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New genus, two new species and new records of subterranean freshwater snails (Caenogastropoda; Cochliopidae and Lithoglyphidae) from Coahuila and Durango, Northern Mexico

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Abstract

This paper describes a new genus, two new species and new records of subterranean gastropods from the Sabinas and Álamos River, Coahuila, and the Nazas River, Durango, in northern Mexico. *Phreatomascogos gregoi* **gen. n. et sp. n.** from Don Martín Basin, Coahuila, is described based on shells and opercula that show some morphological similarities with shells of *Phreatodrobia* Hershler & Longley, 1986 (Lithoglyphidae), which is a subterranean genus from neighboring area in Texas, United States. Conchologically, the new genus can be distinguished from *Phreatodrobia* and all other subterranean genera by a unique combination of characteristic shell morphology and opercula apomorphies. *Balconorbis sabinasense* **sp. n.** (Cochliopidae) is the second species of this genus, which was previously known only from caves and associated subterranean habitats in Texas. The new record of *Coahuilix parrasense*, Czaja, Estrada-Rodríguez, Romero-Méndez, Ávila-Rodríguez, Meza-Sánchez & Covich, 2017 (Cochliopidae) from Durango and

Coahuila is the first record of extant member of this genus out of its hitherto known habitat in the Cuatro Ciénegas basin, Coahuila. These records are remarkable because *C. parrasense* had been described recently as a fossil species. Shell morphologies of the new subterranean snails could be interpreted as possible evolutional adaptations to different hydrodynamic and other specific conditions in their habitat.

Keywords
Gastropods, phreatic, North America, systematics, interstitial habitat, shell adaptations

Introduction

Compared to worldwide biodiversity hotspots as the Balkans (Sket, 2012), the North American subterranean snail fauna is not very rich in known species, including only 39 species of 17 genera (Hershler and Longley 1990; Czaja et al. 2017a; Grego et al. 2019). Seven of these genera occur in Mexico: *Paludiscala* Taylor, 1966, *Phreatoceras* Hershler & Longley, 1987, *Coahuilix* Taylor, 1966, in Cuatro Ciénegas Valley, Coahuila, *Emmericiella* Pilsbry, 1909, *Pterides* Pilsbry, 1909 in the state of San Luis Potosí, *Pyrgophorus* Ancey, 1888 and the recently described genus *Mexicenotica* Grego, Angyal and Liévano-Beltrán, 2019 in Yucatán. The first two genera and *Mexicenotica* are monotypic, *Coahuilix* and *Emmericiella* have two, *Pterides* has three and *Pyrgophorus* has one extant subterranean species. Almost all of them are stygobiont (obligate subterranean) and only a few forms are stygophiles and they also occur in epigean habitats (surface-dwelling species). Very little is known regarding fossil subterranean snails of North America. From Mexico, so far only five species of the genera *Coahuilix*, *Paludiscala* and *Phreatoceras* have been reported from Coahuila (Czaja et al. 2014a, 2017a).

The aim of the present study is to describe the new subterranean snails from Coahuila and Durango, compare similarities and differences to their known relatives from Cuatro Ciénegas and Texas and to briefly discuss their shell adaptations. Like many of the worldwide subterranean snails, also the present new *Balconorbis* species was described based exclusively on shell morphology, in the case of *Phreatomascogos* gen. n., on shell and operculum morphology. Therefore, especially the family assignation of the new genus is tentative until living specimens will be obtained for anatomical and molecular studies. The present investigations form part of a broader study of fossil and extant land and freshwater molluscs from North Mexico, which began in 2013 and includes research on systematics, ecology and evolution (Czaja et al. 2014a, 2014b; Czaja and Estrada-Rodríguez 2015; Czaja et al. 2015, 2017a, 2017b, 2017c).

Material and methods

The studied subterranean snails were collected during July and November 2018 in nine sites along the Sabinas/Álamos River, Don Martín Basin, Coahuila and in one site on the Nazas River, northeastern Durango, Mexico (Fig. 1, Table 1). Fine sand and gravel

