

REVISION OF “*HAUFFENIA JADERTINA*” KUŠČER 1933, AND DESCRIPTION OF A NEW SPECIES FROM PAG ISLAND, CROATIA (GASTROPODA: HYDROBIIDAE)

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Abstract *Hauffenia jadertina* Kuščer 1933, is revised using material from the type localities and others from Croatia, mostly from the Cetina valley. On the basis of anatomical characters it is attributed to the genus *Kerkia* Radoman 1978. *Hauffenia jadertina sinjana* Kuščer 1933, is synonymized with *Kerkia jadertina*. A new species, attributed to the same genus, *Kerkia kareli* n. sp., is described from Pag Island in the northern Adriatic Sea (Croatia). It inhabits phreatic waters and, until now, it has been collected only in three wells situated on the island. In this paper, a detailed description of the two species is given.

Key words *Gastropoda*, *valvatiform Hydrobiidae*, *Kerkia*, *taxonomy*, *Croatia*

INTRODUCTION

In the summer of 2011, while carrying out faunistic research on Pag Island (Croatia), the first author found an unidentified valvatiform hydrobiid in a well. Following dissection, it was established that it does not belong to the genus *Hauffenia* Pollonera, 1893, a valvatiform hydrobiid genus very prevalent in the northern Balkans and in particular Croatia. Additional material was collected during another visit in the winter of 2011 to the same locality, and in other two wells on the island. The study of this new material, examining different characteristics, has confirmed that it belongs to an undescribed species, related, apparently, to the genus *Arganiella* Giusti & Pezzoli 1980.

In Croatia some valvatiform hydrobiids are present but two of them are poorly known: “*Hauffenia jadertina*” Kuščer 1933; and “*Hauffenia jadertina sinjana*” Kuščer 1933. New research from the type localities of these hydrobiids and in other sites has enabled new material to be collected to clarify the synonymy and the taxonomic position of the two taxa and to confirm the validity of a new species from Pag Island.

MATERIAL AND METHODS

Shells and specimens were obtained by washing vegetation, algae, stones, wood and artificial materials (e.g. plastic bags and bottles)

or sediment from springs or wells, extracted using a nylon net or a metal sieve, in some cases mounted on a 3 m handle. Specimens were fixed in 70–80% ethanol.

Preserved specimens were studied by light stereomicroscopy. Bodies were isolated after crushing the shells and were dissected using very fine, pointed watchmaker’s forceps. Images of the body and isolated parts of the genitalia were drawn using a camera lucida. Radulae were obtained by dissecting out buccal bulbs, washed in distilled water, mounted on copper blocks, sputter-coated with gold and photographed using a scanning electron microscope. The protoconch was photographed using a scanning electron microscope, whereas shells were photographed under a light microscope.

SPECIES DESCRIPTIONS

Kerkia jadertina (Kuščer 1933)

Hauffenia jadertina Kuščer, 1933a: 60–62, fig. 1.

Hauffenia jadertina sinjana Kuščer, 1933a: 61–62, fig. 2.

Hauffenia jadertina Kuščer, 1933b: 137–138, fig. 1.

Hauffenia jadertina sinjana Kuščer, 1933b: 138, fig. 2.

Hauffenia (*Hauffenia*) *jadertina*, Willmann & Pieper, 1978: 127.

Hauffenia (*Hauffenia*) *jadertina*, Bole & Velkovrh, 1986: 192.

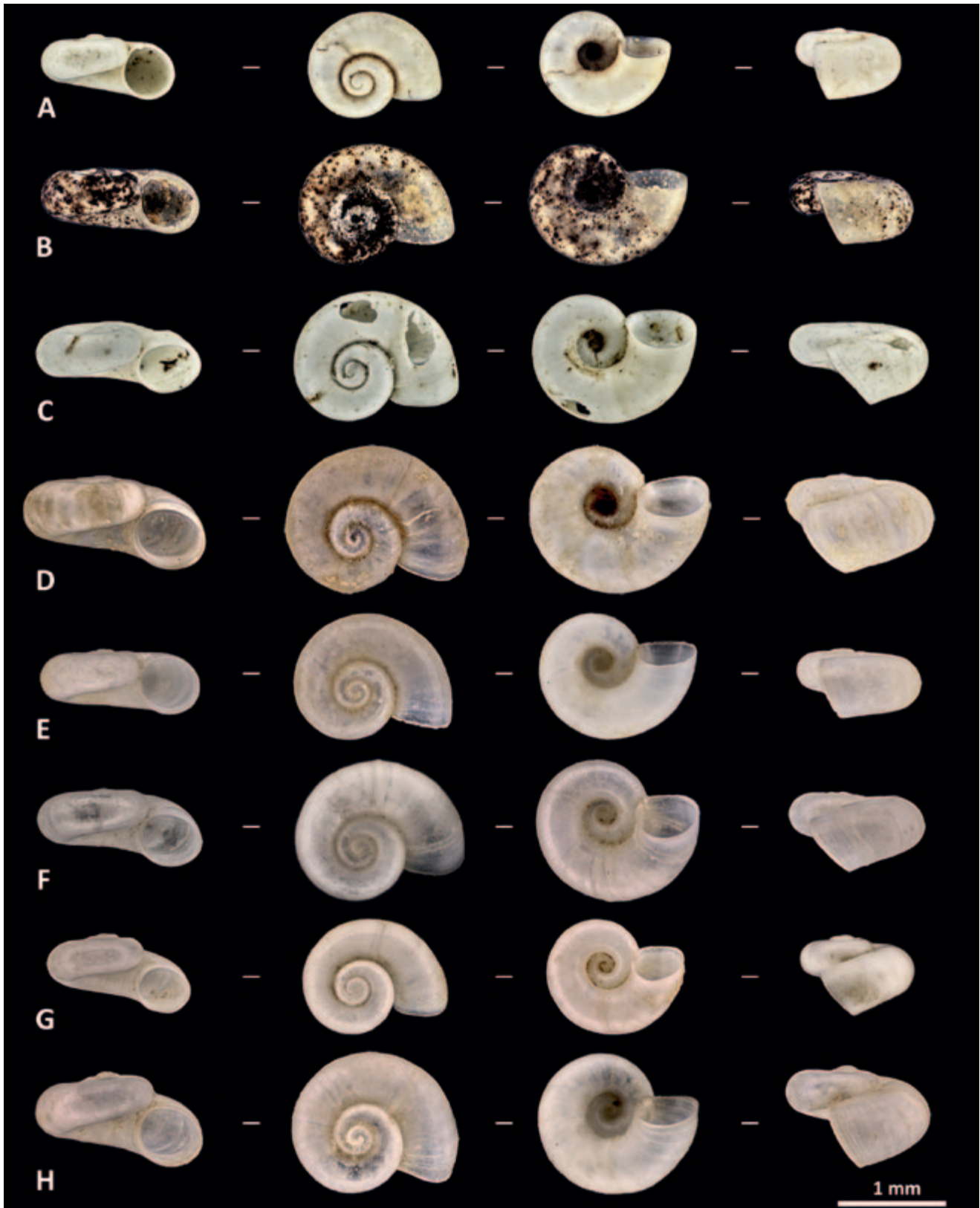


Figure 1 Shells of *Kerkia jadertina* (Kuščer 1933). A–B: topotypes of “*Hauffenia jadertina*” collected in the Izvor Jadra near Split (Croatia), M. Bodon & E. Bodon leg. 06/04/2012 (coll. MZUF GC/42988). C: topotype of “*Hauffenia sinjana*” collected at Žužino Vrelo in the Cetina valley (Croatia), M. Bodon & E. Bodon leg. 06/04/2012 (coll. MZUF GC/42987). D–H: shells collected in the spring of the fountain in front of Podgrade (Croatia), M. Bodon & E. Bodon leg. 08/04/2012 (coll. MZUF GC/41812).

