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Two new species of the genus *Spiralix* Boeters, 1972 (Gastropoda: Moitessieriidae) from Spain

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Two new species of the genus *Spiralix* are described from the locality of Segorbe (Castelló, Spain), which differ conchiliologically from the other known species in the genus.

Keywords: Gastropoda, Moitessieriidae, Spiralix, stygobiotic, new species

Dues noves espècies del gènere *Spiralix* Boeters, 1972 (Gastropoda: Moitessieriidae) per Espanya

Es descriuen dues noves espècies del gènere *Spiralix* a la localitat de Segorbe (Castelló, Espanya), les quals es diferencien conquiològicament de les altres espècies del gènere conegudes

Mots clau: Gastropoda, Moitessieriidae, Spiralix, estigobi, espècie nova

The family Moitessieriidae Bourguignat, 1863 includes small-sized freshwater gastropods, mainly from stygobiotic habitats. It includes the genus *Spiralix* Boeters, 1972, represented in Spain by 13 known species and subspecies.

In the northeast (Basque Country, Castilla and León, Cantabria and Asturias) seven species of this genus have been described, all currently included in the subgenus *Burgosia* Boeters, 2003 after recent taxonomical revisions: *Spiralix burgensis* Boeters, 2003; S. affinitatis Boeters, 2003; *S. septentrionalis* (Rolán & Ramos, 1995); *S. asturica* Quiñonero-Salgado et al., 2017; *S. clarae* Quiñonero-Salgado et al., 2017; *S. mieraensis* Quiñonero-Salgado et al., 2017; and *S. vetusta* Quiñonero-Salgado et al., 2018 (Rolán & Ramos, 1995; Boeters, 2003; Rolán & Arconada, 2003; Quiñonero-Salgado et al., 2017; 2018; Ruiz Cobo & Vázquez Toro, 2019).

In the Levantine area of Spain, the genus is represented by *Spiralix gloriae* (Rolán & Martínez-Ortí, 2003), *S. valenciana valenciana* Boeters, 2003, *S. valenciana castellonica* Boeters, 2003, *S. pequenoensis* Boeters, 2003, *S. calida* Corbella et al., 2014, and *Spiralix tuba* Quiñonero-Salgado et al., 2019 (Boeters, 2003; Rolán & Martínez-Ortí, 2003; Corbella et al., 2014; Quiñonero-Salgado et al., 2019).

In the present work, two new species of the genus *Spiralix* are described from eastern Spain, which can be differentiated from other congeneric species by a series of conchological characters.

Material and methods

Shells of this new species were collected in sediments from two springs; Manantial de los Gallos and Fuente del Hambre, both in the municipality of Segorbe (Castelló province). After cleaning and drying the sediments, sieves of 2 mm, 1 mm and 0.5 mm mesh size were used for shell sorting. Shells were finally separated under a stereomicroscope for their determination and thereafter cleaned with water with the help of a small brush. Given its strict stygobiotic habitat and the difficulty of access, it was very hard to find living specimens, so only empty shells were considered for this study. Shells were scarce and most of them not perfectly preserved. Localities were visited in December 2008, October 2016 and August 2019. Specimens were photographed with a trinocular stereomicroscope Nexius Zoom NZ 1903-S, with a Euromex CMEX-10PRO camera adapted.

Abbreviations:
MZB: Museu de Ciències Naturals de Barcelona, Spain.
SEM: Scanning Electron Microscopy.
CQS: Collection Quiñonero-Salgado.
s: Shell.

Results

Systematics

Family Moitessieriidae Bourguignat, 1863
Genus *Spiralix* Boeters, 1972
Type species: *Spiralix rayi* (Locard, 1883) by original designation

Spiralix gusii sp. n. (Fig. 1, 2)

Type material: Holotype MZB 2020-0665 (Fig. 2A). Paratypes: 1 s MZB 2020-0666, 19 s in CQS.

Type locality: Manantial de los Gallos, Segorbe (Castelló province, Comunitat Valenciana, Spain) [30SYK156169], 359m. (Fig. 7A).

Etymology: This species is named after Josep Maria Gusi Ribas, former Secretary of Associació Catalana de Malacologia (ACM).

