

The *Cochlostoma* genus (Gastropoda, Prosobranchiata) in Yugoslavia. I. Anatomical studies

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ABSTRACT. Anatomical studies on 12 *Cochlostoma* species and subspecies, especially on the development of the reproductive system were conducted. The specific phenomenon "aphalia" is examined, and the taxonomical-systematical value of the reproductive organs is discussed.

A reproductive system of the *Cochlostoma* type is characterized by the presence of an ovary, a bursa copulatrix, uterus gland and a long sinuous oviduct. Right before the opening into the uterus gland a short section of the oviduct is dilated. As regards the physiological function of this dilatation various views are expressed in the literature. This tract of the oviduct is interpreted by TIELECKE (1940) as seminal receptacle whereas GIUSTI (1971) speaks only of a simple widening.

TIELECKE has shown that the Cyclophoridae family, understood in the traditional sense (KOBELT 1902), is generally characterized by the occurrence of seminal receptacle. Relying on the differences among female reproductive systems, TIELECKE proposed a considerably changed taxonomy of this family. Based on the characteristic shape of the seminal receptacle in the reproductive systems of the *Cochlostoma* type, a new family, Cochlostomatiidae, was introduced. The tropical genus *Diplommatina*, having similar anatomical features, was also included into the new family. Two subfamilies, Diplomatinae and Cochlostomatinae, were then distinguished.

The objectives of the present paper are:

- a) to reveal the structure of the dilated tract of the oviduct,
- b) to provide data on the development of the reproductive systems with special attention paid to the penis,
- c) to examine aphalia through the introduction of the terms 'micropenis' and 'macropenis',
- d) to evaluate the taxonomic significance of the reproductive system at specific and subspecific levels.

The material examined was collected in Yugoslavia. I am grateful to Prof. dr. A. WIKTOR (Wrocław), L. PINTÉR, L. DRIMMER, and to the Hungarian Natural History Museum (Budapest) for placing the *Cochlostoma* specimens preserved in alcohol at my disposal. This collection seemed large enough for a thorough anatomical examination of many the *Cochlostoma* species and subspecies from Yugoslavia.

Unfortunately I was unable to perform histological examinations of the dilated section of the oviduct. Thus, in agreement with TIELECKE's view, the term seminal receptacle will be used to refer to this tract.

Remarks on the development of the penis will be given together with the description of each species examined. The observations as regards the early development of the penis will be discussed under the description of *C. elegans imoschiense*. The last phase of penile growth, which is associated with the thickening of the apertural lip, will be characterized in the case

of C. septemspirale heydenianum, C. s. bosniense, C. s. riedeli, and C. scalarinum scalarinum.

An interesting version of aphalia was observed in various Cochlostoma species. The penis of some specimens coming from the same population may be reduced. This feature will be described in detail later (see C. scalarinum scalarinum and C. nanum). My studies revealed that the growth of the penis at its early developmental stage, i. e., prior to the formation of apertural lip, stops or slows down due to unknown factors. As a result, only very small penis develops. For each population, the large penis will be termed the 'macro penis', whereas the small, reduced penis will be called consequently the 'micro penis'.

Cochlostoma septemspirale heydenianum (Clessin 1879)

Material: Hrvatska (Croatia), north of Bihac, Pljesevica Mts, in scrub vegetation, 650 m, Ca, coll. A Wiktor, 22.5.1982 (Figs 1-11).

Female reproductive system (Fig. 1). Oviduct thin and sinuous. Stipes of bursa copulatrix joining oviduct much below apex of uterus gland. Seminal receptacle positioned from this point at a distance 1.4 times longer than length of stipes of bursa copulatrix (abbreviated as SBC). Seminal receptacle separated quite well from oviduct, length-width ratio 3:1. SBC continuing as a large elongated sac. Uterus gland strongly developed with an opening into mantle cavity near rectum.

Male reproductive system (Figs 2-10). Thin sperm duct opening at apex of prostrate, shifted slightly to side. Distal part of prostrate more elongated, clearly distinct from strongly developed thick proximal part. Latter with a narrow opening into mantle cavity close to rectum at posterior end, connected to penis by a short tube. Penis large, strong, inflated a little, tapered abruptly but bluntly. Only macro penile form detected in the sample. Length-width ratios at free section of penis 6:1, 5.4:1, 7:1, 8:1, 4.8:1, and 5.5:1, respectively (mature specimens, Figs 2, 4 and 6 to 9), and 6:1 in immature specimens (Fig. 10). Vas deferens gently undulate inside penis. Remarks on the development of penis as based on Fig. 10 are: spire of full size but lip thin and translucent. Intensive increase of penis and completion of its growth coinciding with completion of lip-thickening.