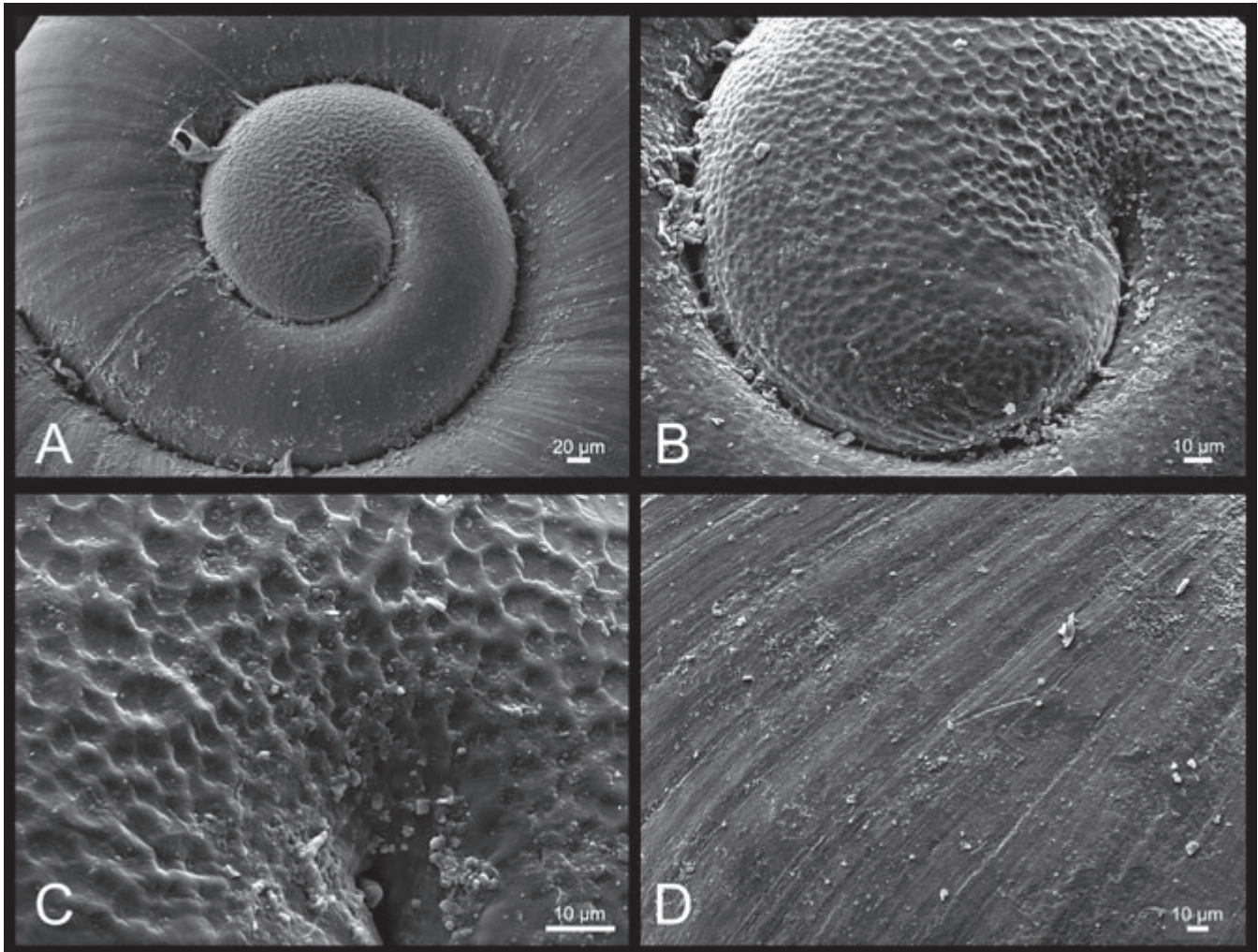


Figure 2 Protoconch and teleoconch of *Kerkia jadertina* (Kuščer 1933). A: protoconch and first whorls. B: protoconch. C: magnification of protoconch. D: magnification of teleoconch on the third whorl. Shells collected in the spring of the fountain in front of Podgrade (Croatia), M. Bodon & E. Bodon leg. 08/04/2012 (coll. MZUF GC/41812 stub SEM MZ/250).

Hauffenia (*Hauffenia*) *sinjana*, Bole & Velkovrh, 1986: 192.

"*Hauffenia*" *jadertina*, Bodon *et al.*, 2001: 175, 178.

"*Hauffenia*" *sinjana*, Bodon *et al.*, 2001: 176, 178.

Hauffenia jadertina, Rađa, 2002: 31.

Hauffenia sinjana, Rađa, 2002: 31.

Hauffenia jadertina, Bilandzija & Jalzic, 2010.

Hauffenia jadertina, Cuttelod *et al.*, 2011: 56.

Hauffenia jadertina jadertina, Bank, 2011: 13.

Hauffenia jadertina sinjana, Bank, 2011: 13.

Hauffenia jadertina, Ozimec, 2011.

Hauffenia jadertina jadertina, Bank, 2013.

Hauffenia jadertina sinjana, Bank, 2013.

Type localities "*Hauffenia jadertina*": "vrelo Izvor v dolini Jadre" (Kuščer, 1933a), i.e. spring in Jadro valley near Split (Croatia) (Bole & Velkovrh,

1986); "*Hauffenia jadertina sinjana*": "Žužino vrelo pri Sinju" (Kuščer, 1933a), i.e. Žužino spring near Sinj (Bole & Velkovrh, 1986).

Type material No type material is present in the collection of the Zoological Institute of Ljubljana University (B. Sket, personal communication 07/05/2012) and in the Museum of Natural History of Trieste (A. Colla, personal communication 30/05/2013).

Diagnosis Shell very small, depressed valviform to almost planispiral, spire slightly raised, umbilicus very wide. Male genitalia with penis rather small, cylindrical, with slender and narrow apex, with a small lobe on left side, then a little dilated before apex, where a refractive area

is present. Female genitalia with loop leaning against pallial oviduct; only one seminal receptacle, distal one (RS1), with long stalk, and a rather large bursa copulatrix, round to oval, with slender, long duct, entering bursa on the anterior side. Radula with central tooth with 2–3 basal cusps on each side.

Shell (Figs 1, 2) Very small, depressed valvati-form to almost planispiral, whitish, waxy and transparent when fresh, consisting of $2\frac{3}{4}$ – $3\frac{1}{4}$ rapidly expanding convex whorls. Spire slightly raised; last whorl very large, with terminal portion often descending near aperture; sutures deep. Aperture prosocline, roundish to oval; peristome complete, rather thin, in contact or slightly detached from the wall of last whorl, slightly reflected only at columellar margin, external margin not sinuous. Umbilicus very wide, about $\frac{1}{3}$ shell major diameter. Surface of protoconch malleated; surface of teleoconch rather smooth, with fine growth lines.

Dimensions (Table 1): shell height, 0.48–1.00 mm; shell major diameter, 1.08–1.77 mm; aperture height, 0.48–0.81 mm; aperture diameter, 0.43–0.71 mm.

Operculum (Fig. 3 A) Corneous, paucispiral, thin, pale, yellowish in colour, with subcentral nucleus and without peg or thickening on inner side.

Body (Fig. 3 B) Unpigmented, but with a few traces of blackish pigment on wall of visceral sac. Eyes spots absent.

Male genitalia (Fig. 3 C–E) Testis near apex of visceral sac; spermiduct convoluted; prostate gland slightly bulging into pallial cavity; vas efferens thin, starting at anterior end of prostate gland, crossing the body wall and entering penis. Penis small, unpigmented, cylindrical, with slender and narrow apex, with a small lobe on its left side and slightly dilated before apex, where a refractive area is visible at its inside. Penial duct zig-zagging through right portion of penis to open at penis tip.

Female genitalia (Fig. 3 G–H) Ovary near apex of visceral sac; gonadal oviduct thin. Renal oviduct wider, forming large loop after insertion of gonopericardial duct, leaning against pallial oviduct. Only one seminal receptacle, a distal one (RS1), with long stalk, its apex reaching wall of bursa

Table 1 Shell parameters of six populations of *Kerkia jadertina* (Kuščer 1933) from Dalmatian coast and of two populations of *Kerkia kareli* n. sp. from Pag Island (Croatia). Acronyms: H shell height; D shell major diameter; h mouth height (aperture major diameter); d mouth diameter (aperture minor diameter); N number of shells. Mean \pm standard deviation; min and max value in parenthesis.

Species	Locality	H	D	H/D	h	d	N
<i>K. jadertina</i>	Izvor Jadra, Solin, north of Split	0.64 (0.62–0.66)	1.43 (1.33–1.53)	0.45 (0.40–0.50)	0.61 (0.59–0.62)	0.57 (0.54–0.60)	2
<i>K. jadertina</i>	Žužino Vrelo, at NE of Hrvace, Sinj	0.74	1.61	0.74	0.65	0.46	1
<i>K. jadertina</i>	Spring of the fountain in front of Podgrade, Cetina valley	0.69 \pm 0.08 (0.55–0.91)	1.47 \pm 0.13 (1.24–1.77)	0.47 \pm 0.04 (0.40–0.57)	0.64 \pm 0.05 (0.56–0.76)	0.59 \pm 0.05 (0.50–0.71)	30
<i>K. jadertina</i>	Well near the church of Konjsko, west of Dugopolje	1.00	1.53	0.65	0.66	0.63	1
<i>K. jadertina</i>	Falls of Krka river near Skradin	0.59 \pm 0.08 (0.48–0.80)	1.29 \pm 0.11 (1.08–1.56)	0.45 \pm 0.03 (0.41–0.51)	0.57 \pm 0.06 (0.48–0.71)	0.52 \pm 0.05 (0.43–0.64)	24
<i>K. jadertina</i>	Well in garden of the house n° 39 in Ljubač near Ražanac	0.83 \pm 0.10 (0.71–0.95)	1.54 \pm 0.07 (1.46–1.68)	0.54 \pm 0.06 (0.45–0.61)	0.76 \pm 0.03 (0.71–0.81)	0.67 \pm 0.03 (0.64–0.70)	7
<i>K. kareli</i>	Well in fields in valley north-west of Kolan, Pag Island	0.74 \pm 0.07 (0.63–0.84)	1.44 \pm 0.10 (1.25–1.68)	0.51 \pm 0.05 (0.44–0.57)	0.66 \pm 0.04 (0.59–0.63)	0.60 \pm 0.03 (0.55–0.67)	15
<i>K. kareli</i>	Well by the local road ca. 400 m east of Sv. Nikola, Poveljana, Pag Island	0.75 \pm 0.08 (0.61–0.94)	1.48 \pm 0.11 (1.27–1.71)	0.51 \pm 0.04 (0.43–0.60)	0.70 \pm 0.05 (0.62–0.86)	0.63 \pm 0.05 (0.55–0.75)	40