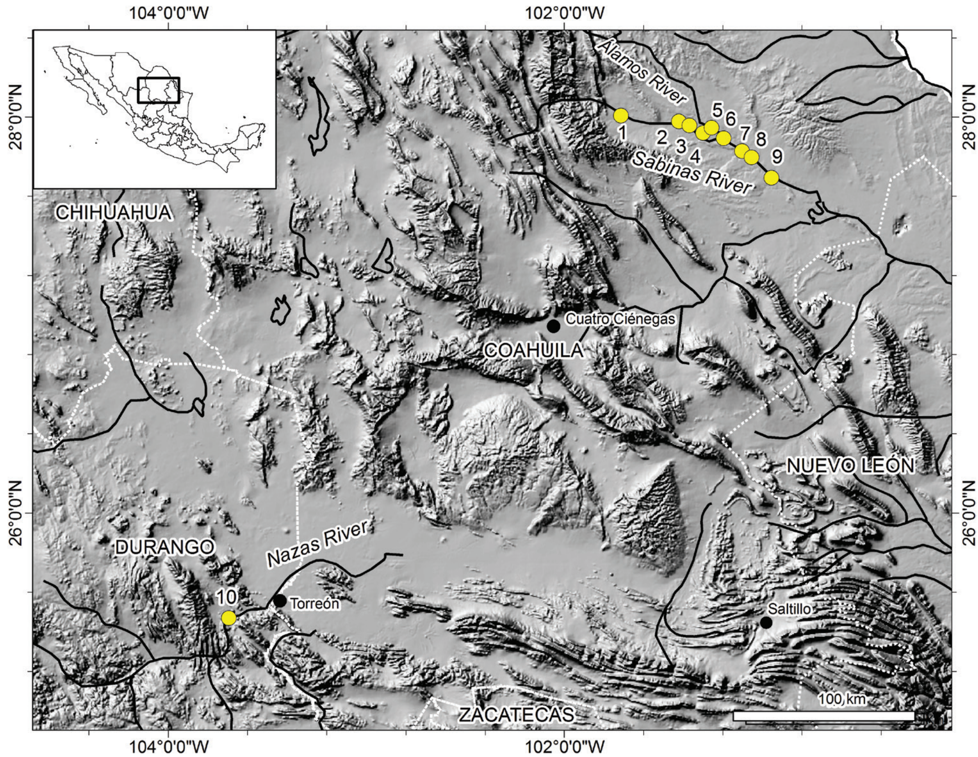


Figure 1. Map of the study area with localization of the sampling sites along the Álamos and Sabinas River in Coahuila and Nazas River in Durango. Sampling sites as in Table 1.

sediment samples of 1.5 kg each were taken from river shores on sites of both localities which were posteriorly screened through two sieves with a mesh size of 0.5 mm and 0.3 mm. Some specimens (especially their apertures) were cleaned of sediments using hydrogen peroxide. For the morphological analysis the shells and opercula were photographed and measured with a Zeiss AxioCamERc 5s camera attached to a Zeiss Stemi 2000-C microscope. Some specimens, especially their protoconchs, were examined in the C.I.D.T. Laboratory of the Peñoles Company in Torreon, Coahuila, using a high performance TESCAN MIRA3 scanning electron microscope (SEM).

We used following shell morphometric dataset (excluding ratios): total number of whorls, shell height, shell width, aperture height, and aperture width. The mean, standard deviation and sample size are given in text (shell measurements). Shell whorls were counted according to the method of Pilsbry (1939).

The studied material is deposited at the Malacological Collection of the Faculty of Biological Science of the Juarez State University of Durango and at the National Collection of Molluscs, National Autonomous University of Mexico (CNMO).

Abbreviations used: **WN**, total number of whorls; **SH**, shell height; **SW**, shell width; **AH**, aperture height; **AW**, aperture width; **HBW**, height of body whorl; **UJMC** = University Juárez Malacological Collection.

Table 1. Sampling localities with geographical coordinates, altitudes and occurrences of *Phreatomascogos gregoi* gen. n. et sp. n., *Balconorbis sabinasense* sp. n. and *Coahuilix parrasense* Czaja, Estrada-Rodríguez, Romero-Méndez, Ávila-Rodríguez, Meza-Sánchez & Covich, 2017 in the study area.

Locality	*P. gregoi*	*C. sabinasense*	*C. parrasense*	Coordinates	
1. Sabinas River, Ejido Nacimiento de los Mascogos II	X			101°42'46''W	28°00'25''N
2. Sabinas River, Ejido Santa María	X	X		101°25'16''W	27°58'37''N
3. Sabinas River, Ejido Sauceda del Naranjo	X			101°22'04''W	27°57'24''N
4. Sabinas River, Ejido San Juan de Sabinas				101°17'54''W	27°55'06''N
5. Álamos River, Ejido Paso del Coyote	X	X		101°15'19''W	27°56'45''N
6. Sabinas River, Las Adjuntas (Rancho San Carlos)	X	X		101°11'41''W	27°53'33''N
7. Sabinas River, Sabinas (Agua Prieta)	X	X		101°06'06''W	27°49'38''N
8. Sabinas River, Las Cazuelas				101°03'14''W	24°47'42''N
9. Sabinas River, La Vega	X	X		100°57'10''W	27°41'35''N
10. Nazas River, Los Cuates (Durango)			X	103°42'13''W	25°27'56''N

Systematics

Superfamily Truncatelloidea Gray, 1840
Family Lithoglyphidae? Tryon, 1866

Genus *Phreatomascogos* Czaja & Estrada-Rodríguez, gen. n.
http://zoobank.org/9A21F18D-6903-4835-B473-35FC7BDA3C1A

Type species: *Phreatomascogos gregoi* sp. n. by present designation.

