

**New hydrobiids from subterranean waters of eastern Sardinia, Italy
(Gastropoda Prosobranchia: Hydrobiidae)**

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Although the discovery of stygobiont hydrobiids in the groundwaters of Sardinia (Italy) is very recent, many taxa have been identified supporting the fact that the Sardinian hydrobiid stygofauna is the richest and most diversified of all the Mediterranean islands. Two new genera and three new species discovered in the karstic systems of eastern Sardinia, north of the Gennargentu massif are described: *Sardopaladilthia* nov. gen., *Sardopaladilthia plagigeyerica* nov. spec., *Sardohoratia* nov. gen., *Sardohoratia sulcata* nov. spec., and *Sardohoratia islamioides* nov. spec. Like many other genera of hydrobiids, *Sardopaladilthia* and *Sardohoratia* have mosaics of characters, some of which are shared with other groups of hydrobiids. Based on the number of characters shared, the genus closest to *Sardopaladilthia* is *Paladilthia* Bourguignat, 1865, and that closest to *Sardohoratia* is *Horatia* Bourguignat, 1887. *Sardopaladilthia* differs from *Paladilthia* in a number of important characters, the most evident of which is the peculiar stylet at the apex of the penis. *Sardohoratia* differs from *Horatia* by virtue of the penis without lateral lobe. The two species of *Sardohoratia* are easily distinguished from each other. They have quite different shell shapes and some anatomical differences; their coexistence in the same karstic systems and the absence of intermediate specimens supports distinct specific status. The fossil *Islamia sarda* Esu, 1984, is tentatively assigned to *Sardohoratia*. The three new species occur in a few restricted areas of eastern Sardinia and the two species of *Sardohoratia* can be considered threatened.

Key words: Gastropoda, Prosobranchia, Hydrobiidae, taxonomy, *Sardopaladilthia* nov. gen., *Sardohoratia* nov. gen., stygofauna, Sardinia, Italy.

INTRODUCTION

Stygobiont hydrobiids were recently discovered in the groundwaters of Sardinia (Italy). The first hydrobiids found belong to the genus *Moitessieria* Bourguignat, 1863, and occur in central and eastern Sardinia. Although differences in shell shape supported the existence of more than one species, all populations studied were provisionally assigned to a single taxon, *M. cf. massoti* Bourguignat, 1863 (Bodon & Giusti, 1991; Bodon et al., 1995). A number of other genera, some with vicariant species, were identified in isolated areas. These discoveries suggest that the stygobiont hydrobiid fauna of the island of Sardinia underwent the widest radiation of all the Mediterranean islands.

This paper is devoted to the description of the new taxa discovered in the karstic

systems of eastern Sardinia, north of the Gennargentu massif. This territory includes some impressive Jurassic limestone plateaus and mountains such as the Sopramonte di Oliena, the coastal massif south of Cala Gonone and the mountains between Dorgali and Siniscola (Monte Sospile, Monte Tuttavista and Monte Albo). The first massif, in particular, is drained by an imposing karstic system which includes the cave Sa Oche and the spring Su Cologone, the most plentiful karstic spring of Sardinia.

MATERIAL AND METHODS

Empty shells and whole specimens were collected by using a net and sorting variable amounts of sediment from caves and springs. Shells were mounted on copper stubs with conductive glue, sputter-coated with gold and photographed using a Philips 515 SEM. All dimensions (shell height, shell diameter, aperture height and aperture diameter) were measured using a micrometer in the light microscope (Wild M5A). Unrelaxed material preserved in 75% ethanol was studied by optical microscopy (Wild M5A). Bodies were isolated after crushing the shells and were dissected using very fine pointed watchmaker's forceps. Images of the whole body and isolated parts of the genitalia were drawn using a Wild camera lucida. Radulae were obtained by dissecting out buccal bulbs. They were washed in distilled water, mounted on copper stubs with conductive glue, sputter-coated with gold and photographed using Philips 505 and 515 SEMs.

The material examined is listed as follows: locality, municipality and province names in parenthesis, UTM reference, collector(s) and date, number of specimens in parentheses. Locality names and UTM references were according to the official 1:25,000 scale map of Italy (series M 891, sheets 195 III SE, 195 IV SE, 208 IV NO, and 208 IV SE).

Holotypes and many paratypes are in the Museo Zoologico "La Specola", Sezione del Museo di Storia Naturale dell'Università di Firenze, Via Romana 17, Firenze, Italy (MZUF). Other paratypes and material examined are in the private collections of M. Bodon (Via delle Eriche 100/8, Genova, Italy), S. Cianfanelli (P.le Porta Romana 13, Firenze), E. Talenti (P.zza Parri 4, Incisa, Firenze), F. Giusti (Dipartimento di Biologia Evolutiva dell'Università, Via Mattioli 4, Siena, Italy), M. Sosso (Via Paglia 65/3, Genova, Italy), and W.J.M. Maassen (Azaleahof 25, Duivendrecht, Holland).

Acronyms: AG albumen gland, BC bursa copulatrix, C ctenidium, CG capsule gland, DSR distal seminal receptacle (RS1), FP fecal pellets, I intestine, O operculum, OE oesophagus, OS osphradium, OV ovary, P penis, PD penial duct (portion of vas deferens running inside penis), PG prostate gland, PI pedal incision, PSR proximal seminal receptacle (RS2), PW posterior wall of pallial cavity, R rectum, SS style sac, TS testis, VD vas deferens, VE vas efferens (seminal vesicle).

Sardopaladilhia nov. gen.

Diagnosis. — Prosobranch, hydrobiid snail with very small, conical shell with peristome flared and reflected, teleoconch surface rather smooth. Male genitalia with conical, slender penis having long apical stylet and no lobe. Female genitalia with one seminal receptacle corresponding to that defined proximal (PSR or RS2) and large bursa copulatrix, with canal ending close to ventral side of bursa. Radula very long; rachidian teeth square, with reduced lateral wings, 1-3 basal cusps at base of each

lateral wing and short plough-like basal projection; lateral and inner (first) marginal teeth with short apex and reduced number of denticles.

Description. — See description of the type species.

Etymology. — From the island of Sardinia and *Paladilhia*, the genus closest anatomically.

Type species. — *Sardopaladilhia plagigeyeric* nov. spec.

***Sardopaladilhia plagigeyeric* nov. spec.**

Diagnosis. — *Sardopaladilhia plagigeyeric* nov. spec. is the only known species of the genus. Consequently its diagnosis is the same as that of the genus.

Shell (figs. 1-10). — Very small, more or less elongate, conical, with acute apex, waxen, whitish and translucent when fresh; spire consisting of 5-6.5 convex whorls, last whorl wide, not descending, about 3/5 of shell height; sutures deep; aperture wide, ovoid and slightly oblique; peristome thickened, continuous, adhering to last whorl, flared and reflected, sinuous at upper external margin; umbilicus open, narrow; surface of protoconch finely malleate (figs. 7-9); surface of teleoconch rather smooth, with some evident growth lines intercalated with fine longitudinal (axial) lines (figs. 1-6, 10) and in some places, fine spiral lines (fig. 7).

Species	Locality	H	D	h	d	H/D
	N					
<i>Sardopaladilhia plagigeyeric</i> n. sp.	Su Cologone	2.76 ± 0.38	1.60 ± 0.20	1.18 ± 0.16	1.03 ± 0.14	1.72 ± 0.15
	30	(2.04 - 3.59)	(1.19 - 1.92)	(0.87 - 1.53)	(0.67 - 1.29)	(1.44 - 1.99)
	Sa Oche	2.77 ± 0.30	1.51 ± 0.12	1.14 ± 0.08	0.91 ± 0.06	1.83 ± 0.13
	7	(2.24 - 3.14)	(1.28 - 1.62)	(0.98 - 1.21)	(0.79 - 0.95)	(1.69 - 2.00)
	Bue Marino	2.31	1.05	0.82	0.58	2.20
	1					
<i>Sardohoratia sulcata</i> n. sp.	Su Cologone	0.84 ± 0.13	0.96 ± 0.12	0.58 ± 0.07	0.51 ± 0.07	0.88 ± 0.07
	30	(0.60 - 1.13)	(0.62 - 1.24)	(0.41 - 0.79)	(0.35 - 0.67)	(0.77 - 1.13)
<i>Sardohoratia islamioides</i> n. sp.	Su Cologone	0.77 ± 0.12	1.22 ± 0.16	0.57 ± 0.07	0.53 ± 0.07	0.62 ± 0.05
	30	(0.60 - 1.03)	(0.92 - 1.52)	(0.44 - 0.89)	(0.42 - 0.66)	(0.51 - 0.73)

Table 1. Dimensions of shell in different populations of *Sardopaladilhia plagigeyeric* nov. spec., *Sardohoratia sulcata* nov. spec. and *Sardohoratia islamioides* nov. spec. Locality and number of shells (N), mean (in mm) ± standard deviation and range (in mm, in parentheses), shell height (H), shell diameter (D), aperture height (h) and aperture diameter (d).

Dimensions (table 1). — Shell height: 2.04-3.59 mm; shell diameter: 1.05-1.92 mm; aperture height: 0.82-1.53 mm; aperture diameter: 0.58-1.29 mm.

Operculum (fig. 14). — Corneous, paucispiral, very thin, pale yellowish in colour, with subcentral nucleus and without projection or thickening on internal side.

Body (figs. 15-16). — Almost depigmented (only a few traces of pigment on visceral sac wall); tentacles lacking eye spots; pallial tentacle absent; foot with short incision at posterior tip.

Male genitalia (figs. 11-13, 15, 17-18). — Testis with many lobes, situated inside second-third whorl, near apex of visceral sac; vas efferens functioning as seminal vesicle; prostate gland pear- or kidney-shaped, with anterior portion not or slightly bulging into

pallial cavity; vas deferens starting from anterior portion of prostate gland, thin, crossing body wall to enter base of penis; penial duct (portion of vas deferens internal to penis) running subcentrally to end at penis tip; penis depigmented, bent upon itself inside pallial cavity, elongated conical when extended, elliptical in transverse section, with sides wrinkled near base, without lobes or internal, refringent, glandular masses; penis tip with long, needle-shaped, corneous, apical stylet, very pale in colour, with groove along its concave side (figs. 11-13).