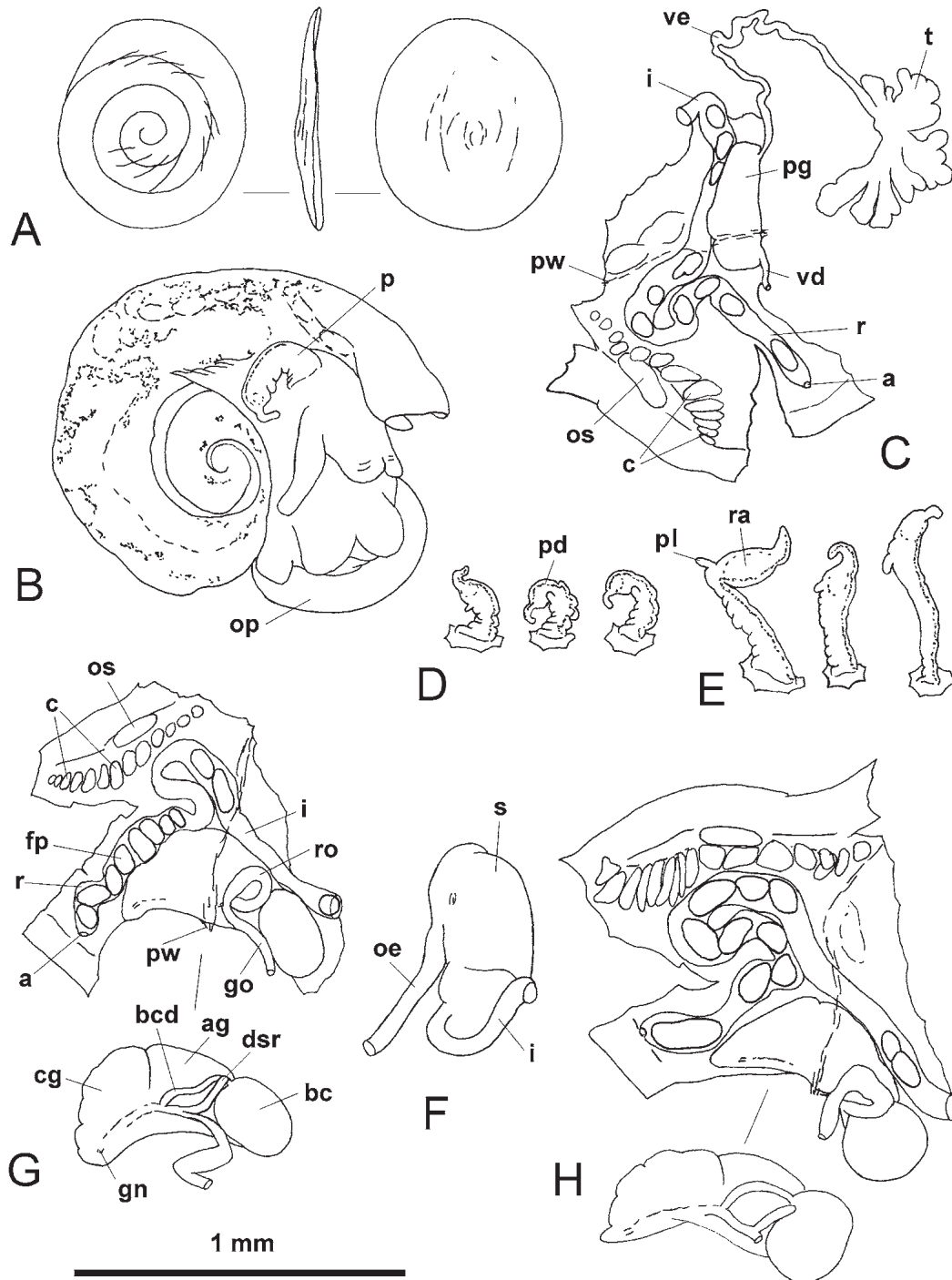


Figure 3 Operculum and anatomical details of *Kerkia jadertina* (Kuščer 1933). A: outer face (left), profile (centre) and inner face (right) of operculum. B: body of a male with pallial cavity open to show head and penis. C: intestine, testis, vas efferens, prostate gland and pallial organs of a male. D–E: penis of six males, from dorsal side. F: stomach. G–H: renal and pallial oviduct and pallial organs of two females, with the loop (upper), without the loop (lower). Specimens collected in the spring of the fountain in front of Podgrade (Croatia), M. Bodon & E. Bodon leg. 08/04/2012 (A, F, H); L. Beran leg. 03/07/2012 (B–D), and in the well in Ljubuč near Ražanac (Croatia), L. Beran leg. 05/07/2012 (E, G).

Acronyms: a anus; ag albumen gland; bc bursa copulatrix; bcd bursa copulatrix duct; c ctenidium; cg capsule gland; dsr distal (first) seminal receptacle; fp fecal pellets; go gonadal oviduct; gn gonopore; i intestine; o ovary; oe oesophagus; op operculum; os osphradium; p penis; pd penial duct; pl penial lobe; pg prostate gland; pw posterior wall of pallial cavity; r rectum; ra refringent area; ro renal oviduct; s stomach; t testis; vd vas deferens; ve vas efferens (seminal vesicle).

copulatrix. Bursa copulatrix rather large, round to oval, overlapping entire posterior portion of pallial oviduct, with long, slender duct, arched or slightly sinuous, entering bursa on anterior side. Pallial oviduct with albumen and capsule gland; seminal groove running along ventral side of capsule gland. Gonopore not far from the pallial margin.

Radula (Fig. 4) Taenioglossan, with many files of seven teeth, each with formula: C=6+1+6 / 2-3+2-3; L=5+1+6; M1=22-25; M2=17-19.

Central tooth trapezoidal, with long lateral wings and basal tongue, its cutting edge V-like, with long central denticle and 6 smaller denticles on both sides in decreasing order of size; two or three basal cusps at point where each lateral wing arises from face of central tooth, inner stronger; lateral teeth apically enlarged, their cutting edge with 12 denticles, central of which longer; first marginal teeth with long lateral wing and elongated apex, its cutting edge with long row of 22-25 long denticles; second marginal teeth with long slender lateral wing and roundish, spoon-like apex with cutting edge carrying rather long row of about 17-19 denticles.

Stomach and intestine (Fig. 3 C, F-H) Stomach without posterior caecum. Intestine with two bends, the first along the stomach, the second, a well developed S-like tight coil, on pallial wall; rectal tract straight, anus near pallial margin.

Osfradium and ctenidium (Fig. 3 C, G-H) Osfradium variable in size, oval or elongated, near pallial margin. Ctenidium consisting of 10-17 lamellae, well developed.

Localities and Material

Izvor Jadra or spring of the Jadro river, Solin, north of Split; plentiful karstic spring downstream of the intake, ca. 20 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 31' 11" E, 43° 32' 30" N, M. Bodon & E. Bodon leg. 06/04/2012 (4 empty shells).

Žužino Vrelo, at NE of Hrvace, Sinj; alluvial spring in fields, ca. 300 m a.s.l. (Splitsko-dalmatinska County, Croatia), 16° 38' 12" E, 43° 45' 14" N, M. Bodon & E. Bodon leg. 06/04/2012 (3 empty shells).

Brook at the bridge of the road north of Hrvace, Sinj, ca. 300 m a.s.l. (Splitsko-dalmatinska County,

Croatia), 16° 37' 54" E, 43° 45' 25" N, M. Bodon & E. Bodon leg. 06/04/2012 (3 empty shells).

Fountain along the road 300 m upstream the bridge on Cetina river in front of Podgrade, ca. 65 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 51' 59" E, 43° 25' 45" N, M. Bodon & E. Bodon leg. 08/04/2012 (18 empty shells).

Spring of the fountain along the road 300 m upstream the bridge on Cetina river in front of Podgrade, ca. 65 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 51' 59" E, 43° 25' 42" N, M. Bodon & E. Bodon leg. 08/04/2012 (1 specimen and 223 empty shells), L. Beran leg. 03/07/2012 (30 specimens and 17 empty shells).

Cetina river, 600 m downstream the bridge in front of Podgrade, debris, ca. 45 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 51' 24" E, 43° 25' 42" N, M. Bodon & E. Bodon leg. 08/04/2012 (5 empty shells).

Spring brook near Radmanove mlinice, that flows as a small fall near the right bank of Cetina river, ca. 20 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 45' 18" E, 43° 26' 12" N, M. Bodon & E. Bodon leg. 08/04/2012 (1 empty shell).