Diagnosis. Shell small, valvatiform to low trochoid; transparent to whitish; teleoconch with one or two prominent, sometimes almost winged keels; umbilicus almost completely covered (bordered) by a basal keel-like structure; operculum near circular, paucispiral, strongly campanulate.

Differential diagnosis. The characteristic combination of mentioned three shell features (bordered umbilicus, prominent keels and strong campanulate operculum) separate the new genus clearly from shells of all other subterranean genera. Similar in size and general form are only shells of some members of *Phreatodrobia* Hershler and Longley from Texas, a genus which includes exclusively subterranean species. Nevertheless, none species of this genus possess keeled shells with a bordered umbilicus, smooth protoconch and such trochoid elevated opercula. The monotypic, recently erected (based on shell morphology) genus *Novalis* Quiñonero-Salgado & Rolán, 2017 (Hydrobiidae) from Spain resembles in some details the material from Coahuila (Quiñonero-Salgado and Rolán 2017). However, beside of the great geographic disjunction, shells of this European species are not keeled and have a different basal structure which do not cover the umbilicus.

Etymology. The genus name derives from the word *phreatos* (referring to the subterranean habitat) and from *Mascogos*, an afrodescendant ethnic group of Coahuila which escaped the threat of slavery in the United States and lives since 1852 in the Sabinas/Álamos River area.

Phreatomascogos gregoi **Czaja & Estrada-Rodríguez, sp. n.**
http://zoobank.org/78A129EE-EA6F-4CEF-B44F-204405955CE5
Figures 2–11

Type locality. MEXICO, Coahuila state, Don Martín Basin, Álamos River, Ejido Paso del Coyote (101°15'19"W, 27°56'45"N, 369 m a.s.l.) (Fig. 1).

Types. Holotype (Figs 2, 3), UJMC 400, from type locality, leg. Y. A. Sanchez-Montañez, 11/vii/2018. Paratypes, UJMC 401, CNMO 7900, from same lot, 16 dry shells.

Etymology. Named after Dr. Jozef Grego, a well renowned Slovakian malacologist and specialist of subterranean snails.

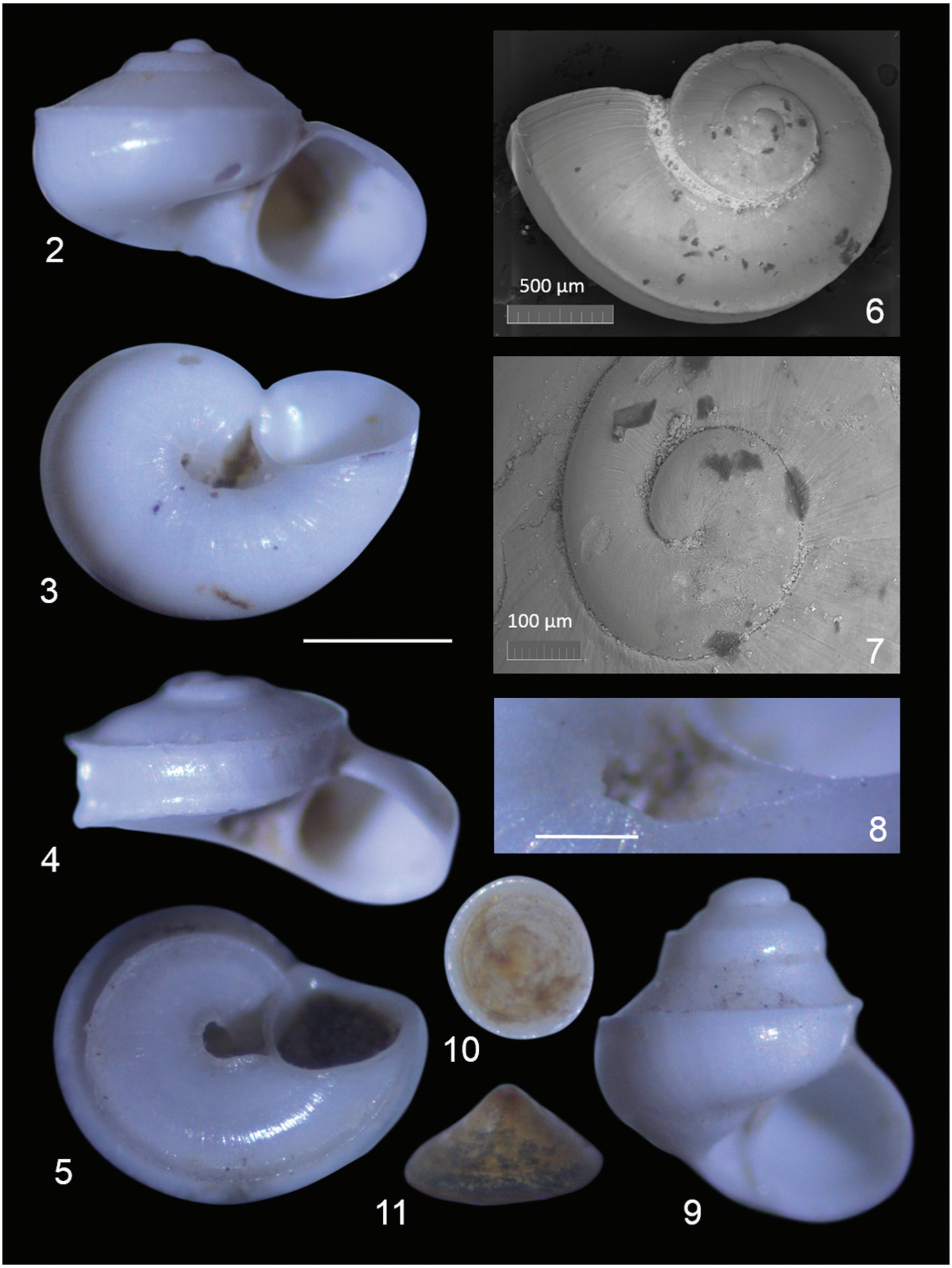
Referred material. COAHUILA. Don Martín Basin, Sabinas/Álamos River, UJMC 402, Ejido Nacimiento de los Mascogos II, Y. A. Sanchez-Montañez, 03/vii/2018. UJMC 403, Ejido Santa María, Y. A. Sanchez-Montañez, 03/vii/2018. UJMC 404, Ejido Sauceda del Naranjo, Y. A. Sanchez-Montañez, 08/vii/2018. UJMC 405, Las Adjuntas (Rancho San Carlos), Y. A. Sanchez-Montañez, 08/vii/2018. UJMC 406, Sabinas (Agua Prieta), Y. A. Sanchez-Montañez, 08/vii/2018. UJMC 407, La Vega, Y. A. Sanchez-Montañez, 08/vii/2018.

