenas, rosaliaga@zicatel.umar.mx

Abstract

Holospira (*Bostrichocentrum*) *goldmani* Bartsch, 1906 is an urocoptid gastropod distributed throughout northwestern Oaxaca in southern Mexico. Since its original description, posterior records have been restricted to the Mixteca Baja region of Oaxaca. The purpose of this paper is to expand on the geographical distribution of this species, georeferencing six additional localities. Five of our sites are located in the Mixteca Alta region of Oaxaca. *Holospira goldmani* can survive in soil derived from non-calcareous rocks. Field observations of ecological preferences of *H. goldmani* suggest that they are more ecologically tolerant than previously thought.

Key words

Mollusca, Mixteca, range extension.

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Introduction

Urocoptid snails are an attractive terrestrial Gastropoda group because of their esthetic shells. *Holospira* Martens, 1860 is a native genus in North America from this family. It is distributed throughout the United States to southern Mexico. Knowledge of Mexican holospirine snails is limited because the lack of specialists and the under-development of terrestrial malacology in this country.

Paradoxically, non-Mexican naturalists developed the early knowledge of terrestrial Gastropoda in Mexico. During the late 19th century, several scientific expeditions from the United States visited Mexico and Central America under the auspices of the Biological Survey of the United States Department of Agriculture. Terrestrial

mollusk specimens were collected during these trips and deposited in scientific collections in the United States (Bartsch 1906).

Two of these collectors, Edward W. Nelson and Edward A. Goldman, visited Oaxaca, a state in southern Mexico characterized by its rich biological diversity. They collected several specimens of Urocoptidae in the locality of “Tamazulapan” (sic) in November 1894. A few years later, based on these specimens, P. Bartsch published a description of *Holospira* (*Bostrichocentrum*) *goldmani* (Bartsch, 1906). Physical characteristics of the locality were not described in the original paper (Bartsch 1906); however, further information on the area was later published by Goldman (1951) as “arid and for the most part treeless, except for the low, scrubby stand of oaks on

the tops of the higher hills and ridges". The lack of precise information does not allow the identification of the type locality of *H. goldmani*. Nowadays, Tamazulapam could be referred to multiple sites, such as the village named "Villa Tamazulapam de la Unión" or the municipality with the same name.

Seemingly, *H. goldmani* is restricted to Oaxacan territory. After the publication of its description, *H. goldmani* was reported in several different localities apart from the original collecting site. Two of them are located northwest of Tamazulapam; however, none of these sites can be located nowadays, e.g., "Mexico, Oaxaca, km 389, Oaxaca highway, Tamazulapam", "Mexico, Oaxaca, W of Huajuapam de Leon (sic)", and "Mexico, Oaxaca, 1 km N of Calvario Church, Huajuapam de Leon". These reported specimens are housed in the Field Museum of Natural History (FMNH-Invertebrate Zoology; Chicago, USA) and in the Florida Museum of Natural History (FLMNH; Gainesville, USA). All these location records are available online in the collection database (<http://www.invertebase.org/portal/collections/list.php?db%5B%5D=1&reset=1&state=Oaxaca>).

The fourth record is referred to as "5.7 miles northwest of Huajuapam de Leon, Oaxaca, and 2.2 miles southeast of Chila, Puebla" (Thompson 1964). All these records of the Oaxacan sites in the Mixteca region lack precise locality data.

Pilsbry and Clapp (1909) reported an uncertain record of *H. goldmani* in Balsas, Guerrero, Mexico. Since their description of the specimens' morphology is not detailed, the identity of this record cannot be confirmed.

An additional online record (<http://mczbase.mcz.harvard.edu/guid/MCZ:Mala:210394>) from the Database of the Zoological Collections of Museum of Comparative Zoology at Harvard University refers to a record of a specimen of *H. goldmani* collected in "Virgin Islands, St Croix, Christiansted". This information is erroneous because the original data from the field notes—available as a picture in the same web page—referred the original location of the specimen as "Huajuapam de León, Oaxaca".