Description: Fragile and translucid shell (when freshly collected), shiny, conical-ovoidal shape, obtuse apex. Height between 1.41-2.12 mm and width 0.82-1.16 mm. 3-41/2 whorls. Deep suture. Last whorl with a straight disposition in the final stretch. Oval shaped

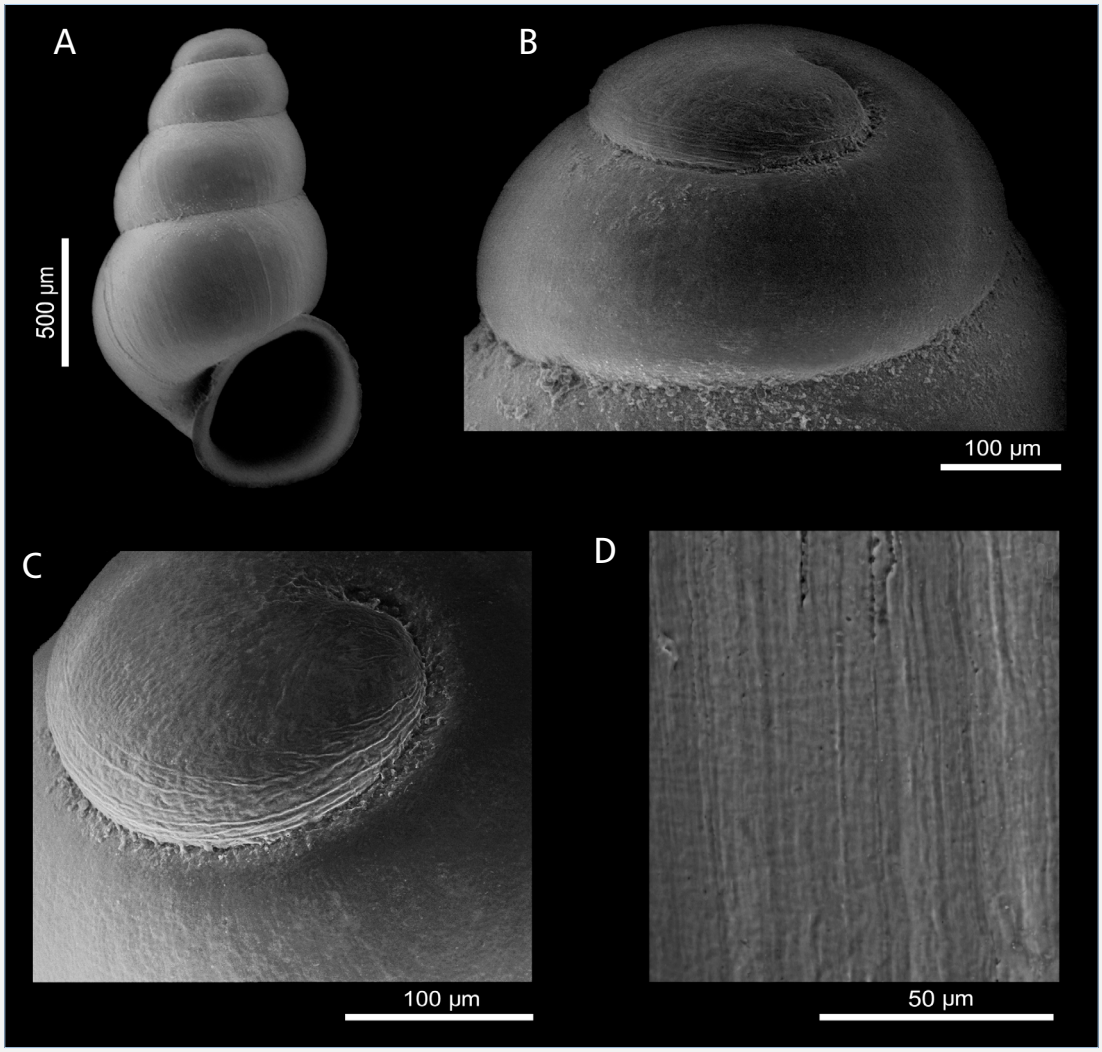

FIGURE 1. SEM photographs of *Spiralix gusii* sp. n. from the type locality. **A**: apertural view; **B**: protoconch; **C**: detail of the protoconch microsculpture; **D**: detail of the teleoconch microsculpture.

Microfotografies de *Spiralix gusii* sp. n. de la localitat tipus. **A**: vista apertural; **B**: protoconquilla; **C**: detall de la microescultura de la protoconquilla; **D**: detall de la microescultura de la teleoconquilla.

aperture, of 0.59-0.82 mm height and 0.54-0.73 mm width. Continuous peristome, a little thickened, everted, reflected towards the columella, and adhered to previous whorl. Narrow umbilicus, partially covered by the columellar edge. Teleoconch smooth, or showing a very faint microsculpture, formed by superficial roughness and occasionally by slightly marked, irregular depressions (Fig. 1D). Protoconch has very faint microsculpture, composed by irregular marks and very fine spiral lines, close to the suture, being more evident in the initial part (Fig. 1 B-C).

Dimensions: See Table 1, Fig. 5.

Habitat: Stygobiotic.