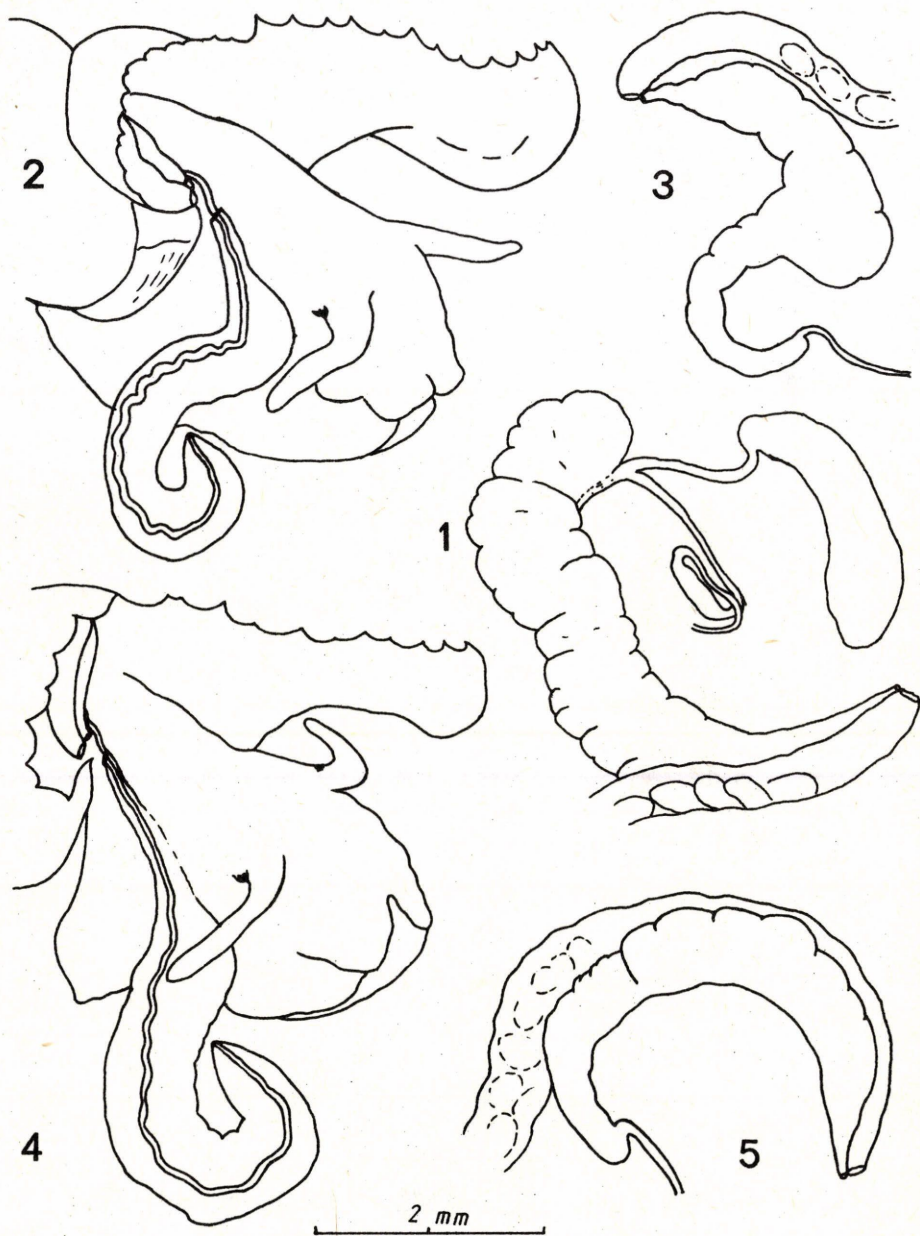
Vastly thickened lip of C. s. heydenianum, a characteristic feature of this subspecies, associated with a modification of mantle. Lateral mantle margin notched, anterior part of mantle protrudes so that head is covered to the eyes (Fig. 11).

Cochlostoma septemspirale bosniense (Boettger 1885)

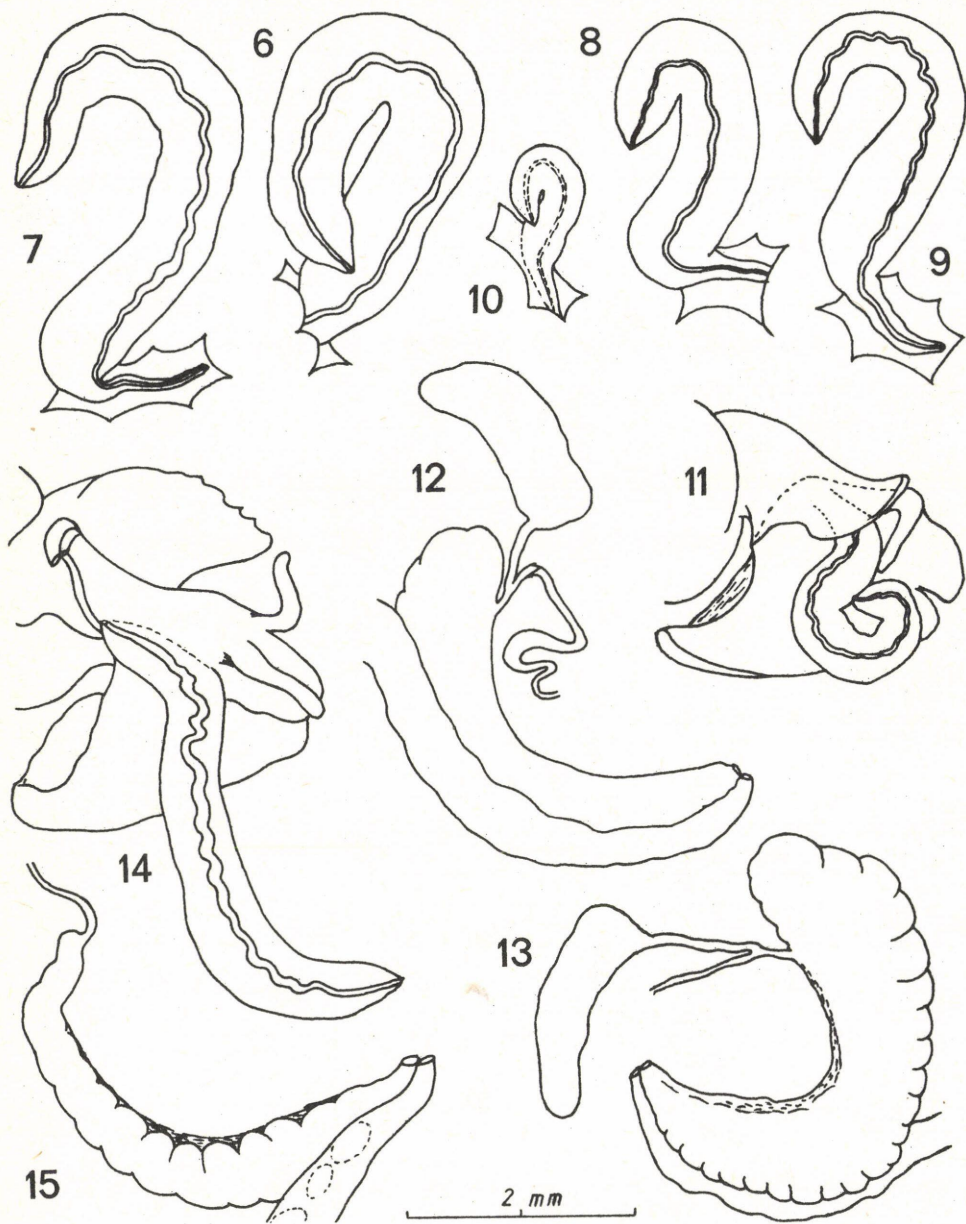
Material: I. Bosna, in the Konjuk Mts near Kladnj (north of Sarajevo), moist beechwood, Ca, 650 m, coll. A. Wiktor, 16.6.1982 (Figs 12 and 22) - II. Bosna, near Olovo in the Zvijezda Mts (north of Sarajevo), on limestone rocks, 800-1000 m, coll. A. Wiktor, 15.6.1982 (Figs 13-18, 24) - III. Bosna, Trebovic Mt in the Jahorina Mts near Sarajevo, 1300-1500 m, Ca, Fagus and Corylus dominated woodland, coll. A. Wiktor, 18.6.1982 (Figs 19-21).