Holospira goldmani, like many other Mexican species described before the 20th century, lacks reports of any ecological preferences. Only limited information about the external and internal anatomy and the type locality are available in the formal literature (Bartsch 1906, Thompson 1964). Hence, the objective of this work is to report 6 new records of populations of *H. goldmani* in northwestern Oaxaca, southern Mexico. In addition to the georeference of these new localities, we report on the type of vegetation in these zones and discuss some issues about the geographic distribution of *H. goldmani*.

Methods

Topographically irregular landscapes characterize the Oaxacan territory. The geographic area of Oaxaca is frequently subdivided to make its management and understanding easier. The research area is located in

the Mixteca region, in the northwestern part of Oaxaca state. This region has an unequal and abrupt landscape, and therefore, a microclimate and ecosystem variations (Mindek 2003). There are 2 zones within this territory, based on altitude differences: the Mixteca Alta and Mixteca Baja. The Mixteca Alta is a cool, relatively moist, starkly folded and microenvironmentally diversified area of mountains, high hills, canyons and valleys. Zones of human occupation range from 1650 to 2500 m. On the contrary, the Mixteca Baja is a topographically diverse, hot, and semiarid zone in which occupation extends from 750 to 1650 m (Spores and Balkansky 2013).

Empty shells were collected by visual search between May 2015 and June 2016. The studied localities are in the Mixteca Alta, except for Site 1, situated on the road to Tezoatlán de Segura y Luna. Specimens were collected in Huajuapam, Teposcolula, and Tlaxiaco Districts, in 6 localities (Figs 1, 4). These sites are described in Table 1. The geodetic datum used for geographic coordinates is WGS84.

The shells were handpicked from the soil between plants. Specimens were collected under permit SGPA/DGVS/09521/2015 from the Subsecretaría de Gestión para la Protección Ambiental. All specimens are housed in the Colección Malacológica de Referencia of the Laboratorio de Paleobiología, Universidad del Mar, campus Puerto Escondido, under the acronym UCMR. Another 8 specimens, all adult shells, are housed in the Colección de Moluscos del Instituto Tecnológico de Ciudad Victoria (in Tamaulipas, in northern Mexico) in the Terrestrial Mollusks Section, under the reference numbers ITCVZ 8382 to ITCVZ 8389.

Results

New records. Table 1.

Identification. Six lots were collected from the same number of sites. The total number of collected specimens is 159 individuals, in different ontogenetic states. The number of specimens from each locality is shown in Table 1. For the purpose of taxonomic identification, only the adult specimens were measured (30 specimens in total, 5 for each population). Shell characteristics (Fig. 2) compare well with Bartsch's (1906) description and the syntype (Fig. 3).

Holospira goldmani has a cylindrical, white and thick shell (Fig. 2A–C). Adult specimens range from 16.0 to 19.5 mm in length, and the maximum width ranges from 4.6 to 5.9 mm; the number of whorls varied from 13 to 15. The nuclear whorls are well-rounded. The terminal cone is crossed by regularly spaced oblique riblets of similar size. The specimens have a small umbilical perforation. The aperture is pyriform, with a height of 3.1 to 4.4 mm. The internal columella has a uniform diameter throughout the cylindrical portion. To assure taxonomic identification, all adult specimens were examined for the diagnostic internal character, that is, the lack of internal