Distribution: Only known from the type locality (Fig. 7A, 8)

Differential diagnosis: It is clearly distinguishable

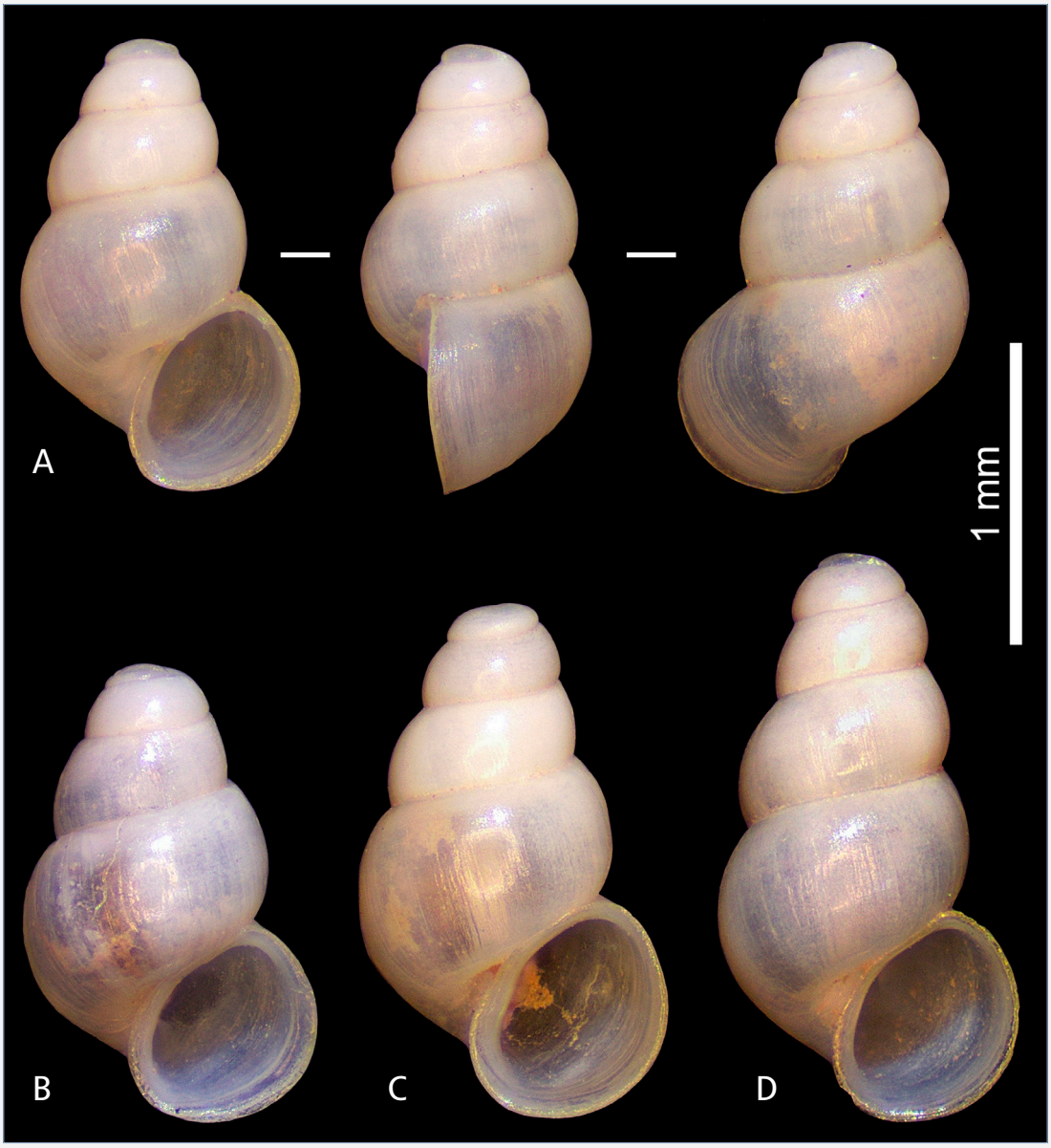

FIGURE 2. Types of *Spiralix gusii* sp. n. **A**: holotype; **B-D**: paratypes.

Exemplars tipus de *Spiralix gusii* sp. n. **A**: holotip; **B-D**: paratips.

from the other species in the genus by these characters:

Spiralix valenciana castellonica has a larger and turriculated shell, with more elevated shape, and wider peristome.

Spiralix tuba has a wider peristome, and a more prominent protoconch microsculpture, formed by multiple rounded or ovoidal depressions, irregularly displayed, showing occasional elevations between them.

Spiralix burgensis has a smaller shell, generally with a separation between last whorl and aperture, and a more marked microsculpture in the protoconch.

Spiralix affinitatis has a smaller shell, ovoidal rather than conical-ovoidal, and may present a small separation between last whorl and aperture, and a slightly more marked microsculpture in the protoconch.

Spiralix cubelli sp. n. (Fig. 3, 4)

Type material: Holotype MZB 2020-0667 (Fig. 4A). Paratypes: 1 s MZB 2020-0668, 12 s in CQS.