Mouth of Cetina river, Omiš, debris, 0 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 41' 14" E, 43° 26' 19" N, M. Bodon & E. Bodon leg. 08/04/2012 (2 empty shells).

Well near the church of Konjsko, west of Dugopolje, ca. 180 m a.s.l. (Splitsko-Dalmatinska County, Croatia), 16° 29' 18,3" E, 43° 35' 34,6" N, L. Beran leg. 03/07/2012 (1 empty shell).

Falls of Krka river near Skradin, ca. 5 m a.s.l. (Šibensko-Kninska County, Croatia), 15° 57' 50" E, 43° 48' 19" N, W.J.M. Maassen leg. 05/1983 (37 empty shells).

Well in garden of the house n° 39 in Ljubač near Ražanac, ca. 35 m a.s.l. (Zadarska County, Croatia), 15° 17' 53" E, 44° 15' 37" N, L. Beran leg. 05/07/2012 (20 specimens).

Topotypes from Izvor Jadra, from Žužino Vrelo and part of the material from the spring of the fountain in front of Podgrade are deposited in the Museum of Natural History, Zoological section "La Specola" University of Florence (MZUF: GC/42988, 4 shells, M. Bodon & E. Bodon leg. 06/04/2012; MZUF: GC/42987, 3 shells, M. Bodon & E. Bodon leg. 06/04/2012; MZUF: GC/41812, 30 shells, M. Bodon & E. Bodon leg. 08/04/2012; GC/41812 stub SEM MZ/250, 4 juv.

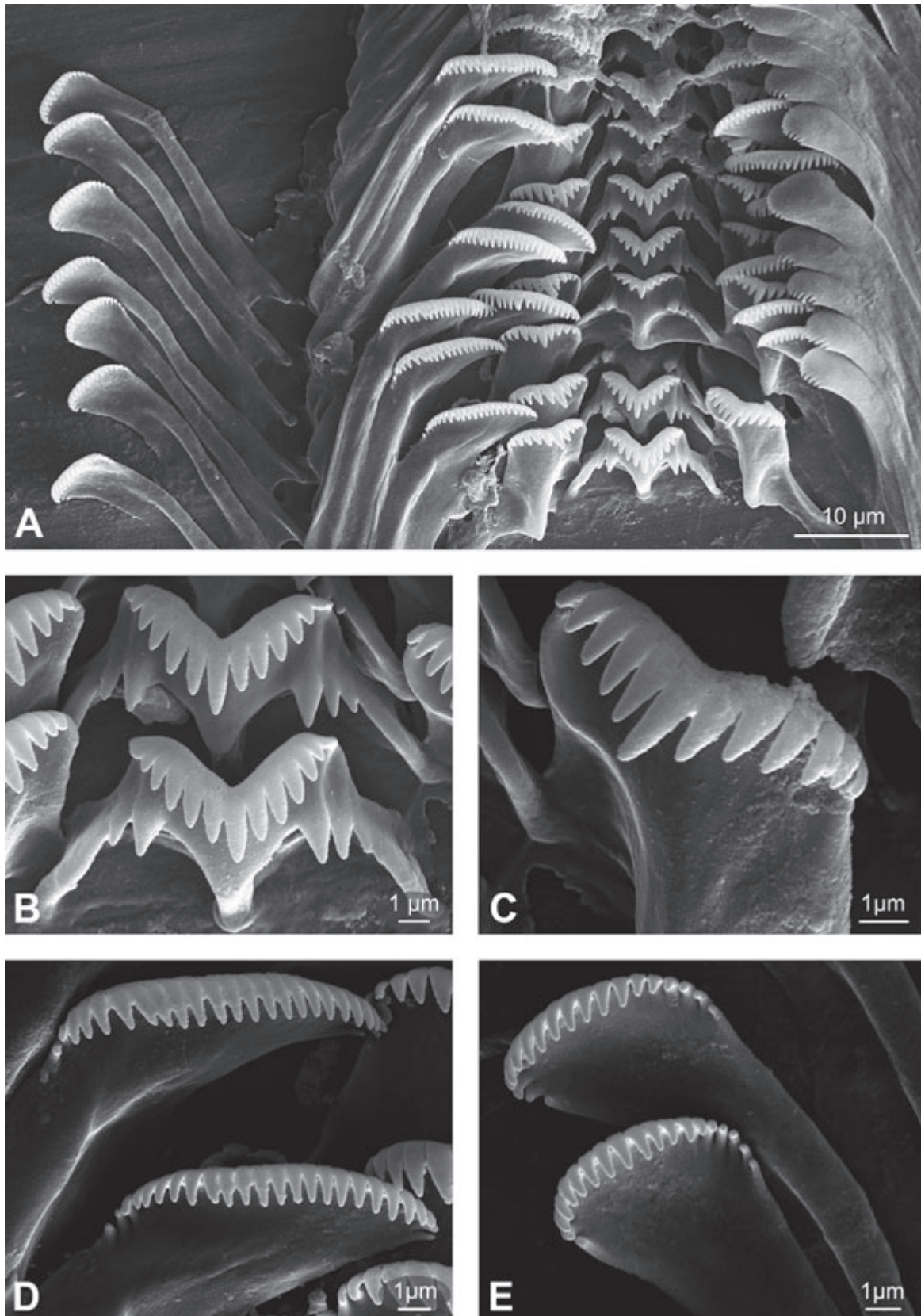


Figure 4 Radula of *Kerkia jadertina* (Kuščer 1933). A: central portion of radula. B: detail of two central teeth. C: magnification of a lateral tooth. E: magnification of two inner marginal teeth. F: detail of two outer marginal teeth. Specimen collected in the spring of the fountain in front of Podgrade (Croatia), L. Beran leg. 03/07/2012 (coll. MZUF GC/42614 stub SEM MB/83).

shells, M. Bodon & E. Bodon leg. 08/04/2012; GC/42614, 6 dissected specimens and 31 undissected specimens, L. Beran leg. 03/07/2012; GC/42614 stub SEM MB/83, radula, L. Beran leg. 03/07/2012); rest of material is deposited in authors' collections.

Habitat and distribution This species inhabits karstic waters and it is spread along the Dalmatian coast, from Ljubač in NW to Cetina valley in SE (Fig. 5); it is recorded also from Bosnia-Herzegovina (Bank, 2011, 2013), but the data from this country may be doubtful (Bilandzija & Jalzic, 2010).

It is listed as critically endangered (Ozimec, 2011) or endangered (Cuttelod *et al.*, 2011) but, in consideration of its rather wide range, the species may be considered, at most, vulnerable.

Kerkia kareli n. sp.

Diagnosis Shell very small, depressed valviform to almost planispiral, spire a bit raised, wide umbilicus. Male genitalia with penis rather small, cylindrical, with slender and narrow apex, with no lobe but a little dilated before apex, where there is a refractive area. Female genitalia with loop welded to pallial oviduct; only one seminal receptacle, the distal one (RS1), with long stalk, and a rather large bursa copulatrix, round to oval, with slender and long duct, slightly sinuous, entering bursa on anterior side. Radula with central tooth with 2 basal cusps on each side.

Shell (Figs 6–7) Very small, depressed valviform to almost planispiral, whitish, waxy and transparent when fresh, consisting of $2\frac{1}{2}$ – $2\frac{3}{4}$ rapidly growing convex whorls. Spire a bit raised; last whorl very large, with the terminal portion often descending near aperture; deep sutures. Aperture prosocline, roundish to oval; peristome complete, rather thin, in contact with the wall of the last whorl, slightly reflected only at the columellar margin, with external margin not sinuous. Umbilicus wide, about $\frac{1}{3}$ – $\frac{1}{4}$ of shell major diameter. Surface of protoconch malleated; surface of teleoconch rather smooth, with fine growth lines and, sometimes, a few irregular spiral groves.

Dimensions (Table 1): shell height, 0.61–0.94 mm; shell major diameter, 1.25–1.71 mm; aperture height, 0.59–0.86 mm; aperture diameter, 0.55–0.75 mm.



Figure 5 Distribution of *Kerkia jadertina* (Kuščer 1933) along the Dalmatian coast (triangles) and of *Kerkia kareli* n. sp. on Pag Island (Croatia) (red circles), on the basis of the studied material. The type localities of “*Hauffenia jadertina*” Kuščer 1933, and of “*Hauffenia jadertina sinjana*” Kuščer 1933, are marked with a yellow and a blue triangle.

Operculum (Fig. 8A) Corneous, paucispiral, thin, pale yellowish in colour, with sub-central nucleus and without peg or thickening on inner side.

Body (Fig. 8B) Unpigmented, but usually with a few traces of blackish pigment in the wall of visceral sac. Eyes spots usually absent, if present very reduced.

Male genitalia (Fig. 8C–F) Testis near apex of visceral sac; convoluted spermiduct; prostate gland slightly bulging into pallial cavity; thin vas efferens, starting at anterior end of prostate gland, crossing the body wall and entering penis. Penis rather small, unpigmented, cylindrical, with slender and narrow apex, with no lobe but a little dilated before apex, where a refractive area is visible at its inside. Penial duct zig-zagging through right portion of penis to open at penis tip.