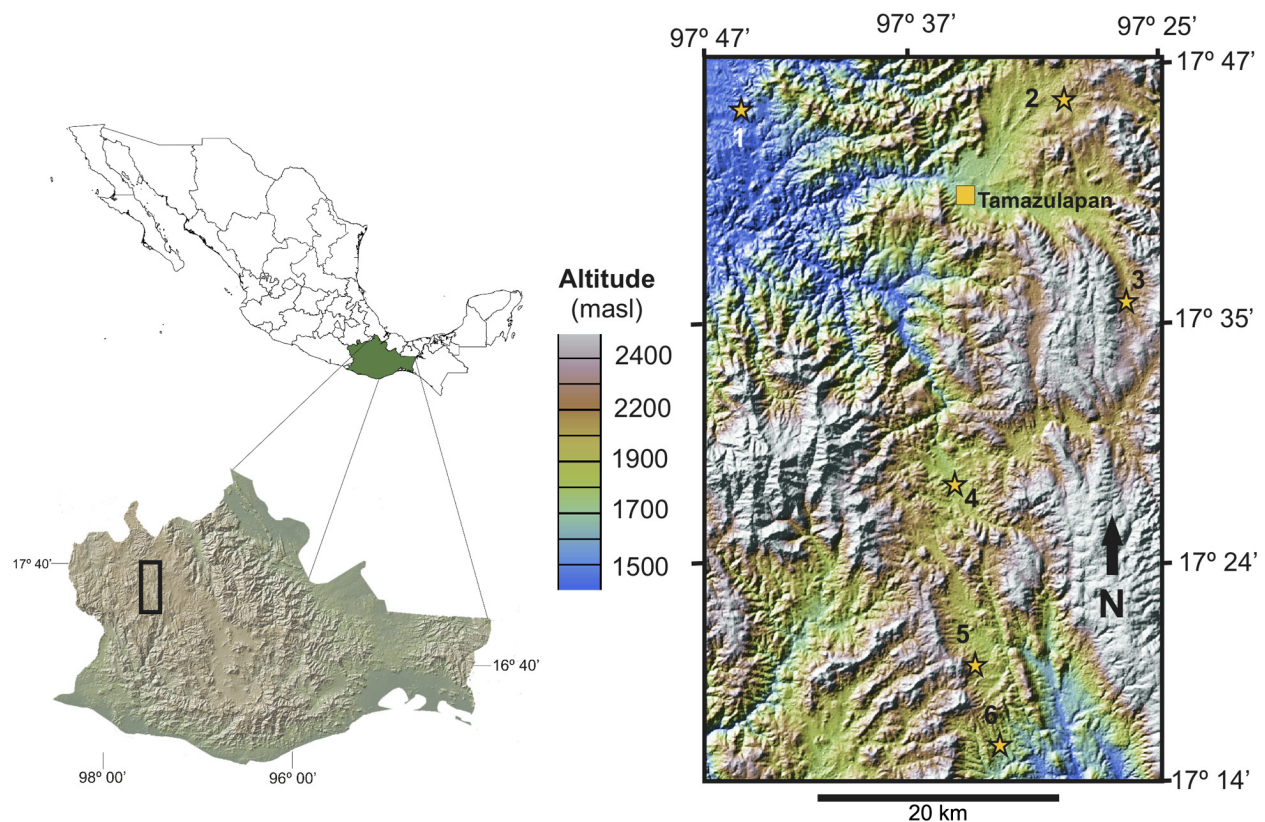


Figure 1. Left: Index map of Mexico showing the research area in northwestern Oaxaca. Right: Collecting sites of *Holospira (Bostrichocentrum) goldmani* in Oaxaca, southern Mexico. For details of the sites, see Table 1.

lamellae in the columella (Fig. 2D).

Dr Alfonso Correa-Sandoval, from Instituto Tecnológico de Ciudad Victoria, México, confirmed our identification. Furthermore, morphological features of the present shells compared favorably with the syntype of *H. goldmani* (USNM 187793, Smithsonian Institution National Museum of Natural History, Washington, DC, USA) (Fig. 3).

Some species of *Holospira* are morphologically similar to *H. goldmani* and mainly differ in internal conchological features. Shells of *H. goldmani* can be very similar to *H. oaxacana* Bartsch, 1906, but the latter is characterized by an internal tetra-lamellate barrier, which

is mainly confined to the last half of the penultimate whorl (Bartsch 1906, Thompson and Mihalcik 2005). *Holospira goldmani* lacks the internal barrier and only bears a columellar lamella in the penultimate whorl (Fig. 2D). Besides morphological distinctions, *H. oaxacana* is known only from the type locality, Tomellín (Bartsch 1906), a town situated 52 miles to the east of the northernmost locality of *H. goldmani* reported herein. Another morphologically similar species is *H. hyperia* Bartsch, 1926, known only from its juvenile type specimen collected in Puebla state (Thompson and Mihalcik 2005). *Holospira hyperia* differs from *H. goldmani* by its tri-lamellate internal structure (Thompson and Mihalcik 2005).