Type locality: Manantial de los Gallos, Segorbe (Castelló province, Comunitat Valenciana, Spain) [30SYK156169], 359m. (Fig. 7A).

Other material examined: Fuente del Hambre, Segorbe (Castelló province, Comunitat Valenciana, Spain) [30SYK161146], 306m. (Fig. 7B).

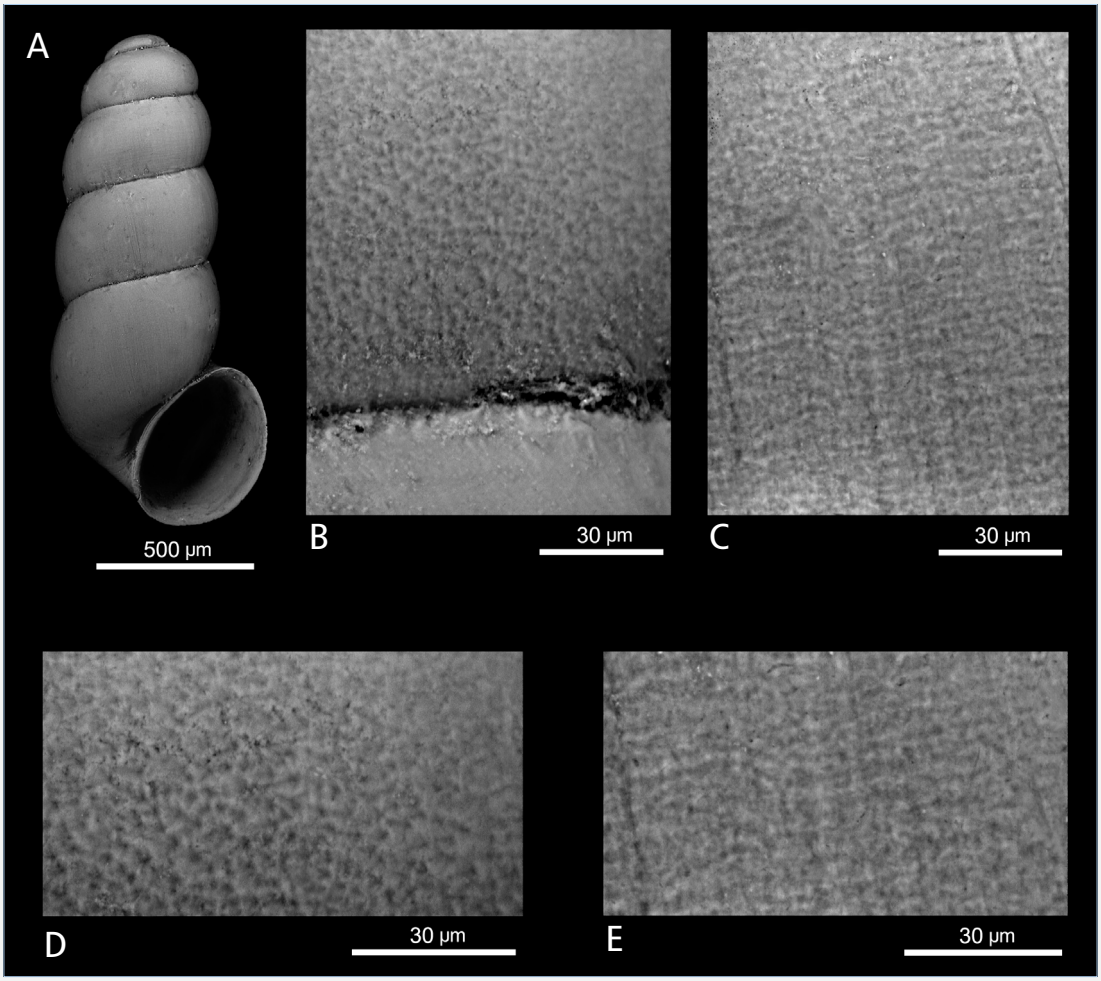

FIGURE 3. SEM photographs of *Spiralix cubelli* sp. n. from the type locality. **A**: apertural view; **B**, **D**: detail of the protoconch microsculpture; **C, E**: detail of the teleoconch microsculpture.

Microfotografies de *Spiralix cubelli* sp. n. de la localitat tipus. **A**: vista apertural; **B, D**: detall de la microescultura de la protoconquilla; **C, E**: detall de la microescultura de la teleoconquilla.