Female genitalia (Fig. 8G–I) Ovary near apex of visceral sac; gonadal oviduct thin. Renal oviduct wider, forming a large loop after insertion of gonopericardial duct, welded to pallial oviduct.

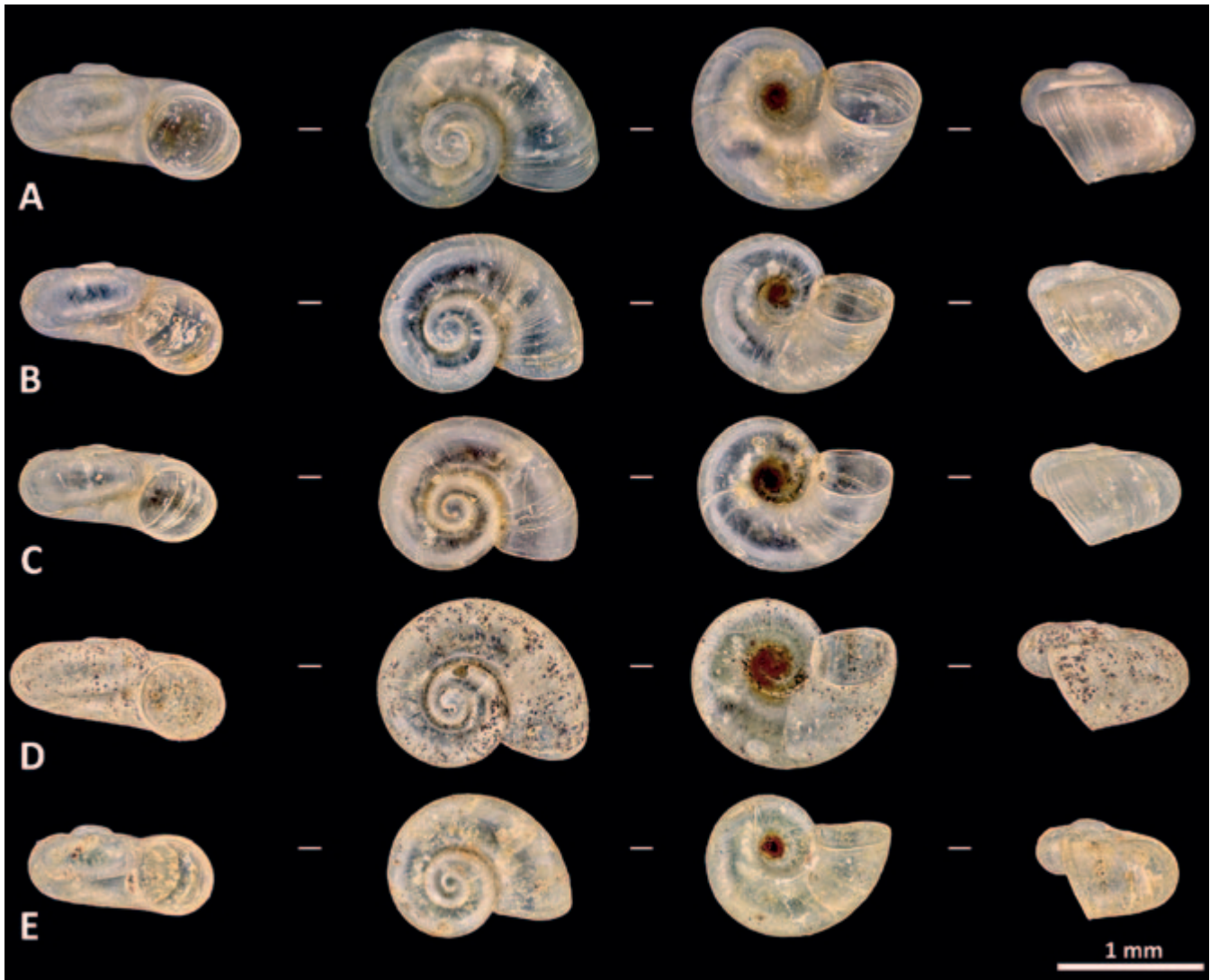


Figure 6 Shells of *Kerkia kareli* n. sp. A: holotype collected in the well by the local road ca. 400 m east of Sv. Nikola, Poveljana, Pag Island (Croatia), L. Beran leg. 29/12/2011 (coll. Croatian Natural History Museum in Zagreb n° 10559). B–C: paratypes from the same locality (coll. Croatian Natural History Museum in Zagreb n° 10560). D–E: specimens collected in the new or rebuilt well in fields in valley north-west of Kolan, Pag Island (Croatia), L. Beran leg., 31/12/2011 (coll. MZUF GC/41741).

Only one seminal receptacle, a distal one (RS1), with long stalk, its apex reaches the wall of the bursa copulatrix. Rather large bursa copulatrix, round to oval, overlapping the entire posterior portion of pallial oviduct, with long, slender duct, slightly sinuous, entering bursa on anterior side. Pallial oviduct with albumen and capsule gland; seminal groove running along ventral side of capsule gland. Gonopore not far from the pallial margin.

Radula (Fig. 9) Taenioglossan, with many files of seven teeth, each with formula: C=5–6+1+5–6/2+2; L=4–5+1+6–7; M1=28–32; M2=20–22.

Central tooth trapezoidal, with long lateral wings and basal tongue, its cutting edge V-like, with long central denticle and 5–6 smaller denticles on both sides in decreasing order of size; two basal cusps at point where each lateral wing arises from face of central tooth, inner stronger; lateral teeth apically enlarged, their cutting edge with 11–13 denticles, central of which longer and larger; first marginal teeth with long lateral wing and elongated apex, its cutting edge with long row of 28–32 long denticles; second marginal teeth with long slender lateral wing and roundish, spoon-like apex with cutting edge carrying rather long row of about 20–22 denticles.

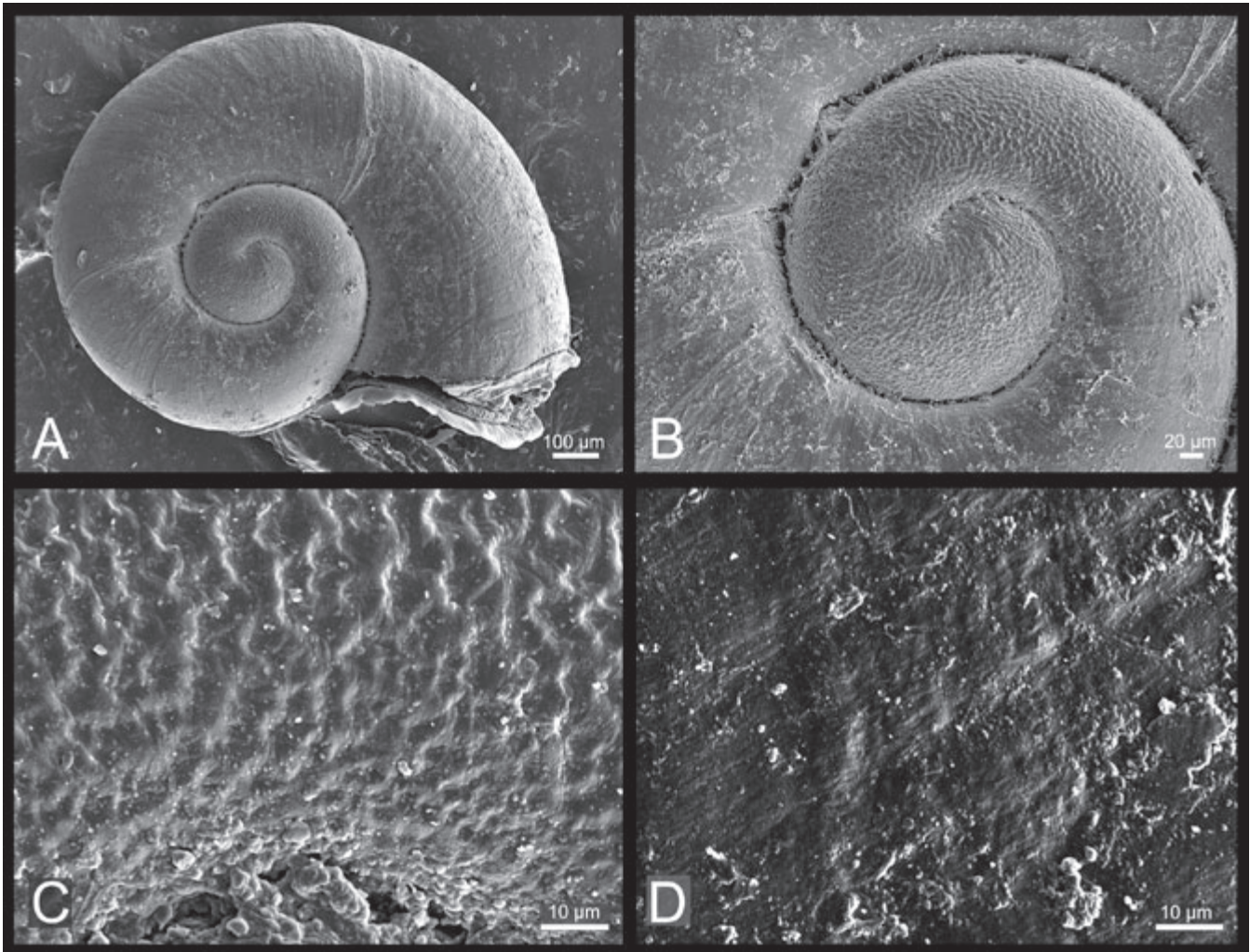


Figure 7 Protoconch and teleconch of *Kerkia kareli* n. sp. A: entire young shell. B: protoconch. C: magnification of protoconch. D: magnification of teleconch on the third whorl. Specimen collected in the well by the local road ca. 400 m east of Sv. Nikola, Poveljana, Pag Island (Croatia), L. Beran leg. 29/12/2011 (coll. MZUF GC/41740, stub SEM MZ/244).