Table 1. Collecting sites of *Holospira (Bostrichocentrum) goldmani* from Mixteca regions in Oaxaca.

Site	District	Locality	Vegetation type	Latitude (N)	Longitude (W)	Altitude (m)	Mixteca zone	UMCMR cat. no.	Quantity	Date
1	Huajuapán	Road to Tezoatlán de Segura y Luna	Secondary vegetation, thorn-scrub forest	17°74.02'	097°75.11'	1652	Baja	0111	25 adults	2 June 2016
2	Teposcolula	San Antonio Acutla	Xeric scrub, secondary vegetation, <i>Cupressus</i> and <i>Pinus</i> plantings	17°74.89'	097°49.13'	2169	Alta	0075	35 adults 4 juveniles	5 Dec. 2015
3	Teposcolula	Morelos	Secondary vegetation	17°59.21'	097°44.13'	2251	Alta	0109	14 adults 1 juvenile	6 Dec. 2015
4	Teposcolula	Santiago Yolomécatl	Open areas with secondary vegetation, introduced conifer plantings and secondary vegetation	17°45.11'	097°57.51'	2081	Alta	0066-A	25 adults 1 juvenile	9 June 2015
5	Tlaxiaco	Cuauhtémoc Tayata	Secondary vegetation, <i>Pinus</i> forest	17°31.51'	097°55.79'	2122	Alta	0069-A	25 adults 4 juveniles	9 Aug. 2015
6	Tlaxiaco	Ignacio Zaragoza, Magdalena Peñasco	Open areas with grasses	17°25.02'	097°53.82'	1989	Alta	0112	25 adults	5 June 2016

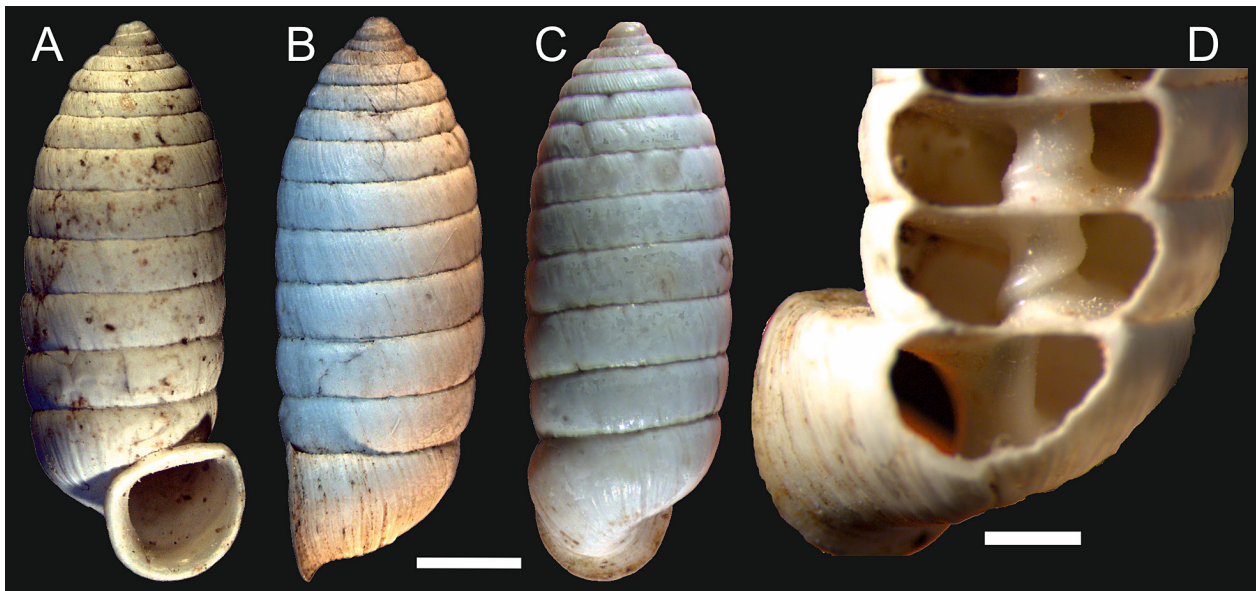


Figure 2. *Holospira (Bostrichocentrum) goldmani*. **A–C.** External morphology of a shell collected at San Antonio Acutla. **D.** Internal view of the columella. Scale bars = 3 mm.