Diagnosis. The colorless, translucent to whitish shells are very small, valvatiform to low trochoid, umbilicate, with 3¾ or fewer rounded whorls; aperture near-circular, adnate to the bodywhorl; operculum paucispiral, strongly campanulate; teleoconch with bodywhorl which frequently has one or two, in some specimens winged, keels; umbilicus almost completely covered by a basal keel-like structure.

Description. Shell small, valvatiform, varying in shape from (mostly) flat-trochoid to (rarely) low conical, height 0.65–0.99 mm (1 trochoid shell of 1.42 mm considerably higher, Fig. 9), width 1.22–1.54 mm; umbilicus almost completely covered by a basal keel of the bodywhorl (Fig. 8); protoconch smooth (Fig. 7); teleoconch with 3¼ or fewer rounded whorls with less prominent axial growth lines (Fig. 6), the border between protoconch and teleoconch approximately after 1.5 whorls, not well distinct (Fig. 7); teleoconch whorls occasionally nearly smooth, frequently with one or two, in some specimens winged, spiral keels (carinae) on the last two whorls, keels on the central and basal part of the bodywhorl, central keel usually more prominent (Figs 2, 4, 5), whorls strongly convex with deep sutures; the aperture is ovate and in almost all specimens angled adapically (Figs 2, 4), inclined 20–30° to the coiling axis; peristome thin, inner lip partly fused to the penultimate whorl; operculum (from five shells obtained by shell cleaning) extremely thin, 0.48–0.51 mm in diameter, near-circular, campanulate (Fig. 11), placed deeply behind the aperture, strongly, light amber colored, paucispiral with sub-central nucleus, nuclear region darker, with 2.5 whorls (Fig. 10).

Shell measurements (mean ± standard deviation in parentheses; n = 16): SH 0.84 (0.09) mm, SW 1.36 (0.08) mm, AH 0.57 (0.07) mm, AW 0.55 (0.06) mm, WN 3.05 (0.19) whorls; HBW 0.72 (0.10) mm. Paratypes from the type locality.

Measurements of Holotype. SH 0.86 mm; SW 1.38 mm; AH 0.52 mm; AW 0.56 mm, WN 3.00 whorls; HBW 0.73 mm.



Figures 2–11. Shells and opercula of *Phreatomascogos gregoi* gen. n. et sp. n. **2, 3** holotype, UJMC 400 **4, 5** paratype 1, UJMC 401 **6, 7** paratype 2, UJMC 401a, shell apex with protoconch **8** umbilicus almost completely covered by a basal keel, UJMC 401b **9** paratype 3, UJMC 401d, conical specimen **10, 11** opercula **11** operculum showing the strongly campanulate shape. Scale bars: 0.5 mm (**2–5**, **9–11**); 0.3 mm (**8**).