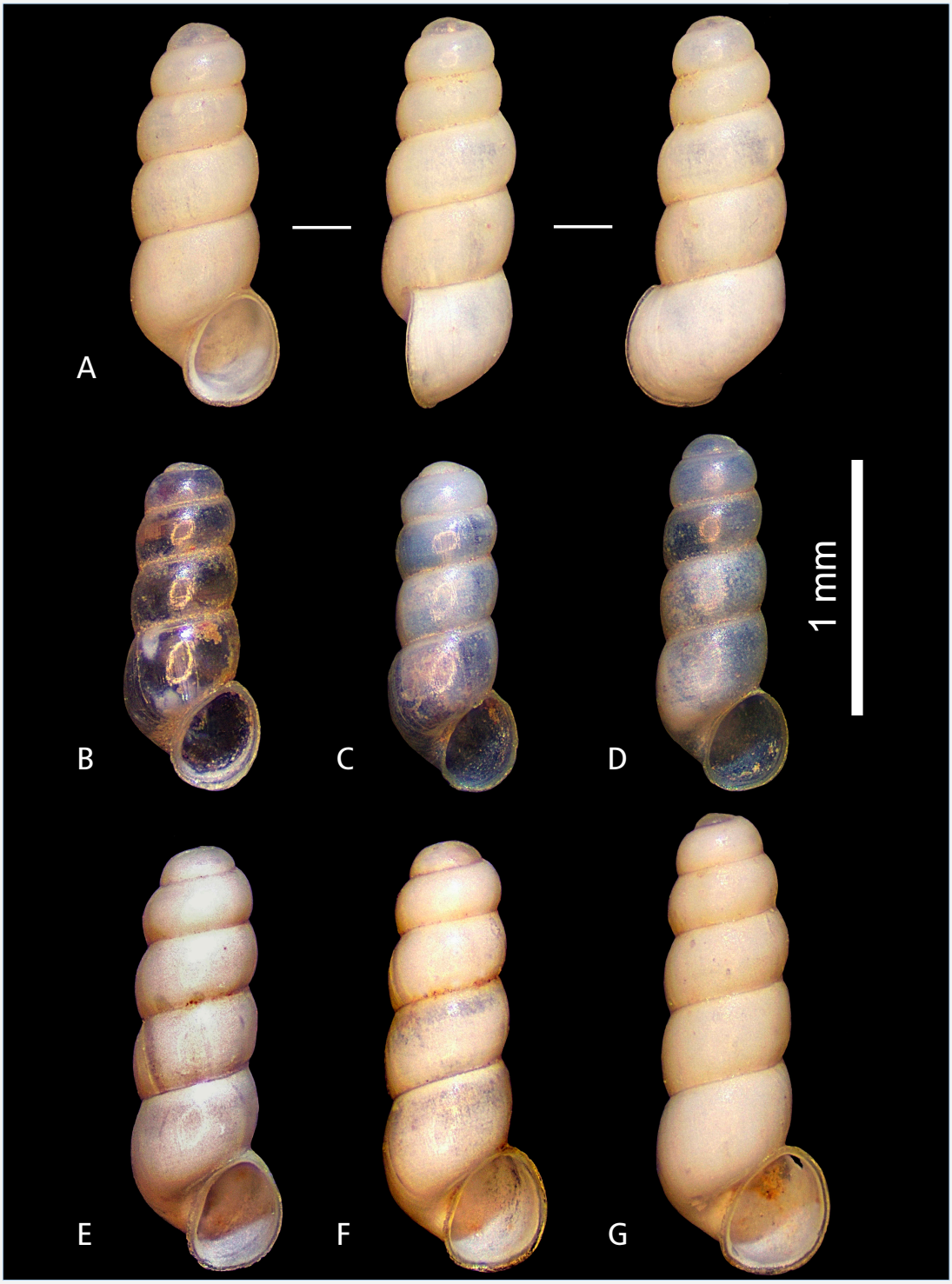

FIGURE 4. Types of *Spiralix cubelli* sp.n. **A**: holotype; **B-D**: paratypes. **A-D**: from type locality. E-G: from Fuente del Hambre.

Exemplars tipus de *Spiralix cubelli* sp. n. **A**: holotip; **B-D**: paratips. **A-D**: de la localitat tipus. E-G: de la Fuente del Hambre.

Etymology: This species is named after Miguel Cubell, member of the Associació Catalana de Malacologia (ACM).

Description: Shell small, very fragile, turriculated, translucid (when freshly collected), shiny. Subcylindrical shape with obtuse apex. Height between 1.43-2.53 mm, and width of 0.58-0.87 mm. Shells of 4-6 whorls, the initial ones slightly narrower in biggest specimens. Deep suture. Last whorl with a straight disposition in the final stretch. Ovoidal aperture, of 0.43-0.67 mm height and 0.37-0.61 mm width, sometimes showing an angle in the upper part. Continuous peristome, fine and reflected towards the columella, adhered to previous whorl. Fissural umbilicus. The microsculpture of the teleoconch is formed by spiral lines or superficial roughness, crossing the growth lines, less evident and slightly prosocline (Fig. 3C, E) Protoconch has dense microsculpture, formed by small depressions of variable shape and irregularly placed. (Fig. 3 B, D).