Female genitalia (fig. 19). — Ovary elongate, inside apex of visceral sac; short gonadal oviduct, slightly wider near point at which gonopericardial duct ends; renal oviduct twisted on itself to form loop which adheres to pallial oviduct; distal portion of renal oviduct (from loop to where the duct of bursa copulatrix arises) very short; only one seminal receptacle, rather large, its duct arising close to end of loop, thus corresponding to that defined as proximal (PSR or RS2); bursa copulatrix very wide, ovoid, lying behind albumen gland portion of pallial oviduct; bursa copulatrix duct of medium length, ending in ventral side of bursa; pallial oviduct not bulging into pallial cavity, consisting of albumen and capsule glands, its opening (female gonopore), small, situated very far from pallial margin, at bottom of pallial cavity; ventral side of pallial oviduct (from where renal oviduct ends to where gonopore opens) with internal channel (sperm channel or ventral groove).

Radula (figs. 20-27). — Taenioglossate, unusually long, with about 300 rows, each of seven teeth, according to the formula: C = 6 + 1 + 6 / 1-3 + 1-3; L = 7; M1 = 7-8; M2 = 13-15; rachidian teeth square, their upper side with 13 denticles, central denticle longer, lateral denticles diminishing in size and length; each rachidian tooth with one reduced basal wing on each lateral side, with 1-3, small basal cusps near base; lower margin extending into short, plough-like projection; lateral teeth square, their anterior margin with 7 denticles; inner (first) marginal teeth (M1) spoon-shaped, with elongated body and short apex with row of 7-8 denticles along anterior margin; outer (second) marginal teeth spoon-shaped, with elongated body and very short apex with 13-15 denticles along margin.

Stomach and intestine (figs. 18-19). — Stomach without gastric caecum. First portion of intestine running not far from wall of style sac before forming first, U-like loop near stomach; second loop on pallial wall small or very small; rectal portion of intestine straight, fecal pellets in it arranged sideways when approached; anus opening at pallial margin.

Osphradium and ctenidium (figs. 15, 18-19). — Osphradium oval or pyriform. Ctenidium consisting of 2-10 small lamellae.

Type locality. — Plentiful karstic spring "Su Cologone" at San Giovanni, 100 m a.s.l. (Oliena, Nuoro). UTM references: 32T NK 4260.

Type material. — Holotype (shell) from the type locality, M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86, in the malacological collection of the Museo Zoologico "La Specola, Università di Firenze (MZUF no. 11577) and many paratypes from the following localities: type locality, M. Bodon, L. Castagnolo, F. Giusti & G. Manganelli leg. 26.IV.85 (1 shell and 2 fragments), M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86 (many shells, MZUF no. 11578 [6 shells]), M. Bodon leg. 24.03.89 (16 shells, 5 juv. shells, 4 juv. specimens), S. Cianfanelli & E. Talenti leg. 29.X.95 (3 shells and 2 juv. shells, MZUF no. 10968), C. Carletti leg. 21.V.96 (2 fragments, MZUF no. 11589). Cave "Su Gianu", 100 m a.s.l. (Oliena, Nuoro), 32T NK 4360, C. Carletti leg. 25.VI.95 (1 shell and 1 fragment, MZUF no. 11590). Cave "Sa Oche" at Lanaitto, 155 m a.s.l. (Oliena, Nuoro), 32T NK 4156, M. Bodon leg. 26.III.89, (1 male spec-

imen, 1 shell, 2 fragments), S. Cianfanelli, G. Masuri & E. Talenti leg. 28.X.95 [6 specimens (4 males, 1 female, 1 juv.), 5 shells, and 8 juv. shells, MZUF no. 11588]. Cave "Bue Marino" (first fresh-water pond inside the southern branch of the cave, about 900 m from entrance, 1.5 m a.s.l.), (Dorgali, Nuoro), 32T NK 5255, M. Bodon leg. 25.III.89 (2 juv. specimens), G. Masuri leg. 18.XI.95 (1 male specimen, MZUF no. 11591). Spring on right bank of Cedrino river, S. Leonardo, about 3 km upstream of Orosei, about 5 m a.s.l. (Onifai, Nuoro), 32T NK 5771, M. Bodon, L. Castagnolo, F. Giusti & G. Manganelli leg. 27.IV.85 (1 fragment), M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86 (2 fragments).

Etymology. — From the apparent likeness in some of its shell characters with species of the genus *Plagigeyeria*.

Discussion. — *Sardopaladilhia plagigeyerica* has a unique combination of shell and anatomical characters that, based in terms of standard hydrobiid taxonomy, prevents its inclusion in any other known genus of the Hydrobiidae. Consequently a new, monotypic genus is necessary to accommodate it. The new genus shares sets of shell and genital characters with a number of stygobiont hydrobiid species of the following European genera: *Bythiospeum* Bourguignat, 1882, *Paladilhia* Bourguignat, 1865, *Paladilhiosis* Pavlovic, 1913, *Palacanthiopsis* Bernasconi, 1988, and *Plagigeyeria* Tomlin, 1930.

The type species of *Bythiospeum*, *Paludina pellucida* Seckendorf, 1846 (currently *B. diaphanum pellucidum*), and the other congeneric species have shells similar in shape (conical, slender and smooth), but without such a flared and reflected peristome as *S. plagigeyerica* (Bolling, 1960: fig. 2; 1966: figs. 1-86; Zilch, 1970: figs. 1-47; Bernasconi, 1972: figs. 1-69; 1974: fig. 5; 1976: fig. 7; 1980: figs. on p. 10-11; 1984: figs. 7a-7b; 1985: fig. 7; 1988b: fig. 1; 1990, figs. 19.1-19.2; Boeters, 1984a: figs. 1, 3, 7; 1984b: pl. 1 figs. 3-6; Glöer & Meier-Brook, 1994: figs. on p. 41; Haase, 1995: fig. 8). This conchological difference is accompanied by differences in the genitalia, more relevant from a taxonomic point of view. The type species of *Bythiospeum* (the anatomy of which is poorly known) and all the congeneric species studied anatomically so far, have males with a simple, cylindrical penis and females with an elongated bursa copulatrix, sac-like, with duct ending at or close to proximal (hind) margin. No stylet or stylet-like structures have ever been described at the penial apex of the type species, nor in any other congeneric species; the usually defined distal seminal receptacle (DSR or RS1) may eventually be taken as a further distinctive character although variability seems to exist as regards its position on the renal oviduct (some figures in the literature are ambiguous and illustrate it close to the end of the loop) (Seibold, 1904, pl. 4 figs. 3, 6; Krull, 1935: fig. 18c; Bernasconi, 1974: fig. 4; 1976: figs. 4-5; 1980: figs. 1-2; 1984: figs. 2-3; 1985: figs. 2-6; 1988b: fig. 2; 1990: figs. 6, 7.2-7.4, 8.2-8.3, 9.2, 10.2, 11.2, 12.2-12.3, 13.2, 14.2, 15.2-15.3, 16.1-16.2, 17, 18; Boeters, 1984a: figs. 1, 3; 1984b: figs. 3, 5-6; Reischütz, 1983: figs. 1-2; Haase, 1995: figs. 10-11).

The radula and the intestine also distinguish *Bythiospeum* from *Sardopaladilhia*. All radulae of the *Bythiospeum* species studied so far have rachidial teeth with the usual, hydrobiid butterfly shape and long, well developed lateral wings at the base of which only one cusp is present (1), and first marginal teeth with an elongate denticled apex (2) (Seibold, 1904, pl. 4 fig. 5; Boeters, 1971: fig. 3; Bernasconi, 1974: fig. 3; 1976: figs. 1-2; 1980: fig. 3; 1984: fig. 2f; 1990: fig. 13.1; Haase, 1995: fig. 12). The intestine forms an evident loop in the pallial cavity (Bernasconi, 1976: fig. 1; 1980: fig. 1; 1984: fig. 3; 1990: fig. 14.1; Boeters, 1971: fig. 6; 1984a: fig. 4; 1984b: figs. 3, 5-6; Haase, 1995: fig. 13).

Recent personal research on five taxa, *Bythiospeum diaphanum quenstedti* (Wiedersheim,

1873) and *B. diaphanum sterkianum* (Clessin, 1882) from Germany, *B. diaphanum charpyi* (Paladilhe, 1867) and *B. bressanum diaphanoides* Bernasconi, 1985, from France, and *B. reisalpense* (Reischütz, 1983) from Austria, besides confirming the genital characters known from the literature, also revealed that *Bythiospeum* further differs from the new genus in that the prostate gland of males and the pallial oviduct of females project well into the pallial cavity (personal unpublished data; but see also, Haase, 1995: 127, for the position of the prostate).

The type species of *Paladilhia*, *P. pleurotoma* Bourguignat, 1865, from France, recently described by Boeters (1967: fig. 1; 1971: fig. 5; 1973: figs. 5-6) and Bodon & Giusti (1991: fig. 12), appears to be close to *S. plagigeyrica*, sharing with the latter some shell and anatomical characters (table 2A). However, the two species are different in many other characters (table 2B), supporting the inclusion of the new species in a distinct new genus, close to *Paladilhia*.