Female reproductive system (Figs 12-13). Oviduct thin and undulate. SBC joining oviduct much below tip of uterus gland. Seminal receptacle positioned from this point twice as far as length of SBC. Seminal receptacle distinctly separated from thin oviduct only at apex, towards uterus gland this separation less clear. Length-width ratio 7:1. SBC directly continued as a vastly inflated elongated sac. Uterus gland strongly developed, opening into mantle cavity close to rectum.

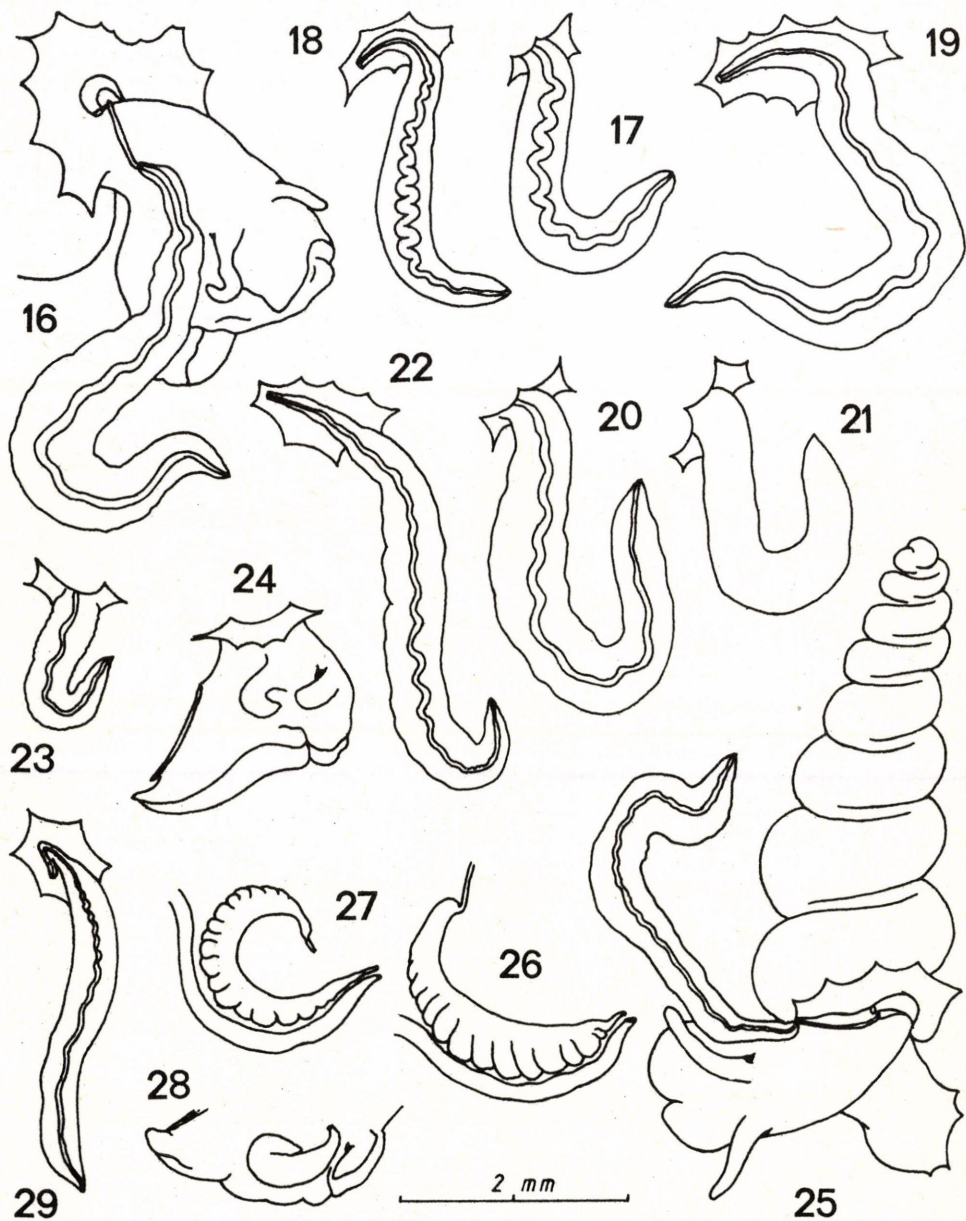
Male reproductive system (Figs 14-24), Sperm duct as in C. s. heydenianum. Distal and proximal parts of prostate less clearly separated than in C. s. heydenianum, but size differences between two sections still existing (Fig. 15). Narrow opening into mantle cavity near rectum at posterior end. Prostrate and penis connected by a tube, which longer than in C. s. heydenianum and more slender. Length-width ratios in the order of Figures 6:1, 6.7:1, 7.5:1, 6.6:1, 7.6:1, 7.5:, 7.8:1, respectively in mature specimens (Figs 14, 16-22), and 5.1:1 and 3.1:1 in immature specimens (Figs 23-24). Vas deferens gently undulate or coiled inside penis (Fig. 18). Remarks on the growth of the penis as based on Figs 23 and 24 are: shells with 8 whorls, no lip developed (Fig. 23). Lip thin, intensive growth of penis and lip thickening just as in C. s. heydenianum. Unlike heydenianum, mantle margin of bosniense not protruded.