Habitat. Stygobiotic. Shells of *Phreatomascogos gregoi* n. sp. were collected on the shore of the river in sandy and clayed sediments with many gravels on the bottom. We suppose, the new species likely inhabits the interstitial waters within the water saturated underground gravel layer of the hyporheic zone (see below). Although the habitat of *Phreatomascogos* lays within one of the eight federal protected zones APRN (=Mexican Protected Natural Resource Areas), their habitat may be threatened (especially the sites Ejido Sauceda del Naranjo and Ejido San Juan de Sabinas) by local coal mining and agriculture.

Distribution. *Phreatomascogos gregoi* sp. n. lives likely sympatrically with *B. sabinasensis* sp. n. (see below) in same subterranean, interstitial habitat. The species appears to be endemic to the Sabinas/Álamos River, Don Martín Basin, between the upper basin and *Venustiano Carranza* dam.

Remarks. The typical strong keels, the almost completely covered umbilicus structure and the strongly campanulate operculum are the most evident characteristics which differentiated the shell morphology of *Phreatomascogos gregoi* sp. n. from the shells of all other described subterranean gastropods. A North American subterranean species conchologically most closely related to our material is *Phreatodrobia nugax* Hershler & Longley, 1986 from South-Central Texas. This species shows similarities in size and general shell shape and in some details of the operculum structure (low conical shape). Nevertheless, they clearly differ by lack of the three mentioned shell features of *Phreatomascogos gregoi* sp. n. We considered especially the extreme campanulate operculum and the covered umbilicus of *Phreatomascogos gregoi* sp. n. as important apomorphic features that justify the erection of a new genus most likely within the Lithoglyphinae family. The mentioned conchological similarities between both *Phreatomascogos* from Coahuila and *Phreatodrobia* from Texas is the main reason of assigning the new genus to the family Lithoglyphinae (and not to the Cochliopidae). However, the resemblance in the shell shape could be also result of an evolutional convergence. There should be also considered the below mentioned biogeographic considerations which indicate a phyletic affinity of both genera gathering within the same family. The Edwards-Trinity-Aquifer region, that hosts all eight *Phreatodrobia* species, is a transboundary aquifer Zone which shares the water resources of the states of Texas and Coahuila. The Sabinas River karst region, where *Phreatomascogos gregoi* sp. n. occurs, belong to this zone and is hydrogeologically the southwestern extension of this huge aquifer (Boghici 2004; Sanchez et al. 2018). Biogeographically, both regions in Texas and Coahuila form a unit (province) where many subterranean forms radiated from a common epigean (?) ancestor (see also Hershler and Holsinger 1990). However, anatomic and molecular genetic data are needed to prove the hypothetical close relationship between both Lithoglyphidae genera.

Family Cochliopidae Tryon, 1866

Genus *Balconorbis* Hershler & Longley, 1986

Type species. *Balconorbis uvaldensis* Hershler & Longley, 1986

Balconorbis sabinasense **Czaja, Cardoza-Martínez & Estrada-Rodríguez, sp. n.**
http://zoobank.org/BAEA864F-38F1-4251-854E-D6AAD57D1B86
Figures 12–18

Type locality. MEXICO, Coahuila state, Don Martín Basin, Sabinas River, Las Adjuntas (Rancho San Carlos): 101°11'41"W, 27°53'33"N, 354 m a.s.l. (Fig. 1).

Type material. Holotype (Figs 12–14), UJMC 410, from type locality, leg. Cecilio Arreola Chapa, 30/xi/2018. Paratypes, UJMC 411, CNMO 7901, from the same lot, 11 specimens.

Etymology. Derived from the name of Sabinas River, Coahuila, where the type locality is situated.

Referred material. COAHUILA. Don Martín Basin, Sabinas River, UJMC 412, Ejido Santa María, Y. A. Sanchez-Montañez, 03/vii/2018. UJMC 413, Ejido Paso del Coyote, Cecilio Arreola Chapa, 30/xi/2018. UJMC 414, Sabinas (Agua Prieta), Y. A. Sanchez-Montañez, 08/vii/2018. UJMC 415, La Vega, Y. A. Sanchez-Montañez, 08/vii/2018.

Diagnosis. Shell minute, less than 2 mm in diameter (width), planispiral, apertural plane not or only slightly inclined, with 3¾ or less whorls, bodywhorl keeled, with spiral lines and axial growth lines, protoconch smooth.