Stomach and intestine (Fig. 8C, G–I) Stomach without posterior caecum. Intestine with two bends, the first along the stomach, the second, a well developed, S-like tight coil, on pallial wall; rectal tract straight, anus near pallial margin.

Osfradium and ctenidium (Fig. 8C, G–I) Osfradium variable in size, oval or kidney-shaped, near pallial margin. Ctenidium consisting of 11–16 lamellae, well developed.

Type locality (Fig. 10 A–B) Old well by the local road ca. 400 m east of Sv. Nikola, Poveljana, Pag Island, ca. 8 m a.s.l. (Zadarska County, Croatia), $15^{\circ} 06' 44.03''$ E, $44^{\circ} 20' 31.34''$ N.

Other localities (Fig. 10 C–D)

Old well in fields in a valley near the western edge of Kolan, Pag Island, ca. 66 m a.s.l. (Ličko-senjska County, Croatia), $14^{\circ} 57' 11.59''$ E $44^{\circ} 29' 48.65''$ N.

New or rebuilt well in fields in a valley northwest of Kolan, Pag Island, ca. 57 m a.s.l. (Ličko-senjska County, Croatia), $14^{\circ} 57' 02.05''$ E, $44^{\circ} 29' 58.53''$ N.

Type material Holotype; dry specimen collected in the type locality, L. Beran leg. 29/12/2011. Paratypes: from type locality, L. Beran leg. 04/07/2011 (12 specimens), 29/12/2011 (31 specimens). From well west of Kolan, L. Beran leg. 29/12/2011 (1 specimen and 3 empty shells).

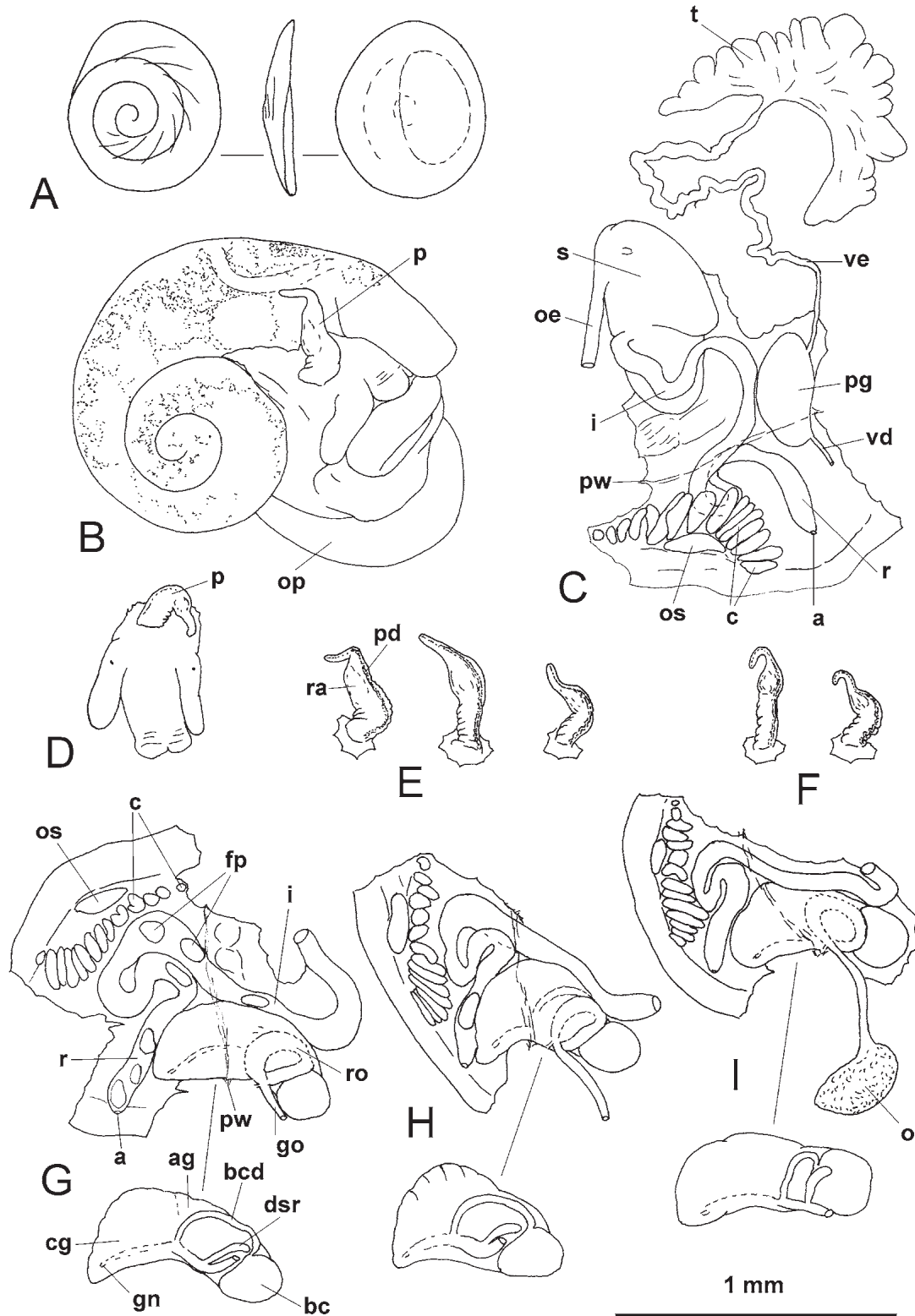


Figure 8 Operculum and anatomical details of *Kerkia kareli* n. sp. A: outer face (left), profile (centre) and inner face (right) of operculum. B: body of a male with pallial cavity open to show head and penis. C: stomach, intestine, testis, vas efferens, prostate gland and pallial organs of a male. D: head of another male. E–F: penis of five males, from dorsal side. G–I: gonadal (I), renal and pallial oviduct and pallial organs (G–H) of three females, with the loop (upper), without the loop (lower). Well by the local road ca. 400 m east of Sv. Nikola, Povoljana, Pag Island (Croatia), L. Beran leg. 4/7/2011 and 29/12/2011 (A–E, G, I), and in the well in fields in valley north-west of Kolan, Pag Island (Croatia), L. Beran leg. 31/12/2011 (F, H). Acronyms as in Fig. 3.