Another holospirine species occurring in the vicinities of the presently reported localities is *Holospira redheri* Bartsch, 1947, collected on a limestone hill in Teposcolula (Thompson and Mihalcik 2005) near Sites 3 and 4. However, the shell of *H. redheri* is readily distinguishable, being sculptured with well-developed and slightly oblique ribs (Thompson and Mihalcik 2005).

Discussion

Previous records of *H. goldmani*—even the type locality—cannot be precisely located today due to the ambiguity of their geographic records. Today, Tamazulapan and Huajuapán de León are cities in constant expansion. For instance “Calvary Church”, a reference mentioned in one of the earlier records, is now located in the middle of the city.

All records reported prior to our research belong to

the Mixteca Baja area. From our results, 5 of the new records are located in the Mixteca Alta area (Sites 2–6), and only 1 in Mixteca Baja area (Site 1).

The southern range limit of *H. goldmani*, Magdalena Peñasco (Site 6), is around 45 km to the south of Tamazulapan (the type locality of the species). Tezoatlán is located about 8 km to the northwest, and Acutla approximately 9 km northeast of Tamazulapan (Fig. 1). These localities range in altitude from 1652 m (Site 1) to 2169 m (Site 2) above sea level, which indicates that *H. goldmani* can exist in different microclimates. Climate in Site 1 is referred to as tropical dry, while Site 2 has a mild desert climate (Instituto Nacional de Estadística y Geografía 2017). With the new records, the distribution of this species has been expanded from hot and semiarid zones, to more temperate and cool areas.

Almost all the localities have secondary vegetation because the Mixteca region has suffered several ecologi-



Figure 3. Syntype of *H. goldmani* (USNM 187793). Photograph courtesy of the Smithsonian Institution National Museum of Natural History.