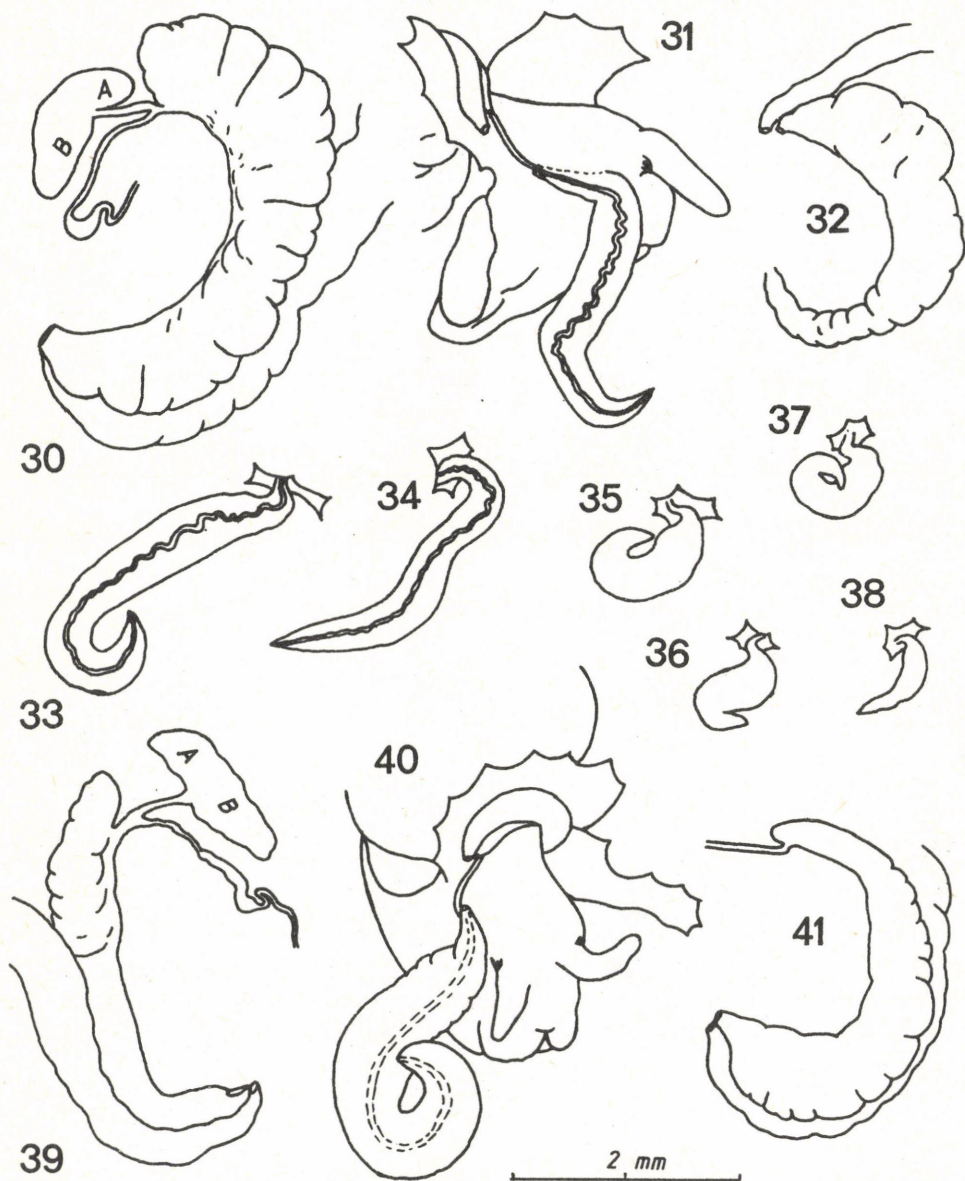
Figs 1-5: *Cochlostoma septemspirale heydenianum* (Clessin)
(1= female genitalia; 2-5= male genitalia)



Figs 7-11: *C. septemspirale heydenianum* (Clessin)
 (6-10= penis; 11= mantle)
 Figs 12-14: *C. septemspirale bosniense* (Boettger)
 (12-13= female genitalia; 14-15= male genitalia)