The type species of *Paladilhioipsis*, *Paladilhia robiciana* Clessin, 1882, from Slovenia and the other congeneric species so far studied anatomically [*P. grobbeni* Kuščer, 1928, from Slovenia and *P. virei* (Locard, 1903) from Italy] are very similar to *Bythiospeum* and thus differ to a similar extent from *S. plagigeyrica*. Moreover, all these *Paladilhioipsis* species are characterized with respect to *S. plagigeyrica* and *Bythiospeum* species by the subapical swelling of the penial apex (personal unpublished data and Bole, 1970: fig. 4; Giusti, 1970: fig. 1; Giusti & Pezzoli, 1980: fig. 14; Radoman, 1983: fig. 56). Incidentally, the taxonomic status of *Paladilhioipsis* is still debatable. Some authors consider it a subgenus of *Bythiospeum* (Bernasconi, 1990, 1992; Slapnik, 1995), or a junior synonym of the latter (Giusti & Pezzoli, 1982; Haase, 1995). For the time being, it seems preferable to leave it as a distinct genus as proposed by Bodon & Giovannelli (1994), Bodon et al. (1995)

Table 2A

- (1) shell conical with peristome sinuous at upper vertex (for *P. pleurotoma*, see Bolling, 1960: fig. 1);
- (2) teleoconch with very faint spiral microsculpture (for *P. pleurotoma*, see Bodon & Giusti, 1991: fig. 5 E-F);
- (3) penis without lobes or subapical swelling (for *P. pleurotoma*, see Boeters, 1967: fig. 1; 1971, fig. 5);
- (4) post-loop portion of renal oviduct very short (for *P. pleurotoma*, see Bodon & Giusti, 1991: fig. 12 L);
- (5) only one seminal receptacle (PSR or RS2), well developed, situated at end of loop, but, due to reduction of post-loop portion of renal oviduct, not too far from where duct of bursa copulatrix arises (for *P. pleurotoma*, see Bodon & Giusti, 1991: fig. 12 L);
- (6) bursa copulatrix well developed, situated behind albumen gland; bursa copulatrix duct ending in ventral side of bursa (for *P. pleurotoma*, see Bodon & Giusti, 1991: fig. 12 L);
- (7) pallial oviduct bulging very slightly into pallial cavity (for *P. pleurotoma*, see Bodon & Giusti, 1991: fig. 12 L);
- (8) first loop of intestine not close to wall of style sac (for *P. pleurotoma*, see Bodon & Giusti, 1991: fig. 12 M).

Table 2A. Characters shared by *Sardopaladilhia plagigeyrica* and *Paladilhia pleurotoma*.

Table 2B

- (1) peristome thickened, flared and reflected (reflected but rather thin, not well flared in *P. pleurotoma*; Bolling, 1960: fig. 1);
- (2) microsculpture of protoconch surface clearly malleate (malleation not visible in *P. pleurotoma*; Bodon & Giusti, 1991: fig. 5 E);
- (3) no hook on internal surface of operculum (small, rudimental hook in *P. pleurotoma*; Bodon & Giusti, 1991: fig. 12 H);
- (4) no pallial tentacle (pallial tentacle present in *P. pleurotoma*; Boeters, 1971: fig. 5, 1973: fig. 5; Bodon & Giusti, 1991: fig. 12 I);
- (5) foot with short incision at posterior tip (no incision in *P. pleurotoma*; Bodon & Giusti, 1991: fig. 12 I);
- (6) penis with long, apical stylet (no stylet in *P. pleurotoma*; Boeters, 1967: fig. 1; 1971: fig. 5);
- (7) small second loop of intestine on pallial wall (no second loop in *P. pleurotoma*; Boeters, 1973: fig. 5; Bodon & Giusti, 1991: fig. 12 L);
- (8) radula with peculiar rachidian teeth (square, with one short basal wing on each lateral side, with 2-3, small cusps near base; plough-like projection of lower margin short) and first marginal teeth (short apical margin) (typical of hydrobiid rachidian and first marginal teeth in *P. pleurotoma*; Boeters, 1967: fig. 2; 1971: fig. 2; Bodon & Giusti, 1991: fig. 19).

Table 2B. Distinctive characters of *Sardopaladilhia plagigeyrica* with respect to *Paladilhia pleurotoma*.

and Manganelli et al. (1995). Besides the subapical penial swelling, *Paldilhioopsis* differs from *Bythiospeum* in the absence of the intestinal loop (verified in *P. virei*, personal unpublished data) and in the evident reticulate microsculpture derived from intersection of spiral and transverse striae on the teleoconch surface (Giusti, 1975, pl. 2; Pezzoli & Giusti, 1976, pl. 9; 1977, pl. 6; Slapnik, 1995, pl. 3).

Apart from the well developed opercular hook, the shell and the anatomical characters (Bernasconi, 1988a: fig. 2) of the type species of *Palacanthiopsis* Bernasconi, 1988a (*P. vervieri* Bernasconi, 1988a) from France, suggest relationship with *Paladilhioopsis* and consequently distinguish *Palacanthiopsis* from the new genus (see discussion on *Paladilhioopsis*).

The type species of *Plagigeyeria*, *Geyeria plagiostoma* Wagner, 1914, from Bosnia, has never been studied anatomically. Among the many species assigned to *Plagigeyeria*, only two are anatomically known: *P. montenigrina* Bole, 1961, from Montenegro, and *P. piroti* Bole & Velkovrh, 1987, from Serbia (Bodon et al., 1996). These species show a genital scheme similar to that of *Bythiospeum* [male genitalia with penis without lobes, subapical swelling and stylet; female genitalia with only one, distal seminal receptacle (DSR or RS1) and bursa copulatrix with duct ending at the proximal (hind) margin of the bursa (Bole, 1970: fig. 7; Radoman, 1983: fig. 55; Bole & Velkovrh, 1987: fig. 2)]. It is noteworthy that Radoman (1983) described *P. montenigrina* as having an unusually long radula, a character it shares with *S. plagigeyrica*. If the anatomy of *P. plagiostoma* is

identical to that known for *P. montenigrina* and *P. pivoti*, then *Plagigeyeria* is easily distinguished from *Sardopaladilhia*, without considering conchological differences. The species of *Plagigeyeria* nearly always have regularly spaced, well marked axial ribs on the surface of the teleoconch (Schütt, 1972: figs. 1-28; Radoman, 1983, pl. 7 figs. 121-124; Bole & Velkovrh, 1987, pl. 3 fig. 3).

Like many other genera of the hydrobiids, *Sardopaladilhia* has a mosaic of characters, some of which are shared with different groups of hydrobiids. Obviously these characters may be shared by common ancestry (such as symplesiomorphies or synapomorphies) or by homoplasy. The only way to choose between these possibilities is to generate phylogenetic hypotheses, based on other characters. Unfortunately the large number of generic taxa of the Hydrobiidae, scanty anatomical knowledge of many of them and paucity of significant characters has made it difficult to undertake phylogenetical analyses up to now. Although it is obvious that to name genera before having good hypotheses of relationships between taxa is risky and that cladistic analysis will probably produce a drastic taxonomic rearrangement of related taxa, it is impossible to analyze the relationships of *Sardopaladilhia* in phylogenetic terms at present time.

Based on the number of shared characters *Paladilhia* seems to be closest to *Sardopaladilhia* (table 2A). *Paladilhia*, *Moitessieria* Bourguignat, 1863 (type species: *Paludina simoniana* De Charpentier, 1848), from western Europe, and *Clameia* Boeters & Gittenberger, 1990 (type species: *Clameia brooki* Boeters & Gittenberger, 1990), from Greece, were assigned to a family distinct (Moitessieriidae Bourguignat, 1863) from the Hydrobiidae by Boeters & Gittenberger (1990) and Boeters & Meier-Brook (1991). The Moitessieriidae were disregarded by Giusti & Bodon (1991) because their alleged diagnostic characters (absence of gono-pericardial duct and of loop of renal oviduct; Boeters, 1972, 1973; Boeters & Gittenberger, 1990; Boeters & Meier-Brook, 1991) were not confirmed by other studies (Bodon & Giusti, 1991). Incidentally, with respect to *Paladilhia*, *Moitessieria* and *Clameia* are both characterized by the absence of the pallial tentacle, *Moitessieria* by peculiar microsculpture on the teleoconch surface and the absence of the seminal receptacles (Bodon & Giusti, 1991, figs. 4, 9, 12, 16) and *Clameia* by the distal seminal receptacle with long duct and the marked microsculpture on the teleoconch, similar to that in some species of *Moitessieria* (Boeters & Gittenberger, 1990: figs. 1-6, 9).

The long penial stylet is one of the principal diagnostic, anatomical characters of *S. plagigeyerica*. This feature has so far been found in only three genera of the European hydrobiids, all clearly distinguished from *Sardopaladilhia* by their female genital scheme, the typical hydrobiid radula and the different shell shape. They include the valvatoid *Hauffenia* Pollonera, 1898 (type species *Horatia tellinii* Pollonera, 1898) and *Lobaunia* Haase, 1993 (type species *Lobaunia danubialis* Haase, 1993) and the bythinelloid *Istriana* Velkovrh, 1971 (type species *Istriana mirnae* Velkovrh, 1971) (Haase, 1992: figs. 9, 11, 1993: fig. 8; Bodon & Giovannelli, 1993: figs. 6, 10; Bodon et al., in press). In the first two genera the stylet is very small and situated inside the penis tip, bordering the end of the penial duct, while in the third genus it is apical and external, but always small and short.

S. plagigeyerica is the only known species of the genus *Sardopaladilhia*. No similarly shelled species do occur in Sardinia; only the species of *Paladilhia*, *Palacanthitopsis*, and *Plagigeyeria* in any way resemble *Sardopaladilhia plagigeyerica* in shell characters. The round aperture and thickened peristome, not very sinuous at upper vertex, are diagnostic with respect to *Paladilhia pleurotoma* Bourguignat, 1865. The structure of peristome also distinguishes the new species from other, anatomically unknown, French taxa assigned

to *Paladilhia* by Germain (1931: 639-641, figs. 683-685, 688-691) such as *P. conica* Paladilhe, 1867, and *P. moitesseri* Bourguignat, 1865.

Palacanthiopsis verrieri has also a shell shape very similar to that of *S. plagigeyrica* but easily distinguished by the simpler, unflared peristome and the clear reticulate micro-sculpture on the teleoconch surface (Bernasconi, 1988a: 290: fig. 1).

The shell of *S. plagigeyrica* is more similar to that of some species of the genus *Plagigeyrica*, living in the Balkans. However, these species usually have a clearly ribbed shell (Schütt, 1972: figs. 1-28; Radoman, 1983, pl. 7 figs. 121-124; Bole & Velkovrh, 1987, pl. 3 fig. 3).

The thin, unflared peristome of "*Plagigeyrica*" *conilis* Boeters, 1974, from France (Boeters, 1974: figs. 9-11), distinguishes it from *S. plagigeyrica*. "*P.*" *conilis* is another species anatomically unstudied and consequently of unclear taxonomic status.

Sardohoratia nov. gen.

Diagnosis. — Prosobranch, hydrobiid snail with shell very small, valvatoid, from globose-conical to depressed. Male genitalia with penis conical to cylindro-conical, without lobes or internal, refringent glandular masses. Female genitalia with two seminal receptacles, proximal one (PSR or RS2) bent outwards to face distal one (DSR or RS1), distal seminal receptacle equal or slightly larger than proximal one; bursa copulatrix large, oval, with duct ending at distal (anterior) margin.