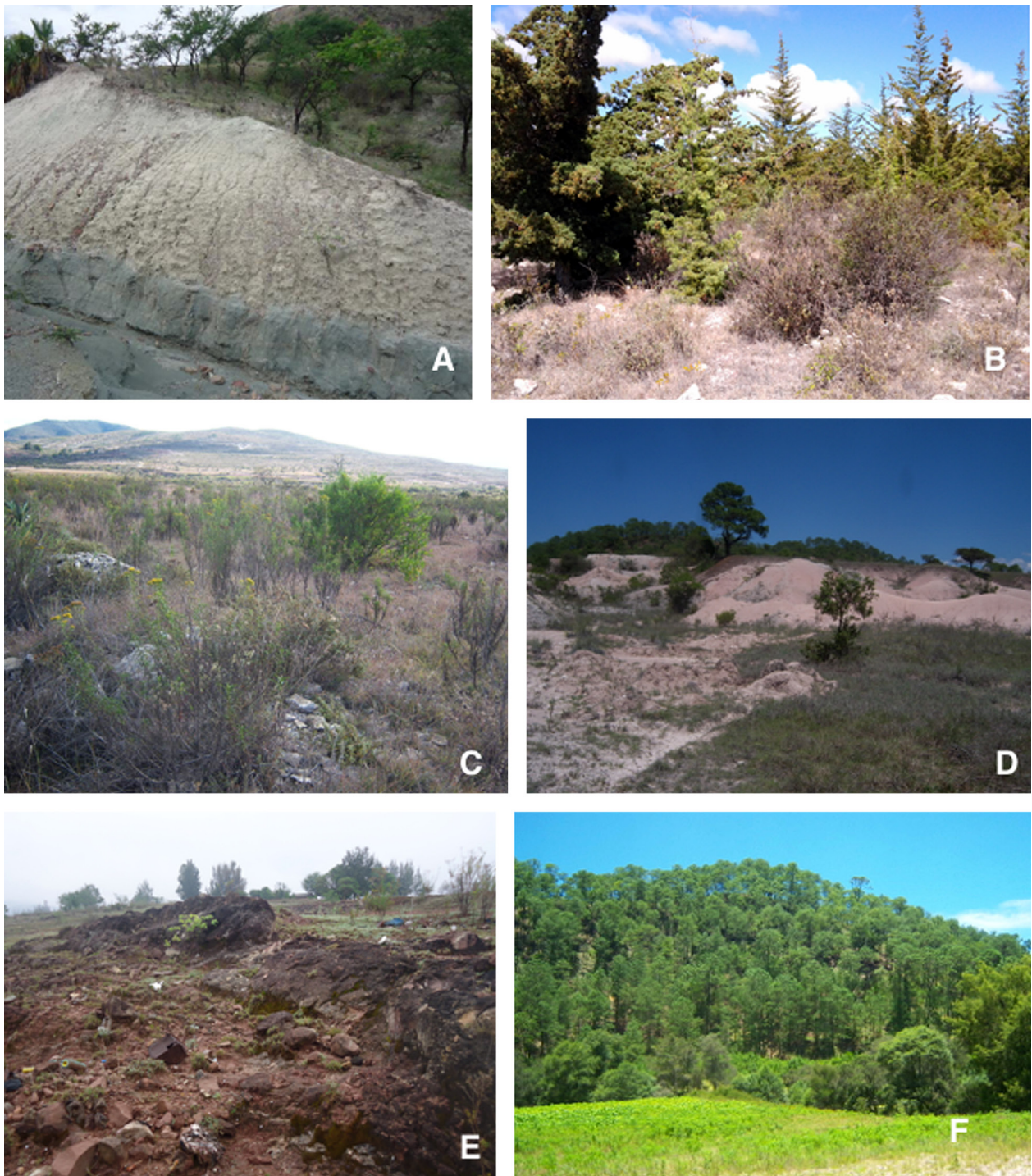


Figure 4. Panoramic views of the 6 sites of *Holospira (Bostrichocentrum) goldmani*. **A.** Exposures of volcanic rocks on the road to Tezoatlán de Segura y Luna (Site 1). **B.** Introduced conifer plantations at San Antonio Acutla (Site 2). **C.** Xeric forest at San Antonio Acutla (Site 3). **D.** Secondary vegetation at ravines in Santiago Yolomécatl (Site 4). **E.** Open areas with grasses in Ignacio Zaragoza, Magdalena Peñasco (Site 6). **F.** Pine forest in Cuahtémoc Tayata (Site 5).

cal disturbances since the 16th century (Guerrero-Arenas et al. 2010), and the original vegetation was wiped out in many areas. There is no evidence that *H. goldmani* has been introduced to plantations of conifers by anthropogenic processes, but further studies are necessary to understand the dispersion processes of this species.

Information about ecological preferences of holospirine snails is practically unknown. Thompson and Mihalcik (2005) noted that precise ecological parameters limit the immediate deployment of colonies, mention-

ing that holospirines are restricted in their distribution because of their confinement to calcareous terrain. Five of our six sites have calcareous sediments, mainly due to Mesozoic limestone formations in the area. However, soils present in the proximities of Tezoatlán de Segura y Luna (Site 1; Figure 4A) are not calcareous, but derived from volcanic tuffs. These findings suggest that *H. goldmani* can survive in non-calcareous soils.

Holospira goldmani was found in several types of vegetation: xeric scrub (Site 2), open areas with secondary

vegetation (Sites 1–5; Fig. 4A, D), introduced conifer plantations (Site 4; Fig. 4C), native pine forests (Site 5; Fig. 4), and open grassland areas (Site 6; Fig. 4F). Apparently, the survival of this species is not bound to any specific vegetation type. The new records presented herein, related to soil type and vegetation, suggest that *H. goldmani* may be a more generalist species than previously believed.

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Authors' Contributions

All of the authors collected the data and wrote the text. RGA and EJH conducted the analysis.

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