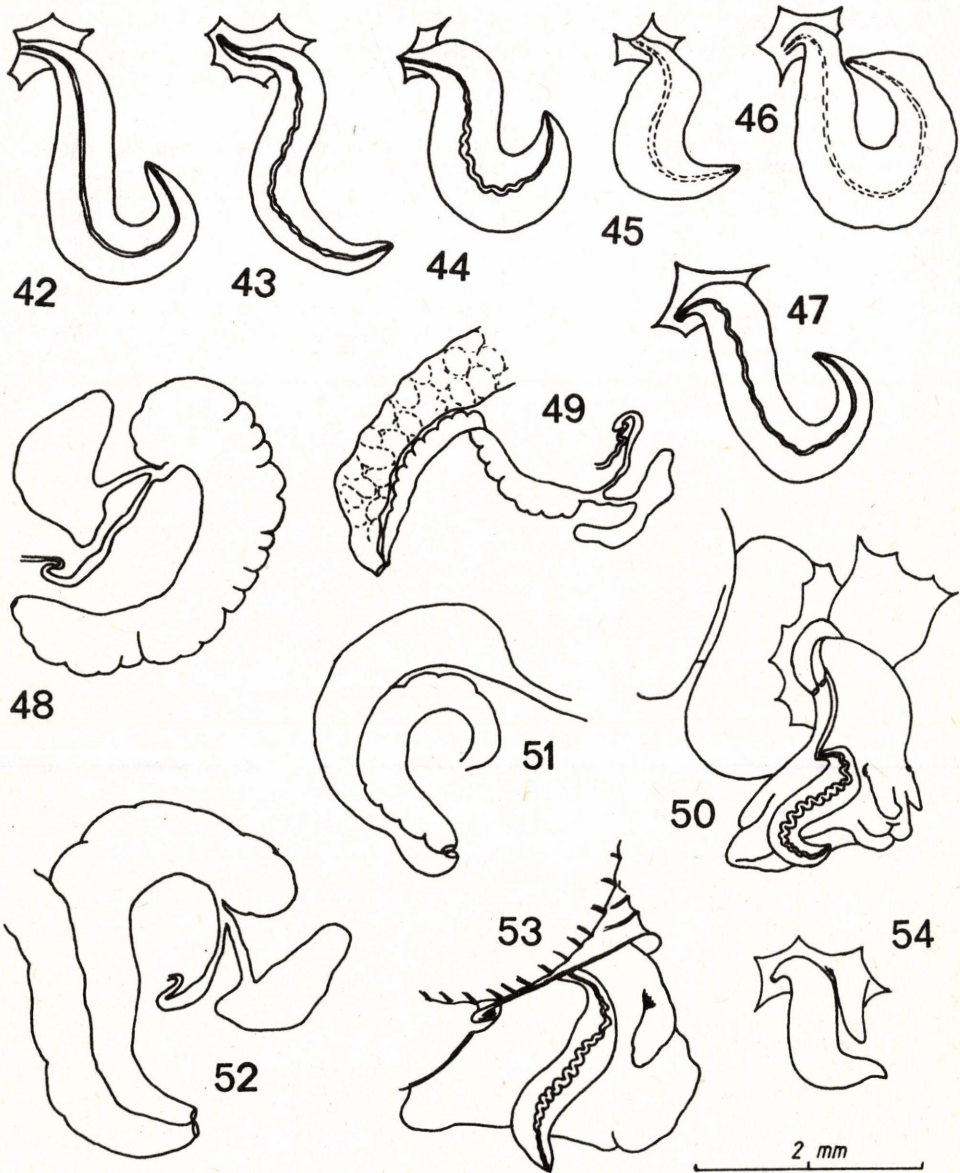


Figs 16-24: *C. septemspirale bosniense* (Boettger)
 (16= male genitalia; 17-23= penis; 24= young male)
 Figs 25-29: *C. septemspirale riedeli* Varga
 (25-26= male genitalia; 27-28= genital of young male; 29= penis)



Figs 30-38: *C. scalarinum scalarinum* (A & J.B. Villa)
 (30= female genitalia; 31-32= male genitalia; 33-38= penis 35= micropenis; 36-38= penis
 of juvenile specimens)

Figs 39-41: *C. scalarinum hirci* (Hirc)
 (39= female genitalia; 40-41= male genitalia)



Figs 42-47: *C. scalarinum hirci* (Hirc), penis
 Figs 48-51: *C. elegans elegans* (Clessin)
 (48-49= female genitalia; 50-51= male genitalia)
 Figs 52-54: *C. elegans imoschiense* (A. J. Wagner)
 (52= female genitalia; 53-54= male genitalia)

Cochlostoma septemspirale riedeli Varga 1980

Material: Montenegro, 20 kms from Ribarice towards Rozaj, on rocks along the road, coll. L. Pintér, P. Subai and A. Szigethy, 21.7.1972. Paratype (Hungarian Natural History Museum, Budapest, Figs 25-29).

Female reproductive system: unknown.

Male reproductive system (Figs 25-29). Thin sperm duct opening at apex of prostrate with an opening slightly shifted to side. Distal part of prostrate definitely disjunct from proximal part which, in general, regularly and strongly subdivided. Terminal part of prostrate, contrary to C. s. heydenianum and bosniense, continuing as a thin tube and with a narrow opening into mantle cavity at rectum at posterior end of animal. Prostrate connected to penis through a thin and relatively long closed tube. Penis thin and long, finely rugose, tapering. Vas deferens undulate inside penis. Length-width ratios 8.2:1 and 8:1 (Fig. 29). In young specimens this ratio 4.7:1 (Fig. 28). Remarks on penis development as based on Figs 27 and 28: intensive growth of penis in same period as in heydenianum and bosniense. Aperture of illustrated specimen translucent, no thickenings observed. Prostrate developing earlier than penis (Fig. 27).

Contrary to heydenianum, mantle margin simple, not protruded.

Cochlostoma scalarinum scalarinum (A. & J. B. Villa 1841)

Material: Hrvatska, Starigrad, Isle of Hvar, coll. L. Drimmer, 12.8.1983 (Figs 30-38).

Female reproductive system (Fig. 30): Oviduct thin and sinuous. SBC joining oviduct at about apex of uterus gland. Seminal receptacle positioned twice as far from this point as length of SBC. Seminal receptacle clearly distinct from oviduct, with a length-width ratio of 2:1. Sac of bursa copulatrix elongated, with A:B ratio of 1:2.5. Uterus gland strongly developed, opening into mantle cavity close to rectum.