Shell. — Very small, valvatoid, from globose-conical to depressed, waxen, whitish and translucent when fresh; spire consisting of 2.25-3 convex and rapidly increasing whorls; sutures deep; aperture roundish to ovoid; peristome continuous, adhering to last whorl, not sinuous at its upper external margin; umbilicus open, variable; external surface of protoconch markedly malleate.

Operculum. — Corneous, paucispiral, thin, oval to roundish, without projection or thickening on its internal side.

Body. — Depigmented; tentacles lacking eye spots.

Male genitalia. — With anterior portion of prostatic gland bulging well into pallial cavity; penis cylindro-conical or conical, elongate, with central penial duct and without lobes or internal refringent glandular masses.

Female genitalia. — With gonopericardial duct, renal oviduct with two seminal receptacles and bursa copulatrix; proximal seminal receptacle (PSR or RS2) bent outwards (to face distal seminal receptacle DSR or RS1); proximal seminal receptacle equal to or smaller than distal one; bursa copulatrix wide, oval, situated behind albumen gland portion of pallial oviduct; bursa copulatrix duct rather long, ending at distal (anterior) margin of bursa; pallial oviduct bulging well into pallial cavity, its lower portion with internal ventral channel (sperm channel or ventral groove); gonopore not far from margin of pallial cavity.

Radula. — Taenioglossate, with many rows of seven teeth; rachidian teeth butterfly-like, with V-shaped denticled apex, long slender lateral wings and well developed, basal plough-like projection; only one basal cusp at base of each lateral wing; lateral, inner (first) and outer (second) marginal teeth in the usual, hydrobiid shape.

Stomach and intestine. — Stomach without gastric caecum; first portion of intestine running near wall of style sac; second loop of intestine situated on pallial wall.

Osphradium and ctenidium. — Osphradium small, oval; ctenidium, when present, with few branchial lamellae.

Etymology. — From the island of Sardinia and *Horatia*, the genus closest conchologically and anatomically.

Type species. — *Sardohoratia sulcata* nov. spec.

Other species included. — *Sardohoratia islamioides* nov. spec. A fossil species from the Lower Pliocene (Ruscinian) of Mandriola (Sinis, west-Sardinia), ?*Islamia sarda* Esu, 1984, is tentatively assigned to the new genus.

Discussion. — As in the case of *Sardopaladilhia plagigeyrica*, in terms of standard hydrobiid taxonomy, the combination of shell and anatomical characters of *Sardohoratia sulcata* and *S. islamioides*, prevents their inclusion in any other known genus of the Hydrobiidae.

The remarkable conchological differences between the two new species (both assigned to *Sardohoratia* because of identical genital structure), is further evidence that shell characters alone are insufficient for inferring supra-specific taxonomy. On the basis of shell characters alone, the two species of *Sardohoratia* might well be assigned to different genera of the valvatoid hydrobiids: *S. sulcata* to *Horatia* Bourguignat, 1887, and *S. islamioides* to *Islamia* Radoman, 1973, or *Hauffenia* Pollonera, 1898. The following comparative analysis is thus mainly based on anatomical characters and considers all the genera irrespective of their conchological characters.

The following valvatoid shelled genera of the western Palaearctic hydrobiids: *Bracenicia* Radoman, 1973 (type species *B. spiridoni* Radoman, 1973), *Daphniola* Radoman, 1973 (type species *D. graeca* Radoman, 1973), *Fissuria* Boeters, 1981 (type species *F. boui* Boeters, 1981), *Gocea* Hadzisce, 1956 (type species *G. ohridana* Hadzisce, 1956), *Horatia* Bourguignat, 1887 (type species *H. klecakiana* Bourguignat, 1887), *Karevia* Hadzisce, 1959 (type species *Ohrigocea (Karevia) prlitchevi* Hadzisce, 1959), *Ohridohauffenia* Hadzisce, 1959 (type species *Ohridohauffenia (Ohridohauffenia) giorgievici* Hadzisce, 1959), *Ohrigocea* Hadzisce, 1959 (type species *O. samuili* Hadzisce, 1959), *Pezzolia* Bodon & Giusti, 1986 (type species *P. radapalladis* Bodon & Giusti, 1986), *Prespolitorea* Radoman, 1973 (type species *P. valvataeformis* Radoman, 1973) and *Pseudoislamia* Radoman, 1979 (type species *P. balcanica* Radoman, 1979) have the same organization of the female genitalia as *Sardohoratia* (bursa copulatrix and two seminal receptacles arising from the renal oviduct far from one another).

Comparative analysis between *Sardohoratia* and these genera is difficult because many species have been assigned to them after superficial evaluation of shell characters or incomplete and/or unreliable anatomical study. This implies that clear, comprehensive generic diagnoses (and realistic geographical distribution) are unavailable. In this situation it has been necessary to rely upon those diagnostic characters described in the single type species.

The genus *Horatia* seems most closely related to *Sardohoratia*. Its type species, *H. klecakiana*, from the Balkans, has female genitalia very similar to those of *Sardohoratia* by virtue of a proximal seminal receptacle (PSR or RS2) bent outwards. The male genitalia are different and clearly diagnostic by the presence of a lateral penial lobe (Radoman, 1983: 51, fig. 20).

A penis with a lateral lobe also distinguishes all the other valvatoid genera from the Balkans (*Bracenicia*, *Daphniola*, *Gocea*, *Karevia*, *Ohridohauffenia*, *Ohrigocea*, *Prespolitorea*, and *Pseudoislamia*; Radoman, 1983; Bodon et al., in press) and the French *Fissuria* (in which the lobes have a glandular appearance; Boeters, 1981; Bodon et al., in press). Some of these genera (*Daphniola*, *Karevia*, *Ohridohauffenia*, *Ohrigocea*, *Prespolitorea*) differ further from *Sardohoratia* in that the female genitalia of their type species have the proximal seminal receptacle (PSR or RS2) larger than the distal one (DSR or RS1).

The type species of *Pezzolia*, *P. radapalladis*, from Liguria (N.-W. Italy), has a simple penis without lobes (Bodon & Giusti, 1986; Bodon et al., in press), similar to that of the new species. *Sardohoratia* differs from *Pezzolia* in the following characters: penis tapered at tip (penis with subapical swelling in *P. radapalladis*; Bodon & Giusti, 1986: fig. 1G); a centrally located penial duct (penial duct located right of centre of penis in *P. radapalladis*; Bodon & Giusti, 1986: fig. 1G); proximal seminal receptacle not very small, bent outwards (proximal seminal receptacle very small, sessile, bent inwards in *P. radapalladis*; Bodon & Giusti, 1986: figs. 1E-F); large bursa copulatrix, with rather long duct (bursa copulatrix absent or, when present, very reduced and without efferent duct in *P. radapalladis*; Bodon & Giusti, 1986: figs. 1 E-F; Bodon et al., in press). It is noteworthy that some other species from Liguria assigned to *Pezzolia* are even more different, having a penis with glandular lobes (Bodon et al., 1995; in press).

Many valvatod hydrobiids with uncertain taxonomic status (especially at the genus level) are known from western Europe (France and Spain). Some were recently revised and assigned to the genus *Islamia* Radoman, 1973 [female genitalia with two seminal receptacles arising from renal oviduct, proximal seminal receptacle (PSR or SR2) constantly larger and longer than distal (DSR or SR1); bursa copulatrix absent; penis with glandular lobe; Bodon et al., in press]. Others, currently included in the genus *Horatia*, still require revision; however, preliminary research suggests that they must be assigned to other genera, as in the case of "*Horatia*" *exilis* (Paladilhe, 1867) from France. Study of specimens from Hérault revealed that this species (males with penis without lobes and females with only one distal seminal receptacle; Boeters, 1974; Bodon et al., in press) is not related to *Horatia*. Similar conclusions apply to Spanish species included in the genus *Horatia* which, though requiring new detailed examination, have always been described as having a single seminal receptacle (Boeters, 1988; Ramos et al., 1992, 1995).

Regarding hydrobiids without a valvatoid shell, only two European genera have a combination of anatomical characters similar to that of *Sardohoratia* (penis without lobe; two seminal receptacles and bursa copulatrix large, with rather long duct): *Sadleriana* Clessin, 1890 (type species: *Paludina fluminensis* Küster, 1853, from the Balkans and Italy) (Bodon et al., 1992: table 1) and *Terranigra* Radoman, 1978 (type species: *T. kosovica* Radoman, 1978, from the Balkans) (Bodon & Giovannelli, 1993: tables 1-2). The type species of *Sadleriana* is characterized (as are all congeneric species which are known anatomically) by female genitalia having two seminal receptacles arising from the renal oviduct very close to one another (Radoman, 1983: fig. 18; Giusti & Pezzoli, 1980: fig. 19F). The type species of *Terranigra* is not only distinguished by female genitalia with two seminal receptacles which arise close to one another from renal oviduct (the proximal seminal receptacle not bent outwards), but also by male genitalia with a penis having a subapical swelling (Radoman, 1983: 66-67, fig. 30).

Finally, another genus with an ovoid shell and similar anatomical organization is known from Turkey: *Pseudorientalia* Radoman, 1973 (type species *Paludina natolica* Küster, 1853). However, it is distinguished by female genitalia with a very large bursa copulatrix and a rudimental distal seminal receptacle and by male genitalia with a pigmented conical-pointed penis (Radoman, 1983: 85-86, fig. 47).

***Sardohoratia sulcata* nov. spec.**

Diagnosis. — A species of *Sardohoratia* nov. gen., having a very small, valvatoid,

globose-conical shell with the spire raised, aperture ovoid, umbilicus small (about 1/10 of shell diameter) and the surface of the teleoconch with deep, scattered, spiral grooves; female genitalia with two seminal receptacles (PSR or RS2 and DSR or RS1) equal in size; ctenidium absent.