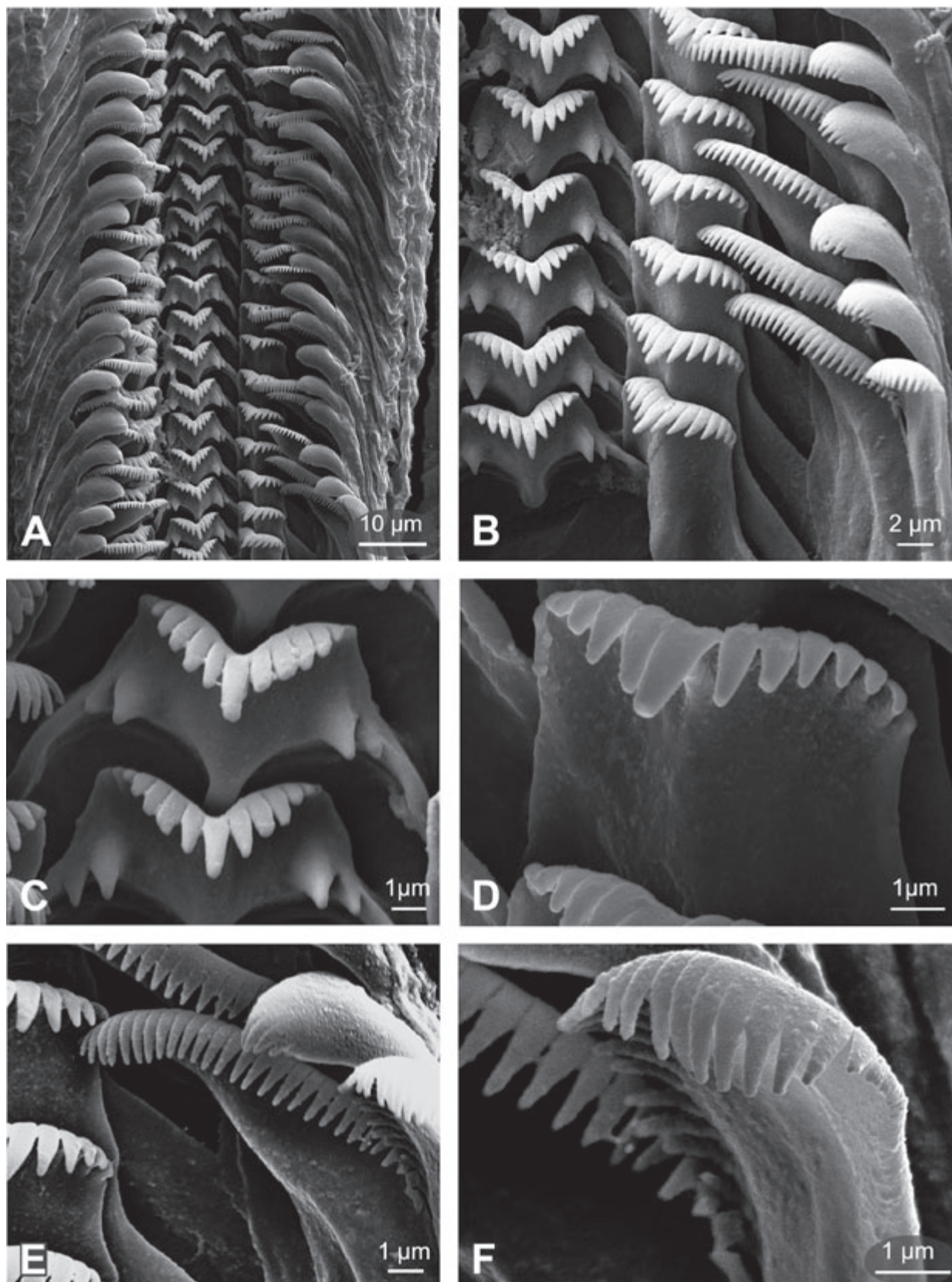


Figure 9 Radula of *Kerkia kareli* n. sp. A: central portion of radula. B: magnification of a portion of radula. C: detail of central teeth. D: magnification of a lateral tooth. E: magnification of an inner marginal tooth. F: detail of an outer marginal tooth. Specimen collected in the well by the local road ca. 400 m east of Sv. Nikola, Poveljana, Pag Island (Croatia), L. Beran leg. 04/07/2011 (coll. MZUF GC/41742, stub SEM MB/81).

From well north-west of Kolan, L. Beran leg., 31/12/2011 (18 specimens).

Holotype (dry), 2 paratypes (dry) and 14 paratypes from type locality preserved in 70% ethanol are deposited in the Croatian Natural History Museum in Zagreb (n° 10559, 10560); other 12 paratypes are deposited in the Museum of Natural History, Zoological section "La Specola" University of Florence (MZUF: GC/41740 stub SEM MZ/244, 1 juv. shell; GC/41742, 9 dissected specimens; GC/41742 stub SEM MB/81, radula; GC/41741, 2 dry specimens) and other 8 paratypes, preserved in 70% ethanol, in the National Museum in Prague (n° NMP P6M29110). The rest of the material is deposited in the authors' collections.

Etymology The new species takes its name from Karel, the son of the first author, who found the first two specimens.

Habitat and distribution So far, this species has been found only in three artificial wells situated in two valleys on Pag Island (Croatia) (Fig. 5). One of them is located near Povljana on the south-western edge of the island; the other valley is near Kolan in the central part of the island. In all the wells, the level of underground water was of a depth of ca. 2 m. Specimens were found on debris, stones, or on the wall of the well. This species inhabits phreatic waters.

In consideration of its very limited range, the species may be vulnerable.

DISCUSSION

The anatomical study of "*Hauffenia jadertina sinjana*" from Cetina valley, not too far from its type locality, confirms its taxonomic status as very different from *Hauffenia* Pollonera 1898, *Horatia* Bourguignat 1877, or *Islamia* Radoman 1973, the

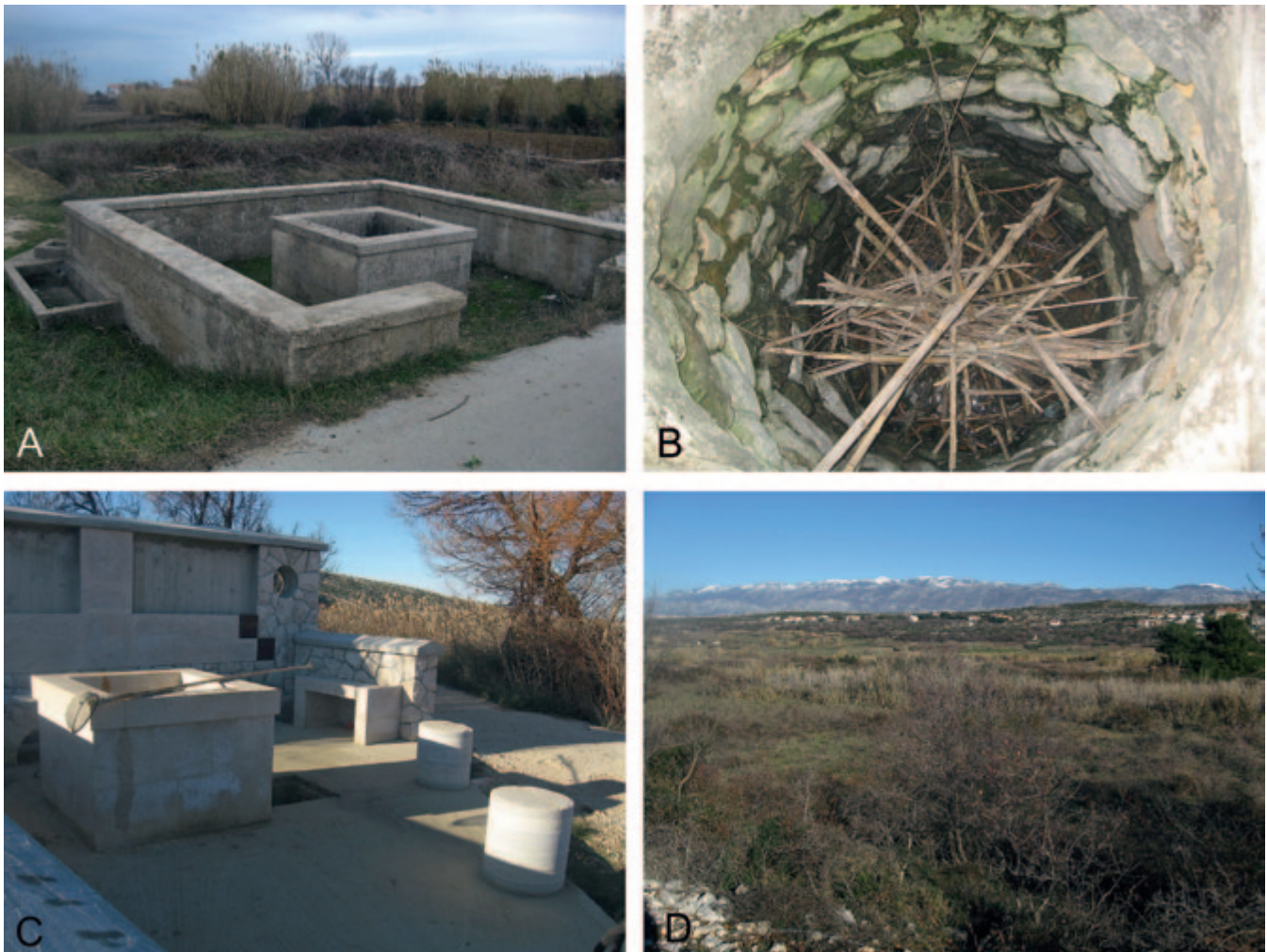


Figure 10 Sites of *Kerkia kareli* n. sp. on Pag Island. A: type locality, an old well near Povljana; B: inner of the well from type locality; C: new or rebuilt well near Kolan; D: valley near the west edge of Kolan. Photo L. Beran.

genera of valvatiform hydrobiids mostly found in the north-western Balkans (Radoman, 1983, 1985; Bodon *et al.*, 2001; Bank, 2011). In fact, the female genital tract of "*Hauffenia jadertina sinjana*" shows a large bursa copulatrix and only one seminal receptacle, the distal one (small bursa copulatrix, a proximal seminal receptacle and no distal seminal receptacle in *Hauffenia*; two seminal receptacles in *Horatia*, no bursa copulatrix and two seminal receptacles in *Islamia*), while the penis of the males does not have a stylet (present in *Hauffenia*) (Radoman, 1983; Bodon *et al.*, 2001; Bodon & Cianfanelli, 2002; Bodon & Cianfanelli, 2012). Only *Kerkia* Radoman 1978, present also in the north-western Balkans, can be compared to "*Hauffenia jadertina sinjana*", for the large bursa copulatrix and only one seminal receptacle, the distal one, in the female genital tract, and for the penis of the males with a lobe (Radoman, 1983; Bodon & Cianfanelli, 1996; Bodon *et al.*, 2001). Two species belong to the genus *Kerkia*: the type species *Kerkia kusceri* (Bole 1961), with valvatiform shell with a spire slightly raised and penis with a large lobe and a blunt apex, and *Kerkia brezicensis* Bodon & Cianfanelli 1996, with planispiral shell and penis with a smaller penial lobe and a slender apex. The operculum of both taxa has no peg, but shows a crest-like projection (*K. kusceri*) or a thickening on its inner face (*K. brezicensis*). "*Hauffenia jadertina sinjana*" is similar to *K. brezicensis* in shell and penial characters, but the penial apex is slender and narrower; moreover the operculum has no thickening on its inner face. Through these characteristics it is possible to confirm "*Hauffenia jadertina sinjana*" as a valid species, belonging to the genus *Kerkia*: *Kerkia jadertina* (Kuščer 1933).