Male reproductive system (Figs 30-38): Typical form possessing macropenis. Prostrate evenly thickened (Fig. 32), narrowly opening into mantle cavity near rectum at posterior end. Prostrate connected to penis with a short tube. Free section of penis strongly elongated and pointed. Length-width ratio on free part ranging from 5.6:1 to 6.5:1 (Figs. 31, 33, 34). Vas deferens undulate inside penis. Micropenis form (Fig. 35) with short, thick, curved and abruptly tapering penis with a length-width ratio of 3.1:1.

Cochlostoma scalarinum hirci (Hirc 1881)

Material: Hrvatska, Velebit Mts, Jablanac, on limestone rocks over a sea inlet (Nature Reserve), Ca, extremely dry habitat, coll. A. Wiktor, 25-26. 5. 1982 (Figs 39-47).

Female reproductive system (Fig. 39): Oviduct thin and undulate. SBC joining oviduct at about apex of uterus gland. Seminal receptacle positioned from this point at a distance 1.1 times longer than SBC length. Seminal receptacle clearly separated from oviduct, length-width ratio about 8:1. Sac of bursa copulatrix elongated, A:B ratio is 1.2:1. Uterus gland as in nominal form.

Male reproductive system (Figs 40-47): Contrary to nominal form, no clear distinction between two penile forms observed in the sample. The size differences among specimens illustrated are due to fluctuations in the population or to the contraction of penis. Prostrate (Fig. 4) as in nominal form, length-width ratios being 5.2:1, 5.3:1, 5:1, 4:1, 5.1:1, 5.1:1, respectively (Figs 40, 42-47). Vas deferens linear or undulate inside penis. The so-called micropenis form was not encountered in the material examined.

Cochlostoma elegans elegans (Clessin 1879)

Material: Hrvatska, Velebit Mts, above Karlobag in a dry gorge, elmwood, Ca, coll. A. Wiktor, 27. 5. 1982 (Figs 48-51).

Sexes differing in colour. Shells of females uniformly bright. Shells of males with bright ground colour and upper whorls dark violet.

Female reproductive system (Figs 48-49): Oviduct thin and undulate. SBC joining oviduct below apex of uterus gland. Seminal receptacle positioned from this point at a distance 1.5 times longer than SBC length. Seminal receptacle a merely slightly inflated part of oviduct. Sac of bursa copulatrix one-sided. A:B ratio 1:4. Uterus gland fully developed over its total length, opening into mantle cavity at rectum. The specimen illustrated in Fig. 49 has a fully developed shell but the reproductive system is deformed.

Male reproductive system (Figs 50-51). Prostate small, divided, opening into mantle cavity near rectum. Prostrate connected to penis with a short tube. Penis short, thick, curved, tapering towards tip. Length-width ratio 5.1:1. Vas deferens strongly undulate inside penis.

Cochlostoma elegans imoschiense (A. J. Wagner 1906)

Material: I. Hrvatska, Starigrad, coll. P. Subai, 17.6.1970 (Hung. Nat. Hist. Mus., A. 521). Figs 52-56. - II. Starigrad, Paklenica National Park, coll. L. Pintér, P. Subai and A. Szigethy, 5.8.1972 (Hung. Nat. Hist. Mus., A. 825). Fig. 57.

Colour difference between sexes as above.

Female reproductive system (Fig. 52). Main features identical with those of nominal form. Seminal receptacle appearing as a weakly inflated section of oviduct, so distinction difficult. SBC joining oviduct below apex of prostrate. Seminal receptacle positioned from this point at a distance equal to SBC length. Sac of bursa copulatrix one-sided, A:B ratio 1:4.

Male reproductive system (Figs 53-57). Chief characteristics of penis as in nominal form. Figs 53-54 illustrate mature specimens with a length-width ratio of the free section of penis of 5:1 and 4.4:1, respectively. Remarks on the development of penis: Fig. 55: shell with 7 whorls, lip not developed. Under high magnification interesting phases of early development of penis may be observed (Fig. 56 and the associated details). Penis rooted with two radicles below tentacle. Sinistral branch long, dextral branch shorter and with a wide basal area. These two branches bending towards each other, enclosing a funnel-like opening. At meeting point of radicles a slit formed, latter running over penis. This slit is not identical with the penis stria characteristic for the genus *Toffolettia* Giusti, because in that case the stria corresponds to the vas deferens. In *C. e. imoschiense* vas deferens runs inside the sinistral branch (see the cross sections and Fig. 57). In Fig. 57 the next step of penis development is seen. Now the two radicles are almost completely fused, being separated only at the basal part of penis. Vas deferens clearly seen in the sinistral branch. On the surface of the penis of an old specimen's traces of the aforementioned slit, shifted to the right, may be recognized.

Cochlostoma mostarensis (A. J. Wagner 1906)

Material: Mostar, above the town, Ca, coll. A. Wiktor, 7.6.1982 (Figs 58-60).

Female reproductive system (Fig. 58). Oviduct thin and sinuous. SBC joining oviduct approximately at tip of uterus gland. Seminal receptacle appearing as slightly inflated section of oviduct, but no clear separation seen. Sac of bursa copulatrix mushroom-shaped with an A:B ratio of about 1:1. Uterus gland strongly developed, opening into mantle cavity at rectum.