Shell (figs. 28-30, 34-37). — Very small, valvatoïd, globose-conical, incrassate, waxy, whitish and translucent when fresh; spire consisting of 2 ¼-3 convex and rapidly increasing whorls, last whorl not or slightly descending and slightly dilated near aperture; sutures deep; aperture ovoid, oblique; peristome continuous, adhering to last whorl, thickened, not sinuous at upper external margin, slightly reflected at lower and columellar margin; umbilicus open, rather small, slightly covered by reflected columellar margin of peristome; surface of protoconch markedly malleate (figs. 35-36); surface of teleoconch rather smooth, with very fine, longitudinal (axial) lines, irregularly interspersed with few more marked, imbricated growth lines and with deep, scattered, spiral grooves (figs. 28-29, 34, 36-37).

Dimensions (table 1). — Shell diameter: 0.62–1.24 mm; shell height: 0.60–1.13 mm; aperture height: 0.41–0.79 mm; aperture diameter: 0.35–0.67 mm.

Operculum (fig. 40). — Corneous, paucispiral, oval, very thin, pale yellow in colour, very slightly thickened on internal face near subcentral nucleus.

Body (fig. 41). — Unpigmented; tentacles lacking eye spots.

Male genitalia (figs. 41-43). — Testis near apex of visceral sac; spermiduct (vas efferens) moderately long; prostate gland pear-shaped, with anterior portion bulging well into pallial cavity; vas deferens thin, crossing body wall to enter base of penis, then running (as "penial duct") near centre of penis to penis tip; penis depigmented, cylindrical-conical or conical in shape, elliptical in transverse section, with sides wrinkled near base, bent upon itself inside pallial cavity; penis apex short, regularly tapering; penial lateral lobe/lobes absent; refringent glandular mass not seen inside penis by light microscope.

Female genitalia (figs. 44-45). — Ovary near apex of visceral sac, kidney-shaped; gonadal oviduct short; gonopericardial duct thin; renal oviduct wide and twisted on itself to form loop which adheres to proximal part of pallial oviduct; two seminal receptacles, equal in size, proximal (PSR or RS2) arising from renal oviduct at end of loop, bent outwards, distal (DSR or RS1) arising close to where renal oviduct enters pallial oviduct (far from end of loop); bursa copulatrix wide, oval in shape, situated behind albumen gland portion of pallial oviduct, with duct rather long entering bursa at distal (anterior) margin; pallial oviduct bulging well into pallial cavity, consisting of albumen and capsule glands; capsule gland with internal ventral channel, opening into small gonopore not far from margin of pallial cavity.

Radula (figs. 53-57). — Taenioglossate, with many rows of seven teeth. Radular formula: C = 5 + 1 + 5/ 1 + 1; L = 4+1+4; M1 = 20-22; M2 = 12-15. Central teeth butterfly-shaped, with long slender lateral wings and body extending downwards to form plough-shaped projection; apical margin V-like, with row of 11 denticles, central longer than laterals, lateral denticles progressively diminishing in size; one basal cusp at base of each lateral wing. Lateral teeth with elongate body and anterior margin with 9 denticles, central longer. Inner (first) marginal teeth rake-shaped, with elongate body and long apex with row of 20-22 denticles on anterior margin. Outer (second) marginal teeth with elongate body and spoon-shaped apex with row of approximately 12-15 denticles on lateroposterior margin.

Stomach and intestine (figs. 42, 44). — Stomach without gastric caecum; first portion of intestine running along wall of style sac, then forming first U-like loop near stomach

and second S-like loop on pallial wall; rectal portion of intestine straight; anal opening near pallial margin.

Osphradium and ctenidium (figs. 42, 44). — Osphradium oval, near pallial margin; ctenidium absent.

Type locality. — Plentiful karstic spring "Su Cologone" at San Giovanni, 100 m a.s.l. (Oliena, Nuoro). UTM references: 32T NK 4260.

Type material. — Holotype (shell) from the type locality, M. Bodon leg. 24.III.89, in the malacological collection of the Museo Zoologico "La Specola", Università di Firenze (MZUF no. 11580) and 164 paratypes, M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86 (44 shells), M. Bodon leg. 24.III.89 (105 shells and 14 spirit specimens, MZUF no. 11581 [3 shells]), S. Cianfanelli & E. Talenti leg. 29.X.95 (1 shell, MZUF no. 11559).

Etymology. — From the clear spiral grooves on the teleoconch surface (*sulcatus*, *-a*, *-um*, Latin for grooved).

Discussion. — Besides *Sardohoratia sulcata*, two other species can be assigned to *Sardohoratia*: *S. islamioides* nov. spec. and the fossil "*Sardohoratia*" *sarda* (Esu, 1984).

The two recent species are easily distinguished from each other. They have quite different shell shapes and some anatomical differences; their coexistence in the same karstic system and the absence of intermediate specimens supports the status of species.

S. sulcata has a globose shell with small umbilicus, ovoid aperture and deep spiral grooves on the teleoconch. All the specimens examined lack a ctenidium and have two seminal receptacles equal in size. *S. islamioides* has a depressed shell, with wide umbilicus, roundish aperture and without deep spiral grooves on the teleoconch. All the specimens examined have a ctenidium and the proximal seminal receptacle (PSR or RS2) smaller than the distal one (DSR or RS1).

The fossil *?Islamia sarda*, from the Lower Pliocene of Mandriola (Sinis, western Sardinia), probably belongs to *Sardohoratia* because recent species of *Islamia* have never been found in Sardinia. Moreover, although it has a shell-shape very similar to that of *S. sulcata*, we prefer to keep the two species distinct because the shells of the latter are larger (height 1.0-1.5 mm; diameter 1.2-1.5 mm; Esu, 1984: 29) than those of *S. sulcata* and only have growth lines on the teleoconch surface (Esu, 1984, 28-29: figs. 6-8). It is obviously difficult to infer the taxonomic status and affinities of a fossil taxon (especially in the hydrobiids) because only shell characters are available. Our conclusion is therefore only tentative.

***Sardohoratia islamioides* nov. spec.**

Diagnosis. — A species of *Sardohoratia* having a very small, valvatoid, depressed shell with the spire slightly raised to flat, aperture roundish, umbilicus wide (about 1/4-1/5 of shell diameter) and surface of teleoconch without spiral grooves; female genitalia with two seminal receptacles, the proximal one (PSR or RS2) smaller than the distal one (DSR or RS1); ctenidium present.

Shell (figs. 31-33, 38-39). — Very small, valvatoid, depressed, thin, waxen, whitish and translucent when fresh; spire slightly raised to flat, consisting of 2½-3 convex and rapidly growing whorls, last whorl wide, not or slightly descending, slightly dilated near aperture; sutures deep; aperture roundish, slightly oblique; peristome continuous, adhering to last whorl, thin, not sinuous at upper external margin, very slightly reflected at lower and columellar margin; umbilicus open, wide, about 1/4-1/5 of shell diam-

eter; surface of protoconch markedly malleated (fig. 38); surface of teleoconch rather smooth, with very fine, longitudinal (axial) lines (figs. 31-33, 39).

Dimensions (table 1). — Shell diameter: 0.92 – 1.52 mm; shell height: 0.60 – 1.03 mm; aperture height: 0.44 – 0.69 mm; aperture diameter: 0.42 – 0.66 mm.

Operculum (fig. 46). — Differs from that of *S. sulcata* only in slightly more rounded contour.

Body (fig. 47). — Similar to that of *S. sulcata*, except for occasional presence of a few traces of pigment on walls of visceral sac.

Male genitalia (figs. 47, 49-50). — Similar to those described for *S. sulcata*.

Female genitalia (figs. 51-52). — Similar to those described in *S. sulcata*, except that the proximal seminal receptacle is smaller than the distal one.

Radula (figs. 58-62). — Similar to that described for *S. sulcata*, but slightly different in the number of denticles on individual teeth. The radular formula is: C = 4-5 + 1 + 4-5 / 1 + 1; L = 4+1+5; M1 = 26-28; M2 = 12-14. Central teeth have apical margin with row of 9-11 denticles; lateral teeth have anterior margin with 10 denticles; inner (first) marginal teeth have row of 26-28 denticles on anterior margin of apex; outer (second) marginal teeth with approximately 12-14 denticles on latero-posterior margin of apex.

Stomach and intestine (figs. 48-49, 51). — Similar to those of *S. sulcata*.

Osphradium and ctenidium (figs. 49, 51). — Osphradium similar to that described for *S. sulcata*; ctenidium present, consisting of a variable number (2-8) of branchial lamellae.

Type locality. — Plentiful karstic spring "Su Cologone" at San Giovanni, 100 m a.s.l. (Oliena, Nuoro). UTM references: 32T NK 4260.

Type material. — Holotype (shell) from the type locality, M. Bodon leg. 24.III.89, in the malacological collection of the Museo Zoologico "La Specola", Università di Firenze (MZUF no. 11579) and 142 paratypes: M. Bodon, L. Castagnolo, F. Giusti & G. Manganelli leg. 26.IV.85 (1 shell), M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86 (26 shells), M. Bodon leg. 24.III.89 (53 shells and 62 spirit specimens, MZUF no. 11582 [3 shells]).

Other material examined. — Spring on right bank of Cedrino river, S. Leonardo, about 3 Km upstream of Orosei, 5 m a.s.l. (Onifai, Nuoro), 32T NK 5771, M. Bodon, L. Castagnolo, F. Giusti & G. Manganelli leg. 27.IV.85 (1 juv. shell). Spring San Giuseppe, Siniscola, alluvial spring outside the main entrance, 55 m a.s.l. (Siniscola, Nuoro), 32T NK 5790, M. Bodon leg. 24.III.89 (4 shells).

Because the attribution of this material to *S. islamioides* needs to be confirmed by future anatomical studies, these shells do not have the status of paratypes.

Etymology. — From *Islamia*, a genus with many species having a similar valvatoid shell.

Discussion. — For differential analysis with respect to *S. sulcata*, see the discussion of the latter. *S. islamioides* is easily distinguished from the fossil "*S.*" *sarda* (Esu, 1984), by its smaller, more depressed and fragile shell.