Kuščer (1933a) described two new valvatoid hydrobiids similar in size, but slightly distinct in shape: "*Hauffenia jadertina*" from "vrela Izvor v dolini Jadre" (i.e. spring in Jadro valley near Split, Croatia; Bole & Velkovich, 1986) and "*Hauffenia jadertina sinjana*" from "Žužino vrelo pri Sinju" (i.e. Žužino spring near Sinj, Croatia; Bole & Velkovich, 1986). Kuščer (1933a) does not give details about where the specimens were deposited; today the type material of the two taxa does not exist in the collection of the Zoological Institute of Ljubljana University (B. Sket, personal communication 07/05/2012) or in the Museum of Natural History of Trieste (A. Colla, personal communication 30/05/2013).

Research on their type localities allowed only a few valvatoid shelled hydrobiids consisting of scarce and badly conserved shells to be collected. In any event, at Izvor Jadra near Split (type locality of "*Hauffenia jadertina*") in the same population there are shells with a slightly higher spire and a more roundish aperture (Fig. 1 A), like the specimen showed by Kuščer (1933a, Fig. 1), and others with an almost planispiral shell and a more elliptical aperture (Fig. 1B) resembling "*Hauffenia jadertina sinjana*"; at Žužino Vrelo in the Cetina valley (type locality of "*Hauffenia jadertina sinjana*"), the collected shell (Fig. 1C) is identical to "*Hauffenia jadertina sinjana*".

By virtue of the variability of the population of Izvor Jadra and other populations of the Cetina valley, the differences in the shell shape do not appear to warrant a finding that there are two distinct species or subspecies and, therefore, "*Hauffenia jadertina sinjana*" is here considered a synonym of "*Hauffenia jadertina*", with the name of *Kerkia jadertina* (Kuščer 1933).

Also the anatomical study of the taxon from Pag Island confirms its taxonomic status as very different from the genera of valvatiform hydrobiids mostly spread in the north-western Balkans (Radoman, 1983, 1985; Bodon *et al.*, 2001; Rađa, 2002; Bank, 2011). In fact, the female genital tract of *Kerkia kareli* shows a large bursa copulatrix and only one seminal receptacle, the distal one (small bursa copulatrix, a proximal seminal receptacle and no distal seminal receptacle in *Hauffenia*; two seminal receptacles in *Horatia*, no bursa copulatrix and two seminal receptacle in *Islamia*), while the penis of the males has neither stylet nor lobe(s) (stylet and usually lobe(s) in *Hauffenia*, always lobe(s) in *Kerkia*, *Horatia* and in *Islamia*) (Radoman, 1983; Bodon & Cianfanelli, 1996; Bodon *et al.*, 2001, Bodon & Cianfanelli, 2002; Bodon *et al.*, 2012). The only genera that show a large bursa copulatrix, only the distal seminal receptacle in the females and no lobe(s) in the penis of the males are: *Hadziella* Kuščer 1932, *Heraultiella* Bodon, Manganelli & Giusti 2002, and *Arganiella* Giusti & Pezzoli 1980 (Giusti & Pezzoli, 1980, 1981; Bodon *et al.*, 2001, 2002). In the first one, spread in the Eastern Alps and in the north-western Balkans, the bursa copulatrix has a posteroventral duct and the shell is always planispiral. In *Heraultiella* (*Heraultia* in Bodon *et al.*, 2001), which is represented by a single species, *Heraultiella exilis* (Paladilhe 1867), located in

the south of France, the bursa copulatrix has a lateral-posterior duct. Finally, in *Arganiella*, the bursa copulatrix duct is anterior, as in *K. kareli* n. sp. (*Graecoarganiella* Falniowski & Szarowska 2011, is very different; Falniowski & Szarowska, 2011). Only two species of genus *Arganiella* Giusti & Pezzoli 1980, are known until now. First, the type species, *A. pescei* Giusti & Pezzoli 1980, described from the central Apennines, Italy, and, later, *A. wolffi* (Boeters & Glöer 2007), described from south-western part of Spain as *Boetersiella wolffi* Boeters & Glöer 2007. The same species was one month later described as *Arganiella tartessica* Arconada & Ramos 2007a, from the same area of Spain (Huelva and Badajoz).

A. wolffi has a more globose shell, with higher spire, but differs from *A. pescei* and from *K. kareli* n. sp. mostly by anatomical characters: the penis is not dilated and pigmented before tip; the bursa copulatrix is pyriform (not so large, sac-like or kidney-shaped) and the bursa copulatrix duct is short and larger (not rather long) (Boeters & Glöer, 2007; Arconada & Ramos, 2007a, 2007b). In consideration of these consistent differences and the large geographical gap with the type species, its assignation to *Arganiella* requires confirmation.

As regards the differences from the type species, there are minor but relevant characteristics that differentiate the two species (Giusti & Pezzoli, 1980, 1981; Bodon *et al.*, 2001). In fact *K. kareli* shows: operculum always thin (operculum with a circular thickening at the center of its inner face in *A. pescei*); penis rather small, with slender and narrow apex, with a refractive area before apex (penis with a rather short apical portion with a rather large pointed apex, slightly dilated subapically but without refractive area in *A. pescei*); loop of the renal oviduct welded to pallial oviduct (loop adhering to the renal oviduct in *A. pescei*); bursa copulatrix duct slightly sinuous before entering bursa on anterior side (bursa copulatrix duct no sinuous before entering bursa in *A. pescei*).

These differences confirm *K. kareli* as independent entity, and may be sufficient to collocate the taxa in an independent genus, also in consideration of the large geographical gap with the type species of the genus *Arganiella*. However the shell and the anatomical characters of *K. kareli* are almost identical to those of *K. jadertina*, except for the absence of the small lobe on the penis. Even if the presence/absence of a penial

lobe is generally considered a relevant character for the generic status, in this case the two species *K. kareli* and *K. jadertina* seem very close and therefore it is appropriate to collocate them in the same genus *Kerkia*.

DNA analysis of the mitochondrial COI gene of *Kerkia jadertina* from Ljubač and of *Kerkia kareli* n. sp. from Poveljana indicate that the two taxa are closely related, differing by an uncorrected genetic distance of about 7% (T. Wilke, personal communication, 03/04/2013), and suggest that they belong to the same genus. Unfortunately, no other sequences for specimens of *Kerkia* spp. are available so far at GenBank or in the extensive hydrobiid DNA collection of the University of Giessen Systematics and Biodiversity (UGSB collection), leaving intra-generic phylogenetic relationships unresolved (Wilke *et al.*, 2001, 2013). However anatomical synapomorphies of *K. jadertina* and *K. kareli* suggest that they belong to the genus *Kerkia*.

As far as the specific status of *K. kareli* is concerned, two other taxa from southern Croatia, doubly assigned to *Hauffenia*, are known of: *Hauffenia plana* Bole 1961 and *Hauffenia edlaueri* (Schütt 1961) (Bole, 1961; Schütt, 1961; Maassen, 1978; Bole & Velkovrh, 1986; Schütt, 2000; Bodon *et al.*, 2001). No anatomical data are available for these taxa, and their generic status is problematic because the known distribution of *Hauffenia* is not extended to southern Croatia. *Hauffenia plana* and *Hauffenia edlaueri* have a planospiral shell or spire, and they are found much farther along the southern Dalmatian coast than Pag Island.

CONCLUSION

The rediscovery of a poorly known valvatiform hydrobiid from the coastal area of Croatia and the discovery of a new closely related species in a Croatian island confirm the biogeographical importance of this area and the need to study its molluscan fauna more deeply. Many taxa are already known from the Dalmatian coast, but many of them only on a conchological basis and, therefore, their taxonomy requires more detailed and comparative analysis.

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ADDENDA

Recent researches in Rab Island have led to the discovery of *Kerkia kareli* n. sp. also on this island, in the following locality: well about 100 m south-east of the church of Sv. Peter, near Supertarska Draga, Rab Island, ca. 40 m a.s.l. (Primorsko-Goranska County, Croatia), 14° 45' 10.8" E, 44° 46' 58.3" N; L. Beran leg., 27/12/2013 (3 males and 1 juv. specimen). The presence of a small penis, without lobe, confirms the attribution of this population to the new species.