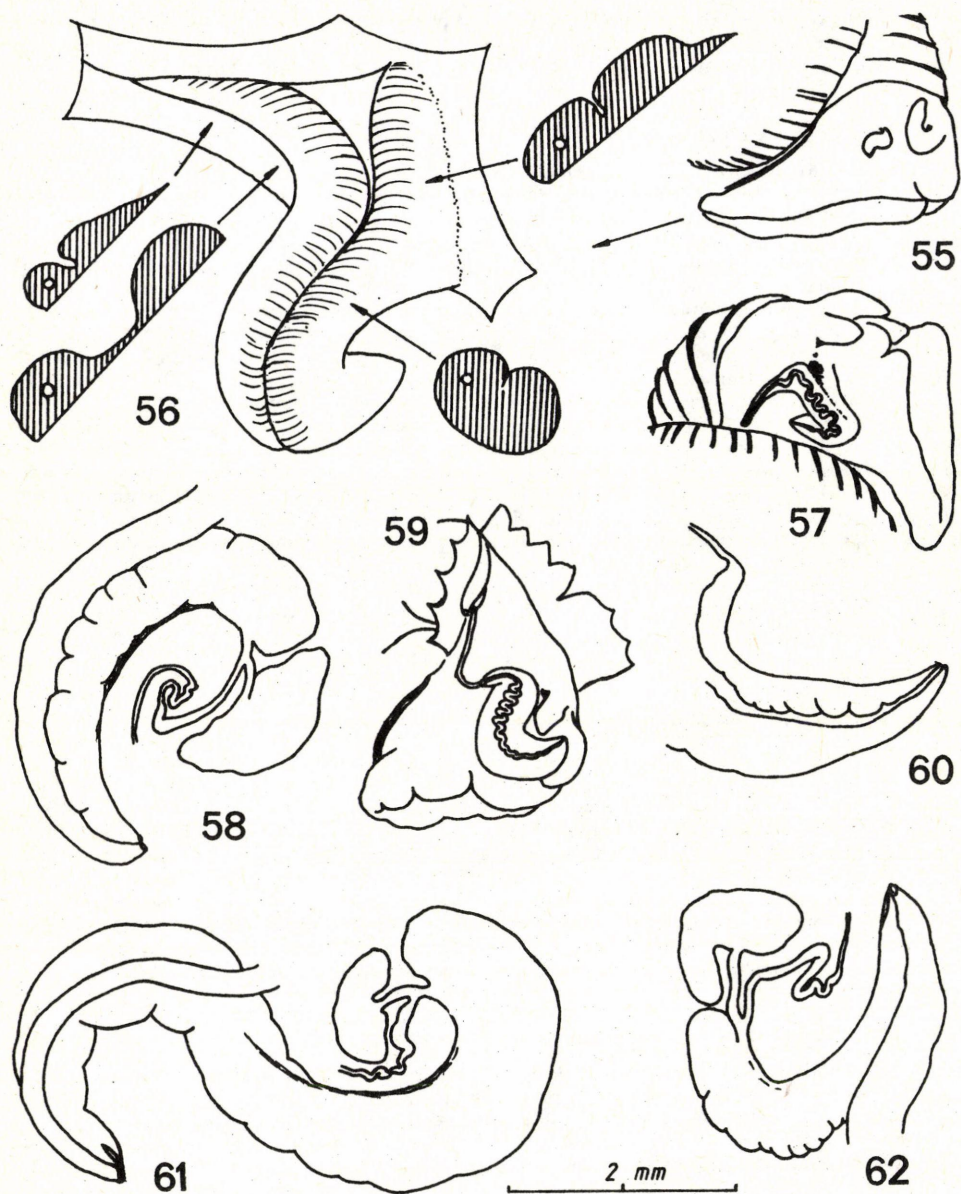
Male reproductive system (Figs 59-60). Gradual transition between sperm duct and band-like prostrate. Prostrate narrowly opening into mantle cavity close to rectum at posterior end of animal. Prostrate connected to penis through a tube. Penis short, thick, curved, pointed. Length-width ratio of free section of penis 3:1. Vas deferens strongly undulate inside penis.

Cochlostoma gracile croaticum (L. Pfeiffer 1871)