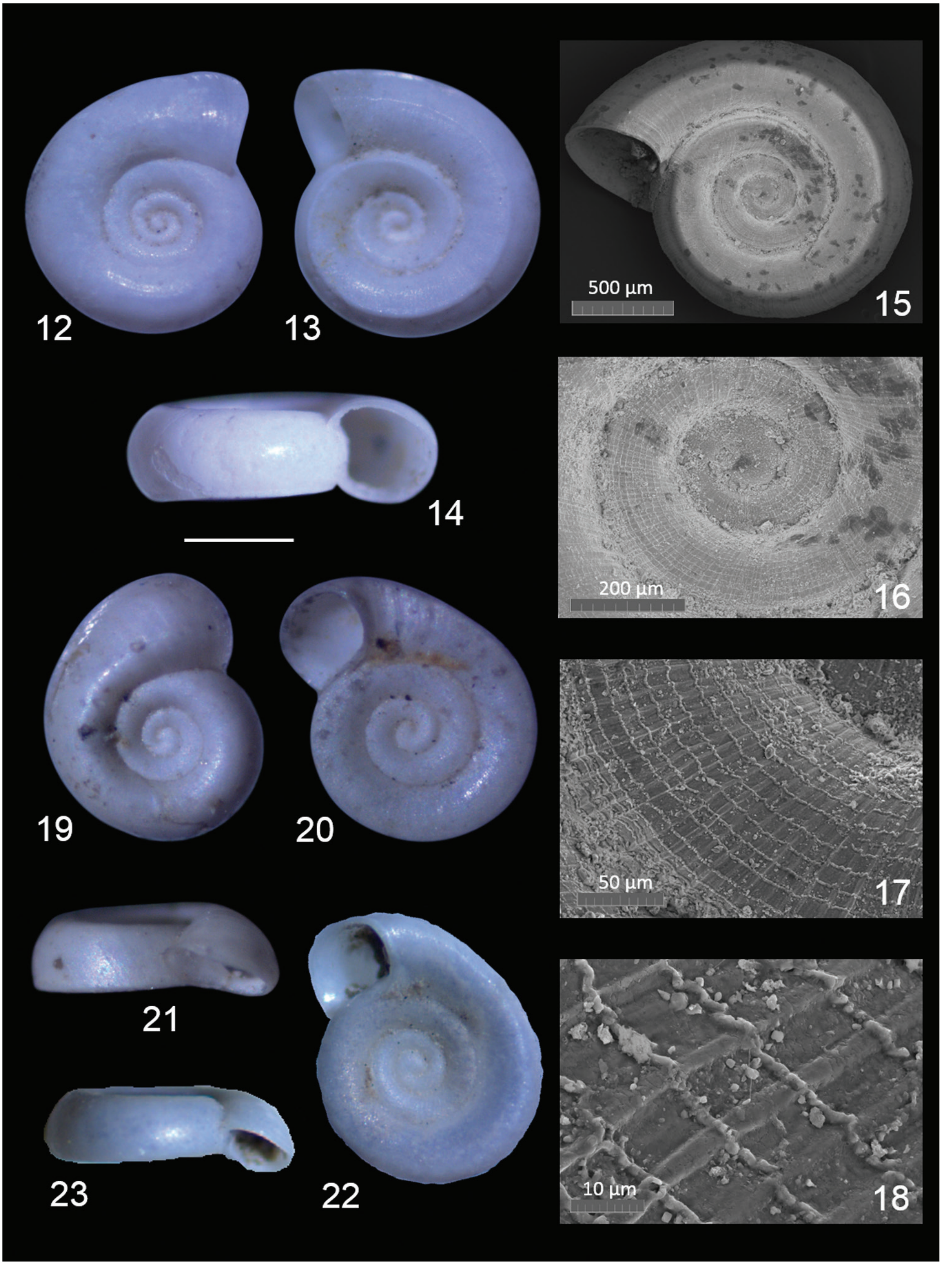
Differential diagnosis. According to Hershler and Longley (1986), the characteristic spiral structure (Figs 16–18) of the shells distinguish the genus *Balconorbis* clearly from other subterranean littoridinines. Shells of the new species differs from *B. uvaldensis* by larger shells (1.51–1.81 mm by *B. sabinasense* sp. n. versus 0.90–1.22 mm by *B. uvaldensis*) with weaker suture, more whorls, smooth to slightly pitted protoconch without spiral lines, and characteristic keels on the bodywhorl. Similar planispiral shells of the genus *Phreatodrobia* (*P. micra* Hershler & Longley, 1986, *P. plana* Hershler & Longley, 1986 and *P. rotunda* Hershler & Longley, 1986) are considerable smaller, lack the keels on the bodywhorl and do not have the characteristic regularly-spaced spiral lines and axial growth lines.