Dimensions: See table 1, Fig. 6

Habitat: Stygobiotic.

Distribution: Only known from the two above mentioned localities. (Fig. 7, 8)

Differential diagnosis: It is clearly distinguishable from the species in the genus by these characters:

Spiralix calida has similar shell height but with a conical-cylindrical to subcylindrical shape, more reflected columellar peristome, and protoconch with very faint to absent microsculpture.

Spiralix pequenoensis has more reflected columellar peristome, less cylindrical shape which is narrowed in the apex (only rarely seen in *S. cubelli* sp. n. in the biggest specimens). Its number of whorls is higher compared to similar sized specimens of *S. cubelli* sp. n.

Spiralix clarae has a larger number of whorls, a separation between last whorl and aperture, and a more marked microsculpture in the protoconch.

Discussion and conclusions

Two new species of the genus *Spiralix* are described for Castelló province, raising to 7 the number of known species in this area, along with the previously described *S. valenciana castellonica*, *S. pequenoensis*, *S. gloriae*, *S. calida*, and *S tuba*. (Fig. 8). The two new species can be attributed to genus and subgenus *Spiralix* because they have very close similarities with all the other described species, characterized by a conical-cylindrical

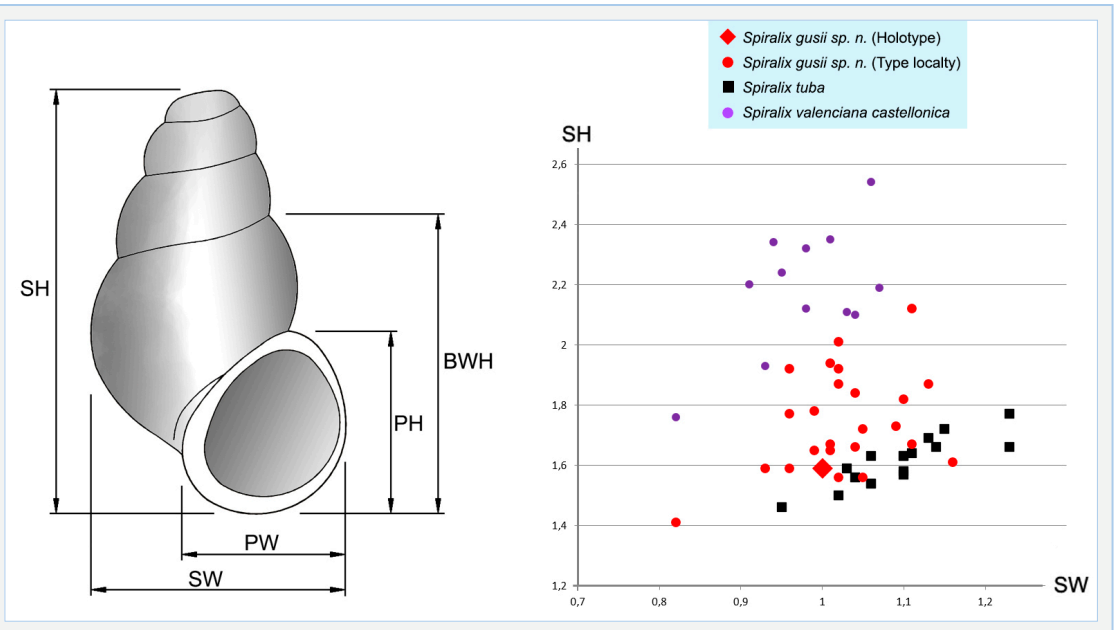

FIGURE 5. Shell measurements of *Spiralix gusii* sp. n. compared to *S. tuba** and *S. valenciana castellonica**. SH: Shell height. SW: Shell diameter. BWL: last whorl height. PH: Aperture height. PW: Aperture width. * see Quiñonero-Salgado et al., 2019.

Dimensions de la conquilla de *Spiralix gusii* sp. n. comparades amb *S. tuba** i *S. valenciana castellonica**. SH: alçada. SW: diàmetre. BWL: alçada de l'última volta PH: alçada de l'obertura. PW: amplada de l'obertura.* mireu Quiñonero-Salgado et al., 2019.