HABITAT, STATUS AND CONSERVATION

The three species described herein are strict stygobionts, with a limited range. Prudent management of the karstic system in which they live is therefore necessary to ensure their survival. *Sardopaladilhia plagigeyrica*, apparently restricted to slow flowing,

underground karstic waters, may not be particularly threatened by potential pollution and exploitation. On the contrary, *Sardohoratia sulcata* and *S. islamioides* which live in interstitial waters (probably only in the external part of the karstic spring Su Cologone), run a higher risk of extinction. It is worrying that so far no living specimens of *Sardohoratia* have been found in the spring Su Cologone, since the spring was exploited and its bottom cemented (*S. sulcata* has never been found at other sites). *S. sulcata* and *S. islamioides* can therefore be defined as threatened, even in the absence of adequate data for an explicit classification (IUCN, 1994) of the risk of extinction.

ACKNOWLEDGEMENTS

Our thanks to C. Carletti and G. Masuri for material from some caves in Sardinia, to M. Ulivi for technical assistance, and to H. Ampt for revising the English text.

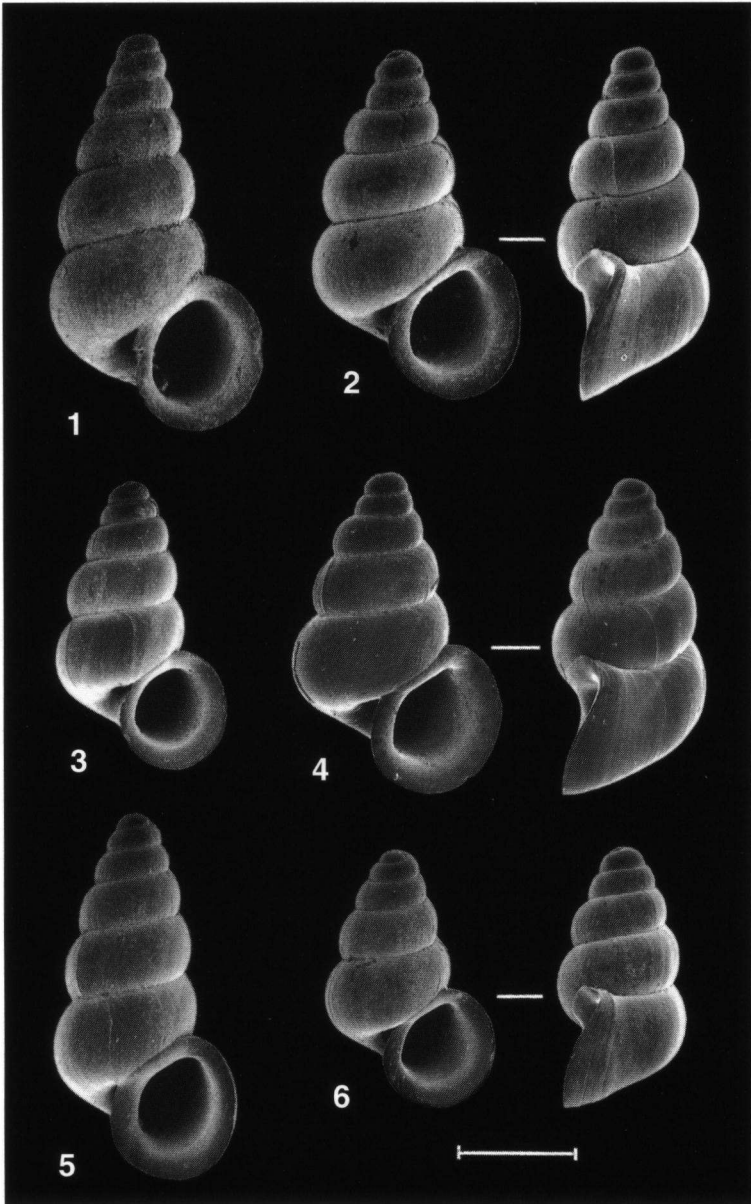
The research was financed in part by grants from the CNR (Sistemática e Zoogeografia della Regione Palearctica), the MURST (40% and 60% funds) and the Museo Zoologico de "La Specola" (Firenze).

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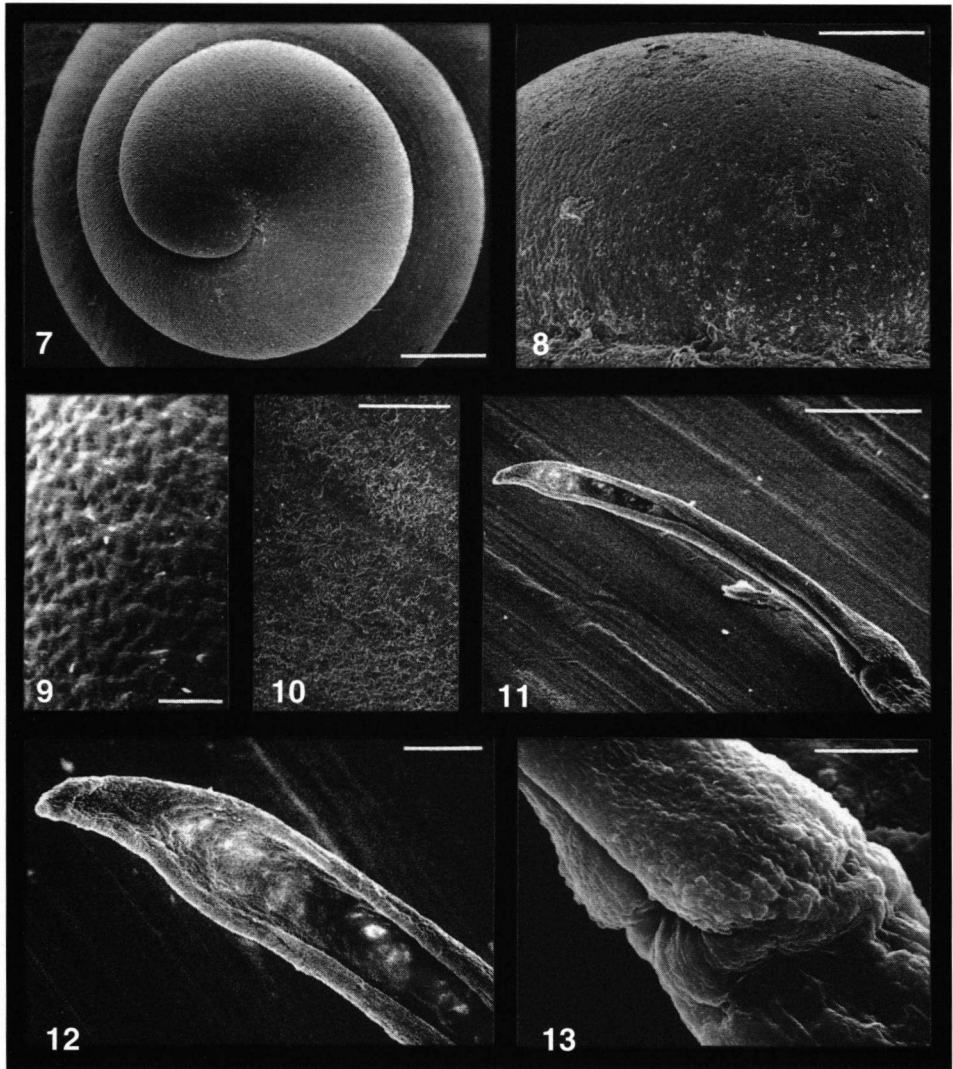
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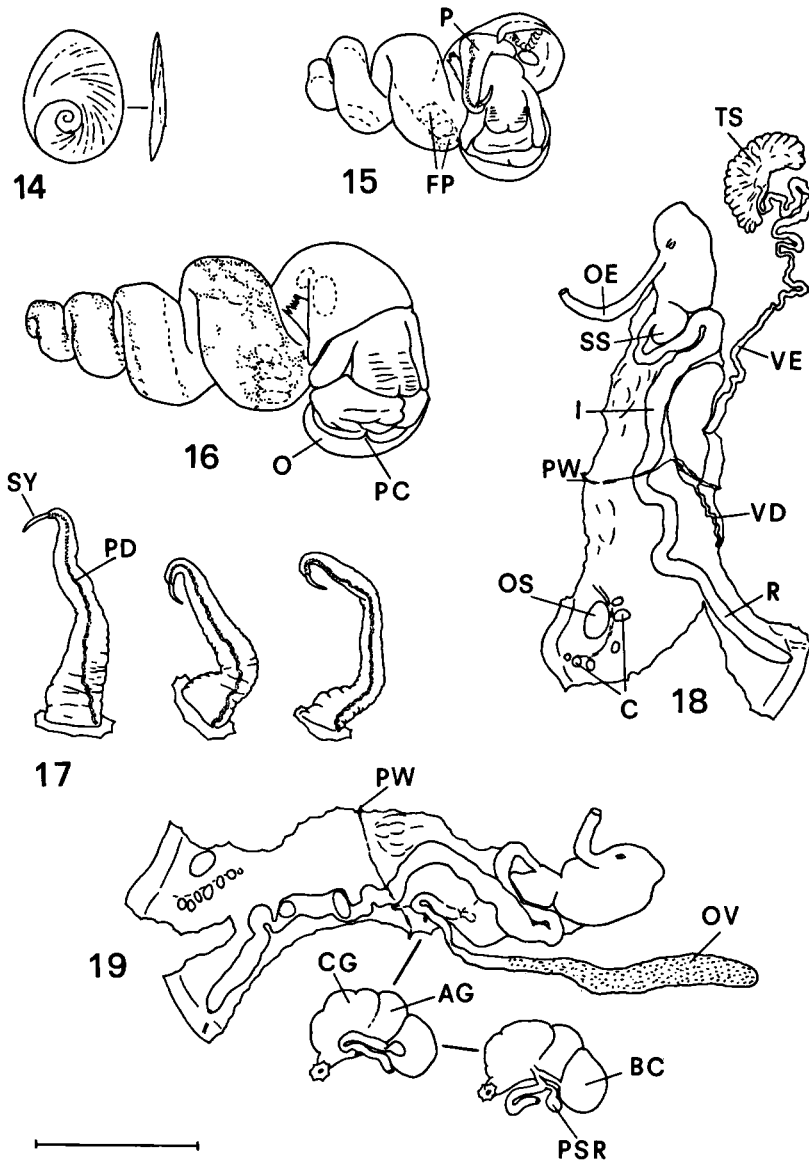
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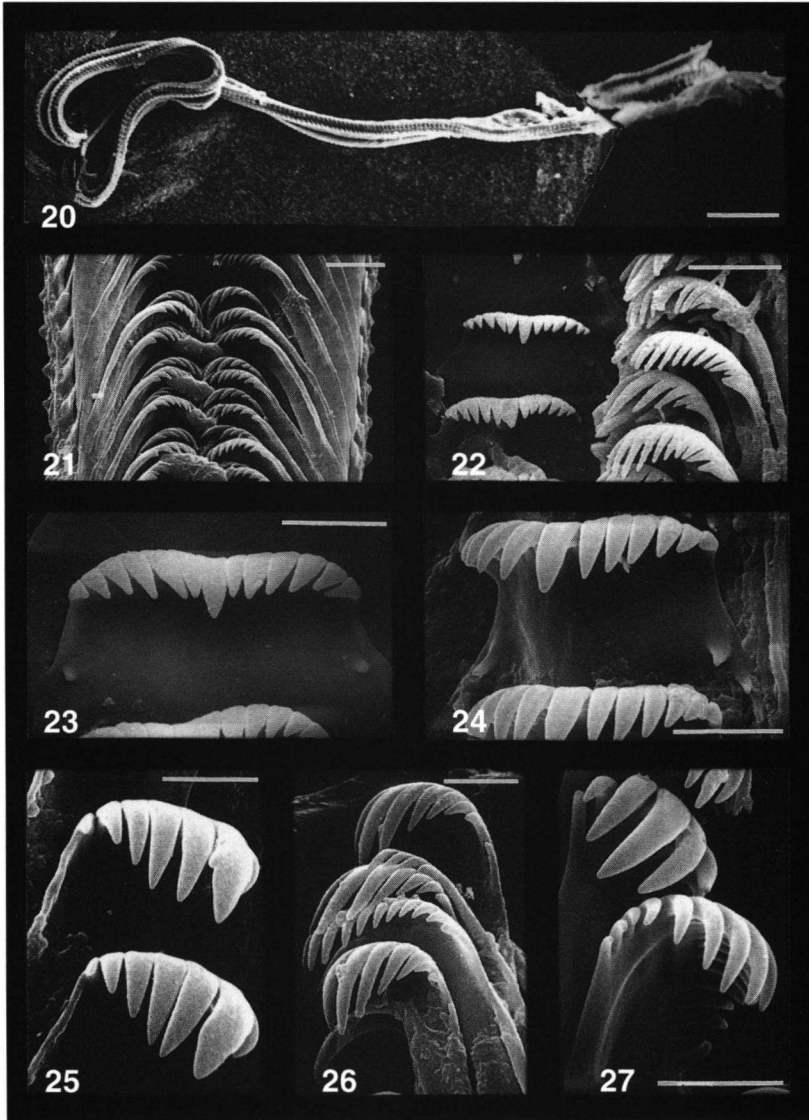
Figs. 1-6. Shells of paratypes of *Sardopaladilhia plagigeyrica* nov. spec. from the spring "Su Cologone", M. Bodon F. Giusti & G. Manganeli leg. 22.XI.86 (MZUF no. 11578). Scale bars 1 mm.