Description. Shell minute, planispiral, width 1.51–1.81 mm, height 0.42–0.61 mm, with 3¼–3¾ whorls; protoconch smooth to slightly pitted (Fig. 16), hidden in ventral view, has 1¼ whorls, first teleoconch whorl with strong and elevated axial growth lines which cross the spiral lines producing a square pattern (Figs 17, 18), about 80 elevated spiral lines are present on the bodywhorl, bodywhorl with one or two keels, one keel usually stronger; aperture rounded to ovate, apertural plane only slightly inclined from the columellar axis (Fig. 13); inner peristome is fused to the penultimate whorl, outer lip strong and advanced relative to the remaining peristome; shells transparent or whitish.

Shell measurements (mean ± standard deviation in parentheses; n = 11): SH 0.53 (0.07) mm, SW 1.68 (0.10) mm, AH 0.59 (0.05) mm, AW 0.49 (0.08) mm, WN 3.5 (0.19), aperture plane inclination relative to shell axis = 22°–31°. Paratypes from the type locality.

Measurements of holotype. SH 0.55 mm, SW 1.58 mm, AH 0.59 mm, AW 0.58 mm, HBW 0.50 mm, WN 3½, aperture plane inclination relative to shell axis = 25°.

Habitat. Similar to *Phreatomascogos gregoi* sp. n.



Figures 12–23. Shells of *Balconorbis sabinasense* sp. n. and *Coahuilix parrasense* Czaja, Estrada-Rodríguez, Romero-Méndez, Ávila-Rodríguez, Meza-Sánchez & Covich, 2017. **12–14** *B. sabinasense* n. sp., holotype, UJMC 410. **15–18** Paratype 1, UJMC 411. **19–21** *C. parrasense*, UJMC 418, from Nazas River, Durango. **22, 23** *C. parrasense*, fossil specimen from Parras de la Fuente, Coahuila, holotype, UJMC-320, from Czaja et al. 2017c, Fig. 4A, C. Scale bar: 0.5 mm (**12–14**, **19–23**).

Distribution. Known from the type locality and various sites among the Sabinas River between the localities Ejido Santa María and La Vega. Within the type locality and most other sites the new species occurs sympatrically to *Phreatomascogos gregoi* sp. n.

Remarks. Almost all the members of Cochliopidae family with planispiral shells are subterranean forms. Freshwater gastropods with similar shell characteristics can be found only in the genus *Balconorbis* which is monotypic with *B. uvaldensis* in the Edwards (Balcones Fault Zone) Aquifer in Uvalde County, Texas, United State. Our new species resembles *B. uvaldensis* but differs from this by having larger shells, smooth protoconch, one more whorl and a bodywhorl with one or two more or less strong keels and by much closer, compressed set of the whorls resulting in weaker suture and larger columellar peristome. The later feature is unique in the genus *Balconorbis* and could indicate the possible position of the new species in a new geographically isolated genus. These conchological differences confirm that the new species is morphologically diagnosable and distinct to shells of the snails from Texas. It is the first record of the genus *Balconorbis* in Mexico.

***Coahuilix* cf. *parrasense* Czaja, Estrada-Rodríguez, Romero-Méndez, Ávila-Rodríguez, Meza-Sánchez & Covich, 2017**

Figures 19–21

Material. COAHUILA, Don Martín Basin, Sabinas River, Las Adjuntas (Rancho San Carlos), UJMC 416, 417: 101°11'41"W, 27°53'33"N, 354 m a.s.l., 2 shells. DURANGO, Leon Guzmán District, Nazas River, 1 km E of the Bridge *Los Cuates,* UJMC 418, 103°42'13"W, 25°27'56"N, 1.158 m a.s.l., 1 shell (Figs 19–21).

Description. See Czaja et al. 2017a: 230.

Shell measurements. Shell 1 from Coahuila (UJMC 416): SH 0.39 mm, SW 1.44 mm, AH 0.52 mm, AW 0.36 mm, aperture plane inclination relative to shell axis = 58°. Shell 2 from Coahuila (UJMC 417): SH 0.41 mm, SW 1.43 mm, AH 0.46 mm, AW 0.38 mm, aperture plane inclination relative to shell axis = 63°. Shell from Durango (UJMC 418): SH 0.31 mm, SW 1.21 mm, AH 0.45 mm, AW 0.32 mm, aperture plane inclination relative to shell axis = 64°.

Remarks. The three empty shells from Coahuila and Durango resembles in all details the shells of *C. parrasense*, a sub-fossil species described recently from a dried-up stream (arroyo) near the town Molino, Parras de la Fuente, Coahuila by Czaja et al. (2017a) (Figs 22, 23). The only difference is the lack of the tooth-like bulges behind the peristome by the present shells so they can be placed only tentatively to this species. The strong inclination of the apertural plane in relation to the axis which reaches almost 60° (Figs 21, 23), is the main difference to the extant *C. landyei* Hershler, 1985 from Cuatro Ciénegas. *Coahuilix parrasense* seems to occur in Sabinas River sympatrically with *B. sabinasense* sp. n.