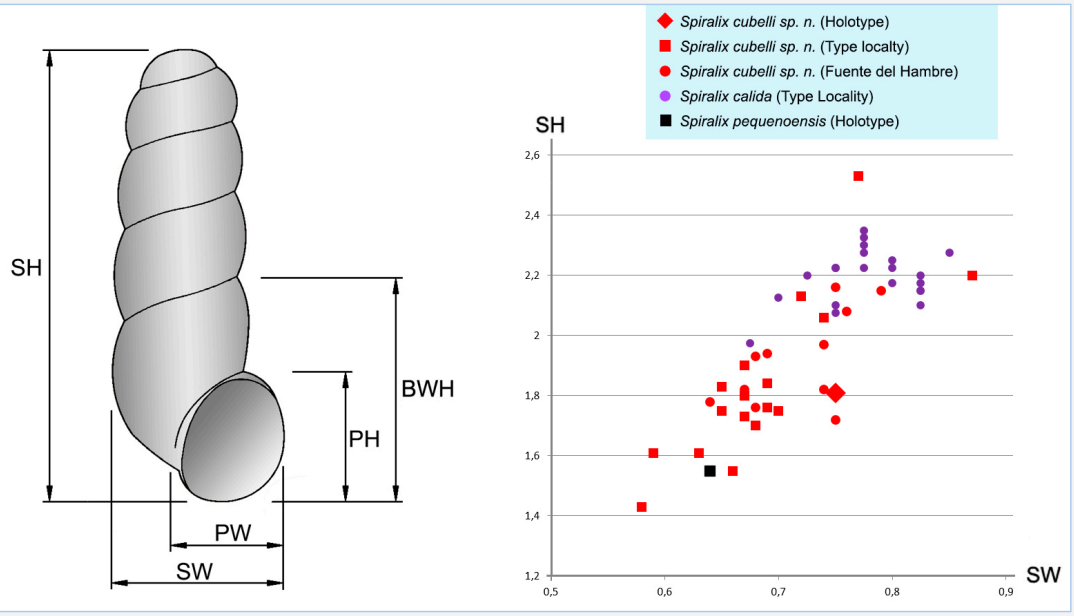

FIGURE 6. Shell measurements of *Spiralix cubelli* sp. n. compared to *S. calida** and *S. pequenoensis***. SH: Shell height. SW: Shell diameter. BWL: last whorl height. PH: Aperture height. PW: Aperture width. *see Corbella et al 2014. ** see Boeters, 2003.

Dimensions de la conquilla de *Spiralix cubelli* sp. n. comparades amb *S. calida** i *S. pequenoensis***. SH: alçada. SW: diàmetre. BWL: alçada de l'última volta PH: alçada de l'obertura. PW: amplada de l'obertura. *mireu Corbella et al 2014. ** mireu Boeters, 2003.

		S. Height	S. Width	BWH	Peristome height	Peristome width
		SH	SW	BWH	PH	PW
Spiralix gusii (n=25)	HOLOTYPE	**1.59**	**1**	**1.12**	**0.71**	**0.61**
	min.	1.41	0.82	1	0.59	0.54
	max.	2.12	1.16	1.35	0.82	0.73
	mean	1.74	1.02	1.20	0.72	0.62
	st.dev.	0.167	0.072	0.077	0.049	0.052
Spiralix cubelli (Type locality) (n=18)	HOLOTYPE	**1.81**	**0.75**	**0.93**	**0.57**	**0.47**
	min.	1.43	0.58	0.77	0.43	0.37
	max.	2.53	0.87	1.11	0.67	0.61
	mean	1.83	0.69	0.91	0.50	0.43
	st.dev.	0.261	0.067	0.089	0.058	0.060
Spiralix cubelli (Fuente del Hambre) (n=12)	min.	1.72	0.64	0.64	0.47	0.41
	max.	2.16	2.16	2.16	2.16	2.16
	mean	1.91	0.72	0.92	0.53	0.45
	st.dev.	0.152	0.046	0.039	0.037	0.038

TABLE 1. Measurements of *Spiralix gusii* sp. n. and *S. cubelli* sp. n. shells. SH: shell height. SW: shell diameter. BWH: last whorl height. PH: aperture height. PW: aperture width. See also Fig. 5 and 6.

Mesures de la conquilla de *Spiralix gusii* sp. n. i *S. cubelli* sp. n. SH: alçada. SW: diàmetre. BWH: alçada de l'última volta. PH: alçada de l'obertura. PW: amplada de l'obertura. Cal veure també les Fig. 5 i 6.

to subcylindrical shape, with the only exception of *S. tuba*, which has a less elevated shell. A main characteristic is also the widened peristome. Shells of this subgenus normally have very scarce teleoconch ornamentation, and slightly but more evident ornamentation in the protoconch, with the exception in the subgenus *Burgosia*, which also has cuneiform marks. The genus *Spiralix* differs from other genera in