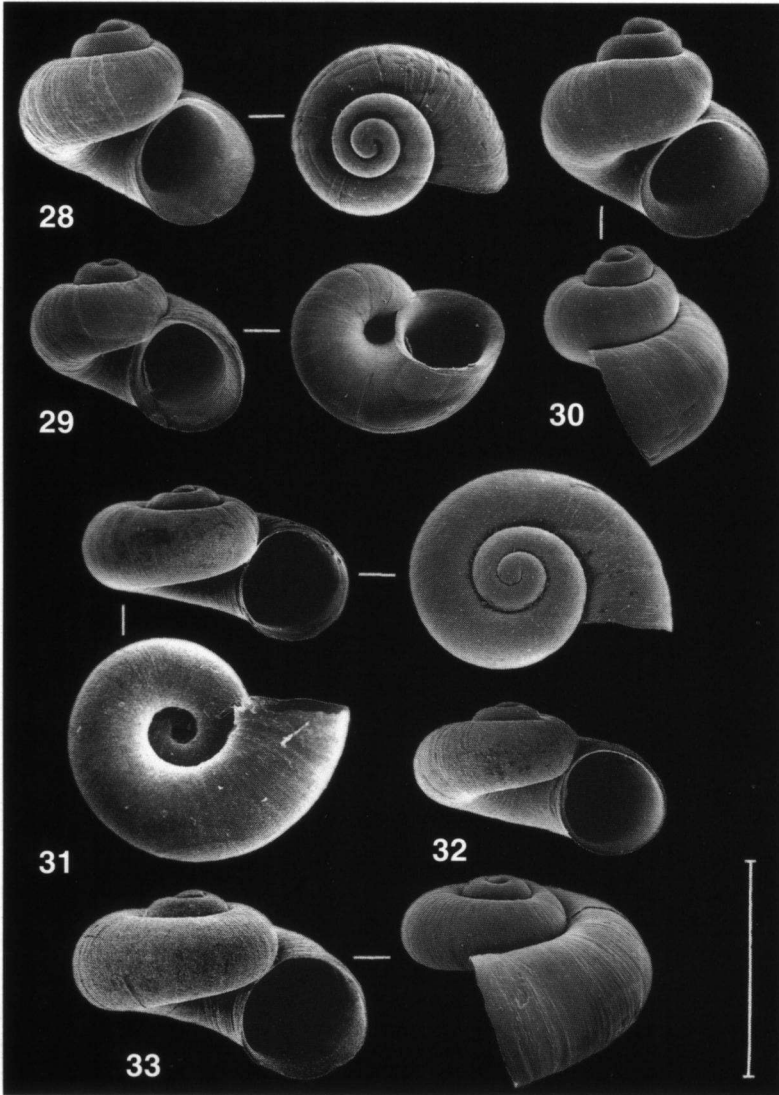
Figs. 7-13. Details of shell (figs. 7-10) and penial stylet (figs. 11-13) in paratypes of *Sardopaladilthia plagigeyrica* nov. spec. from spring "Su Cologone", M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86 (figs. 8, 10) and Cave "Sa Oche", S. Cianfanelli, G. Masuri & E. Talenti leg. 28.X.95 (figs. 7, 9, 11-13). Protoconch and first whorls of teleoconch seen from above (fig. 7), lateral view of protoconch (fig. 8); detail of protoconch microsculpture (fig. 9); detail of teleoconch surface (fig. 10); penial stylet (fig. 11); tip of penial stylet (fig. 12); base of penial stylet (fig. 13). Scale bars 100 μm (fig. 7), 50 μm (figs. 8, 10-11), 10 μm (figs. 9, 12-13).



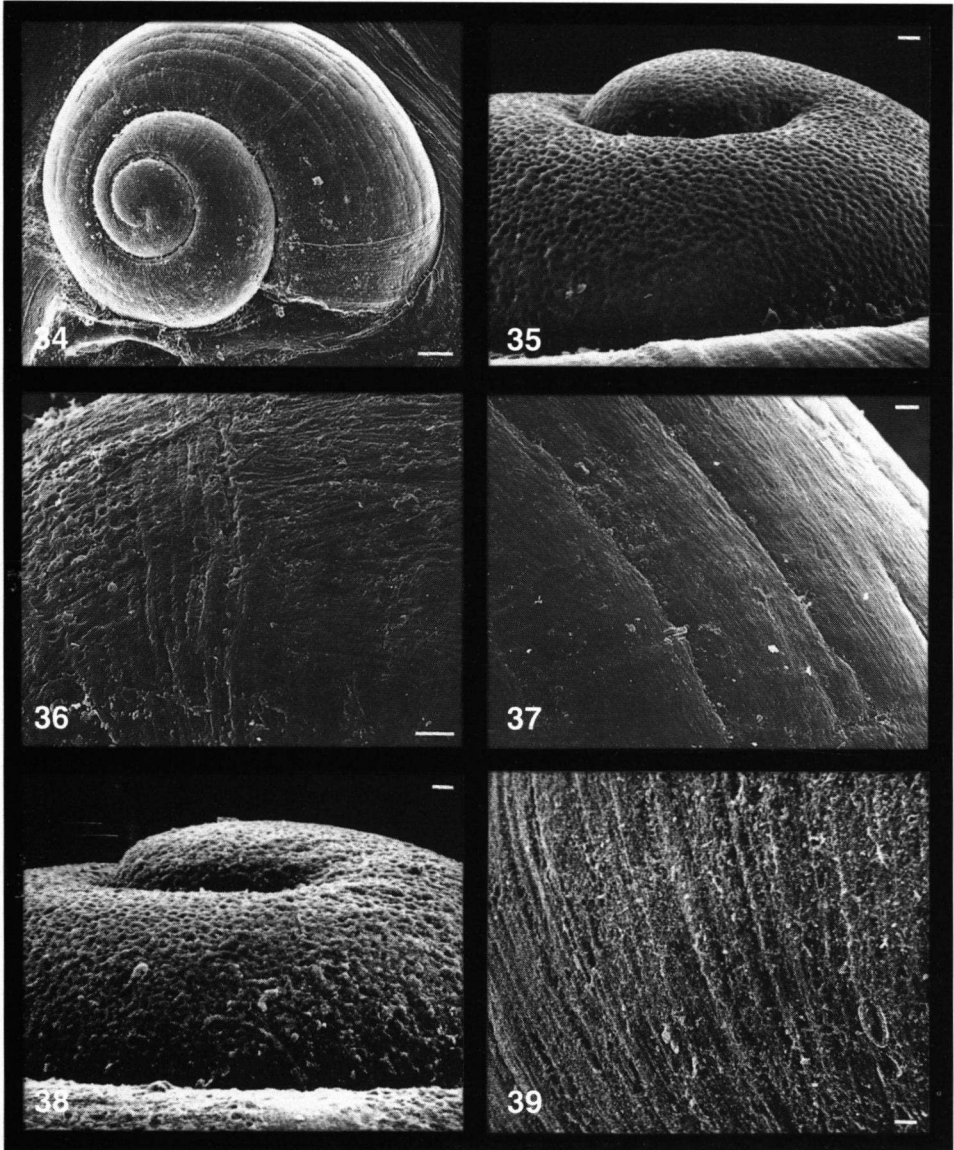
Figs. 14-19. Operculum and anatomy of *Sardopaladilhia plagigeyrica* nov. spec. from the cave "Sa Oche", M. Bodon leg. 26.III.89 and S. Cianfanelli, G. Masuri & E. Talenti leg. 28.X.95 (fig. 14, 16-19) and the cave "Bue Marino", G. Masuri leg. 18.XI.95 (fig. 15). External and lateral views of operculum (fig. 14); bodies of males with pallial cavity closed (fig. 16) and open to show head and penis (fig. 15); penis of three different males (fig. 17); male genitalia (penis excluded), stomach, intestine and pallial organs (fig. 18); female genitalia, stomach, intestine and pallial organs (fig. 19). For acronyms, see Material and Methods. Scale bar 1 mm.