Discussion

Shell convergences

Because of convergences, the description of hydrobioid snails based only on shell characters can be misleading (see discussion in Hershler and Longley 1986 and Falniowski 2018). However, worldwide most of the extant subterranean snails were (and are) described only from empty shells because in many cases living populations were not accessible or available (Georgiev 2013; Grego et al. 2017; Quiñonero-Salgado and Rolán 2017; Hofman et al. 2018). According to Glöer et al. (2015), even empty shells of many phreatic forms are only occasionally washed out to the surface. Like many others subterranean species, also the genera *Coahuilix*, *Phreatoceras* and *Paludiscala* from Coahuila were first described based on empty shells (Taylor 1966) and it often took more than two decades and intensive searches before living specimens could be found and anatomically described (Hershler 1985). In these three mentioned cases and in many others recent descriptions (e.g., Georgiev and Glöer 2015; Glöer et al. 2015; Grego et al. 2017, Grego 2018; Quiñonero-Salgado and Rolán 2017), shell characteristics (including shell wall structure) were sufficient distinguishable for the generic differentiation, underscoring the usefulness of shells for taxonomic purposes. In the case of the described new genus and species from Coahuila, it was certainly helpful that related forms are still living near the area and their shells (and opercula) could be used for comparative diagnosis.

Shell morphology

Grego et al. (2017) emphasizes that subterranean truncatelloids are often referred as cave-dwellers but they are not restricted only to caves and caves-waters. Some of them occur also in the groundwater saturated zone such as interstitial spaces within the coarser sand and gravel sediments in the hyporheic zone of water streams. Our shells come from such river sediments and we are strongly convinced that *P. gregoi* sp. n., *B. sabinasensis* sp. n., and *C. parrasense* live in such interstitial waters. There are no indications for long transport on the shells and the very thin shells (and opercula) are almost all undamaged. The interstitial and cave habitats are cross-connected via the gravel of the alluvial sediments, and it is also likely the interstitial gastropod species could inhabit cave habitats and many of the recognized cave populations could communicate via existing interstitial habitats. However, some species have already adapted their shell morphology to cave habitats and thus have lost their capability to communicate through the interstitial channels.

These conditions of subterranean (interstitial) habitat might also explains the special morphologic adaptations of the shell. According to the hydrodynamic model of

Grego et al. (2017 and pers. com.), flat shells with strongly inclined apertures could be attached flat to the surface and reduce considerably the frontal hydrodynamic resistance area and could be therefore favored by selection (better resistance to stronger and turbulent water flow). The same applies also to the animal mobility within the (interstitial) sediment cavities, where a more inclined shell aperture position could be advantageous by creating lower resistance in the crevices during the moving. The shape also indicates the habitat in larger interstitial cavities (with cavities several fold larger than the shell dimeter) where the stronger water stream could appear at least periodically. Such extremely inclined aperture shows the stygobiont *C. parrasense* from Sabinas and Nazas River (Figs 19–21), while *C. landyei* and *C. hubbsi* Taylor, 1966 that live in the springs, lack such feature.

Also, the singular covered umbilicus and the general variable form from near planispiral to trochoid of *Phreatomascogos gregoi* sp. n. shells might be explained by the same hydrodynamic model of Grego et al. (2017 and pers. com.). A small, or better, a covered umbilicus surely avoids more efficiently the strong buoyancy forces which act on the shell redirecting the water flow. On the other hand, a large and open umbilicus can be disadvantageous because it regularly traps sand grains and sediment particles and thus makes so the snail locomotion difficult or even impossible. Our material also points to a positive correlation between the general shell form of *P. gregoi* sp. n. and (interstitial) water velocity, according to the mentioned hydrodynamic model. But whether the less conical, valvatiform shells (Figs 2, 4) could occur in sites with relatively higher velocities (and large interstitial cavities and larger gravel granularity) of interstitial water and the more trochoid shells (Fig. 9) in areas of lower flow rates (with smaller interstitial cavities and smaller gravel granosity) will be difficult to prove due to the cryptic subterranean environment conditions. However, the hypothesis must be statistically substantiated and further investigations with systematic collections in river sites of different flow rates and more specimens for statistical analysis could prove (or disprove) this hydrodynamic model for interstitial environments.

Conclusion

The above described new genus and species of subterranean snails from Coahuila and the recently reported findings from Yucatán (Grego et al. 2019) demonstrate that there is a great potential for discovering more stygobiont species in these large unexplored karst regions in Mexico. We hope that our efforts will also provide motivation for other researchers to investigate the diversity of phreatic gastropods in Mexico.

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