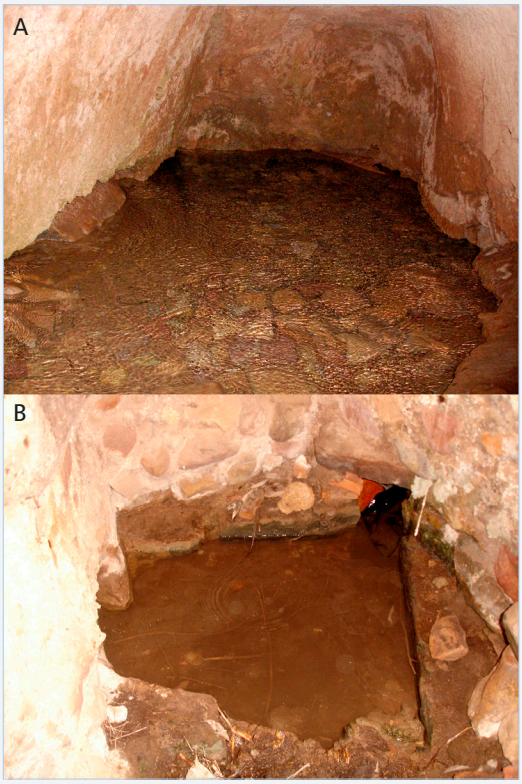

FIGURE 7. **A**: Manantial de los Gallos, type locality of *Spiralix cubelli* sp.n. and *Spiralix gusii* sp.n. **B**: Fuente del Hambre, locality where Spiralix cubelli sp. n. is also found.

A: Manantial de los Gallos, localitat tipus de *Spiralix cubelli* sp.n. i *Spiralix gusii* sp.n. **B**: Fuente del Hambre, localitat on també es troba Spiralix cubelli sp. n.

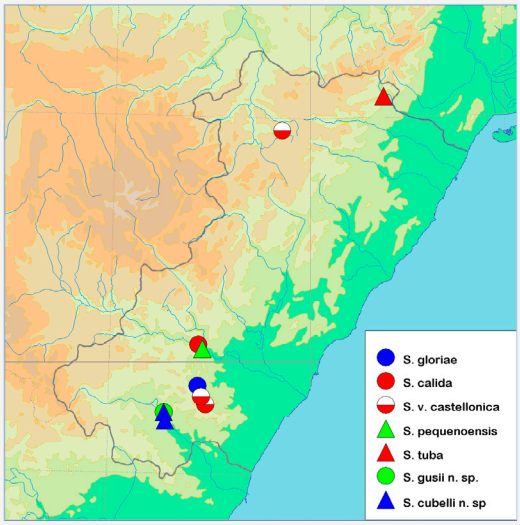

FIGURE 8. Map of Castelló province showing the known distribution range of the species of the genus *Spiralix*.

Mapa de la província de Castelló mostrant el rang de distribució de les espècies del gènere *Spiralix*.

the same family by some diagnostic charactersistics: compared to *Palaospeum* Boeters, 2003, it has a less conical shape, and less widened aperture; compared to *Moitessieria* Bourguignat, 1863, it does not show the well-defined spiral ornamentation, very characteristic of this genus; *Sardopaladilhia* Manganelli, Bodon, Cianfaneli, Talenti & Giusti, 1998 instead has an elevated spire, continuous peristome, slightly everted, and a microsculpture formed by dots or lines. Given all these characteristics, the attribution of the new species to the genus *Spiralix* seems well justified.

Spiralix gusii sp. n. has evident similarities with *S. tuba*, particularly regarding the irregularly displayed rounded depressions of the protoconch, but has different conchological main traits. On the other hand, *S. cubelli* sp. n. seems quite similar to *S. pequenoensis*, whose microsculpture is unknown, and somehow to *S. calida*, because of the very faint to absent ornamentation, but also with the evidently different main characteristics of the shell.

Both species were found syntopically at Manantial de los Gallos (Fig. 7A), along with a yet undescribed *Spiralix* species, of which only shell fragments have so far been found. In addition, *S. cubelli* was also found at Fuente del Hambre (Fig. 7B), where another stygobiotic Moitessieriidae species is found, *Palaospeum lopezsorianoi* Quiñonero-Salgado & Rolán, 2017. In these two localities, another quite characteristic stygobiotic gastropod is found, *Navalis perforatus* Quiñonero-Salgado & Rolán, 2017, form the Hydrobiidae family. All these findings clearly show the richness of the hyporheic habitats in the area, with a number of endemisms.

Different samplings in springs and fountains in the vicinities have yielded so far negative results for the two new *Spiralix* species, although their presence cannot be completely ruled out. Given their narrow range of distribution and the fragility of their habitats, highly vulnerable to any damage by contamination, protection for the whole ecosystem should be guaranteed. Both newly described species should also be considered for inclusion in the Spanish Red List of endangered species to assure their protection.

This study, along with previous descriptions of other freshwater mollusks, shows the high richness and

degree of endemism in the aquatic ecosystems in the Levantine basin of the Iberian Peninsula. Up to three or four endemic gastropod species can be found in the same spot. The geomorphology of the area, combined with a relative isolation of small hydrological basins, characterized by a rather irregular and seasonal water regimen, could explain this high speciation rate among aquatic gastropods. Indeed, there are still many areas, even complete hydrological basins, that have so far not been fully studied, so new surprises could be expected, with multiple as yet unknown new taxa.

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