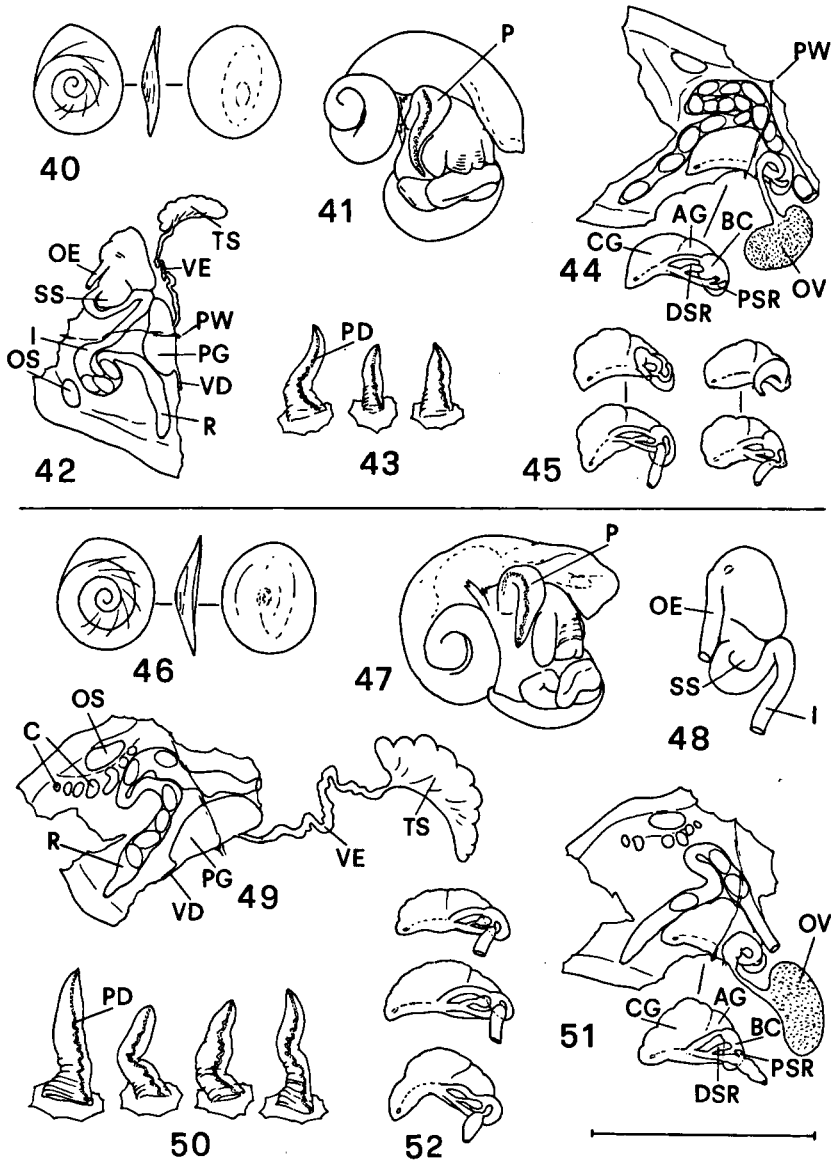
Figs. 20-27. Radula of paratypes of *Sardopaladilhia plagigeyrica* nov. spec. from the cave "Sa Oche", S. Cianfanelli, G. Masuri & E. Talenti leg. 28.X.95. Note peculiar length of the radular ribbon (fig. 20); two views of median portion of the radula (figs. 21-22) (central and lateral teeth not visible in fig. 21 and lateral teeth not visible in fig. 22); central teeth (figs. 23-24) with variable number of cusps at base of each lateral wing (1 in fig. 23; 3 in fig. 24); two lateral teeth (fig. 25); three inner (first) (IM) and two outer (second) (OM) marginal teeth (fig. 26); inner (IM) and outer (OM) marginal teeth (fig. 27). Scale bars 100 μ m (fig. 20), 10 μ m (figs. 21-22), 5 μ m (figs. 23-27).



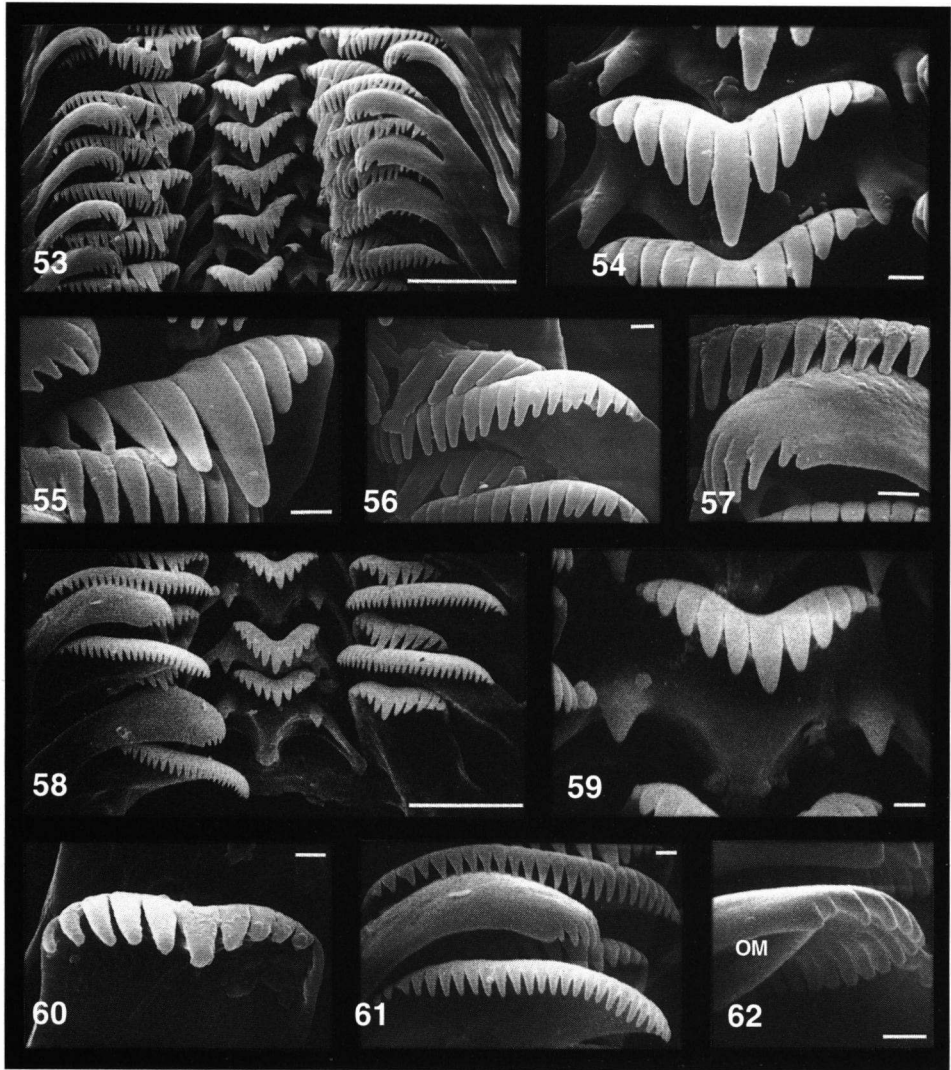
Figs. 28-33. Shells of paratypes of *Sardohoratia sulcata* nov. spec. (figs. 28-30; MZUF 11581) and *Sardohoratia islamioides* nov. spec. (figs. 31-33; MZUF 11582) from the spring "Su Cologone", M. Bodon leg. 24.III.89. Scale bar 1 mm.



Figs. 34-39. Details of shells of paratypes of *Sardohoratia sulcata* nov. spec. (figs. 34-37) and *Sardohoratia islamioides* nov. spec. (figs. 38-39) from the spring "Su Cologone", M. Bodon, F. Giusti & G. Manganelli leg. 22.XI.86 (figs. 34, 36-37), and M. Bodon leg. 24.III.89 (figs. 35, 38-39). Shell seen from above (fig. 34); detail of protoconch (figs. 35, 38); detail at border between protoconch and teleoconch (fig. 36); detail of teleoconch surface (figs. 37, 39). Scale bars 100 μ m (fig. 34), 10 μ m (figs. 35-39).



Figs. 40-52. Operculum and anatomy of *Sardohoratia sulcata* nov. spec. (figs. 40-45) and *Sardohoratia islamioides* nov. spec. (figs. 46-52) from the spring "Su Cologone", M. Bodon leg. 24.III.89. External, lateral and internal views of operculum (figs. 40, 46); body of males with pallial cavity open to show head and penis (figs. 41, 47); male genitalia (penis excluded), stomach (excluded in fig. 49), intestine and pallial organs (figs. 42, 49); penis in various males (figs. 43, 50); female genitalia, intestine and pallial organs (figs. 44, 51); renal and pallial oviduct in various females (figs. 45, 52); stomach (fig. 48). For acronyms, see Material and Methods. Scale bar 1 mm.



Figs. 53-62. Radula of paratypes of *Sardohoratia sulcata* nov. spec. (figs. 53-57) and *Sardohoratia islamioides* nov. spec. (figs. 58-62) from the spring "Su Cologone", M. Bodon leg. 24.III.89. General views of portion of radula (figs. 53, 58); central teeth showing one cusp at base of each lateral wing (figs. 54, 59); lateral teeth (L) (figs. 55, 60); inner (first) marginal teeth (IM) (figs. 56, 61); outer (second) marginal teeth (OM) (figs. 57, 62). Scale bars 10 μm (figs. 53, 58), 1 μm (figs. 54-57, 59-62).