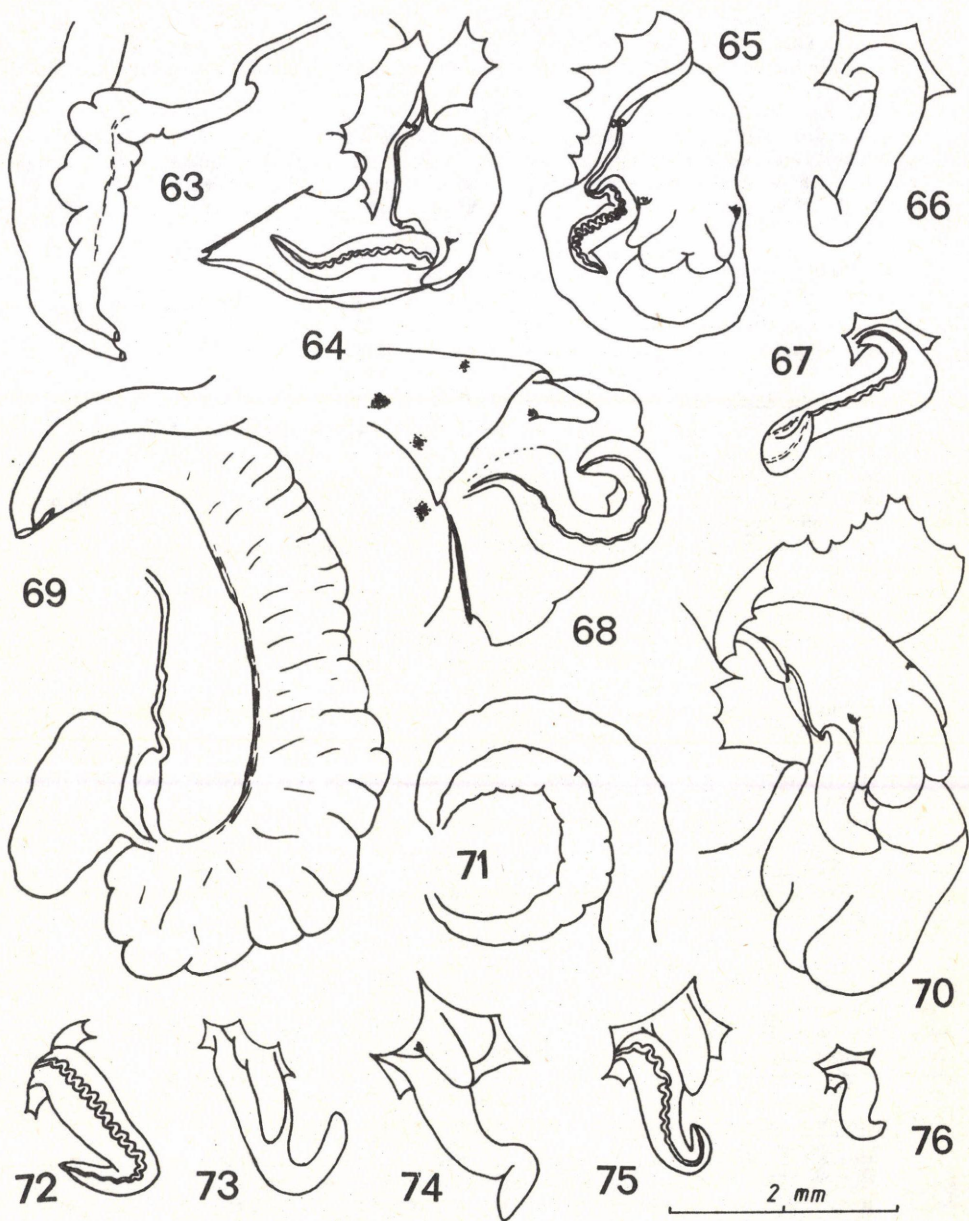
Material: I. Plitvice, coll. L. Pintér, 1972 (Fig. 61) - II. Hrvatska, Velebit Mts., northea stern slopes of Voganski Vrh above the village of Sveti Rok, 1300-1550 m, above the timberline, Ca, steep rocky slopes with grassy vegetation, coll. A. Wiktor, 29.5.1982 (Figs 62-65). - III. Hrvatska, Plitvice area, dry hills over the village of Lavinac, north of Gracac, Ca, 700 m, coll. A. Wiktor, 30.5.1982 (Figs 66-67).

The few Croatian specimens I had a chance to examine yielded only preliminary information on the anatomy of this subspecies. The identification of the gracile complex is often difficult if based on the shells.

Female reproductive system (Figs 61-62). Plitvice specimen (Fig. 61): Oviduct thin and undulate. SBC joining oviduct close to apex of uterus gland. Seminal receptacle situated right over this meeting point. Apex of seminal receptacle clearly distinct from oviduct. Length-width ratio 3:1. SBC very short. Sac falling into sections A and B with their ratio being about 1:1. Uterus gland strong, opening with a slit into mantle cavity at rectum.



Figs 55-57: *C. elegans imoschiense* (A. J. Wagner)
 (55 and 57= young male; 56= penis of juvenils under strong magnification)
 Figs 58-60: *C. mostarense* (A. J. Wagner)
 (58= female genitalia; 59-60= male genitalia)
 Figs 61-62: *C. gracile croaticum* (L. Pfeiffer), female genitalia



Figs 63-67: *C. gracile croaticum* (L. Pfeiffer), male genitalia

Fig. 68: *C. gracile sturanyi* (A. J. Wagner)

Figs 69-76: *C. nanum nanum* (Westrelud)

(69= female genitalia; 70-71= male genitalia; 72-76= penis)

Velebit specimen (Fig. 62): Seminal receptacle 1.5 times length of SBC apart. Seminal receptacle a weakly inflated section of oviduct, therefore not easily recognizable. Bursa copulatrix differing from that of above specimen, stipes longer and sac larger. Uterus gland smaller.

Male reproductive system (Figs 63-67). Sperm duct opening into prostrate on lateral side. Prostrate falling into two parts, tapered apical part followed by a stronger section and elongated terminal part, after opening into mantle cavity at posterior end. Prostrate and penis connected by a thin tube. Penis short, apical part tapering. Length-width ratios 6.6:1 and 4.6:1 (Plitvice specimens, Figs 64-65), and 5.2:1 and 5.5:1 (Velebit specimens, Figs 66-67).

Cochlostoma gracile sturanyi (A. J. Wagner 1897)

Material: Hrvatska, Bihac, ruins of a medieval castle out side the town, 700 m, coll. A. Wiktor, 22. 5. 1982 (Fig. 68).

Only a single male specimen was examined (Fig. 68).

Cochlostoma nanum nanum (Westerlund 1879)

Material: I. Hrvatska, Velebit Mts, above Sveti Rok, northeastern slopes of Voganski Vrh, 1000 m, on rocks, Ca, coll. A. Wiktor, 29. 5. 1982 (Figs 69-71). - II. Same locality, beechwood above 1000 m, Ca, coll. A. Wiktor, 29. 5. 1982 (Figs 72-76).

The colour difference between the sexes is obvious if living specimens or shells preserved in alcohol are examined. Shell of females uniformly bright. Embryonic shells of males brownish, subsequent four whorls bluish black, very different from last whorls. A general conclusion is that the abovementioned sexual difference exists if the shell is whitish or ashen grey. Conversely, no difference may be observed among specimens with brown shells.

Tentacles and proboscidium unexpectedly short in both sexes.

Two populations, found at the same locality but in different habitats, were examined. The first population is characterized by a blunt or little pointed tip of penis. In the other population the penis is tapered, its base is wide and apex pointed. Similar morphological differences among male reproductive systems at the population level were also observed in the case of other species.

These minor but stabilized differences may provide data to the microevolution of the otherwise very flexible Cochlostoma genus. However, the few observations may yield only unreliable basis for general conclusions.

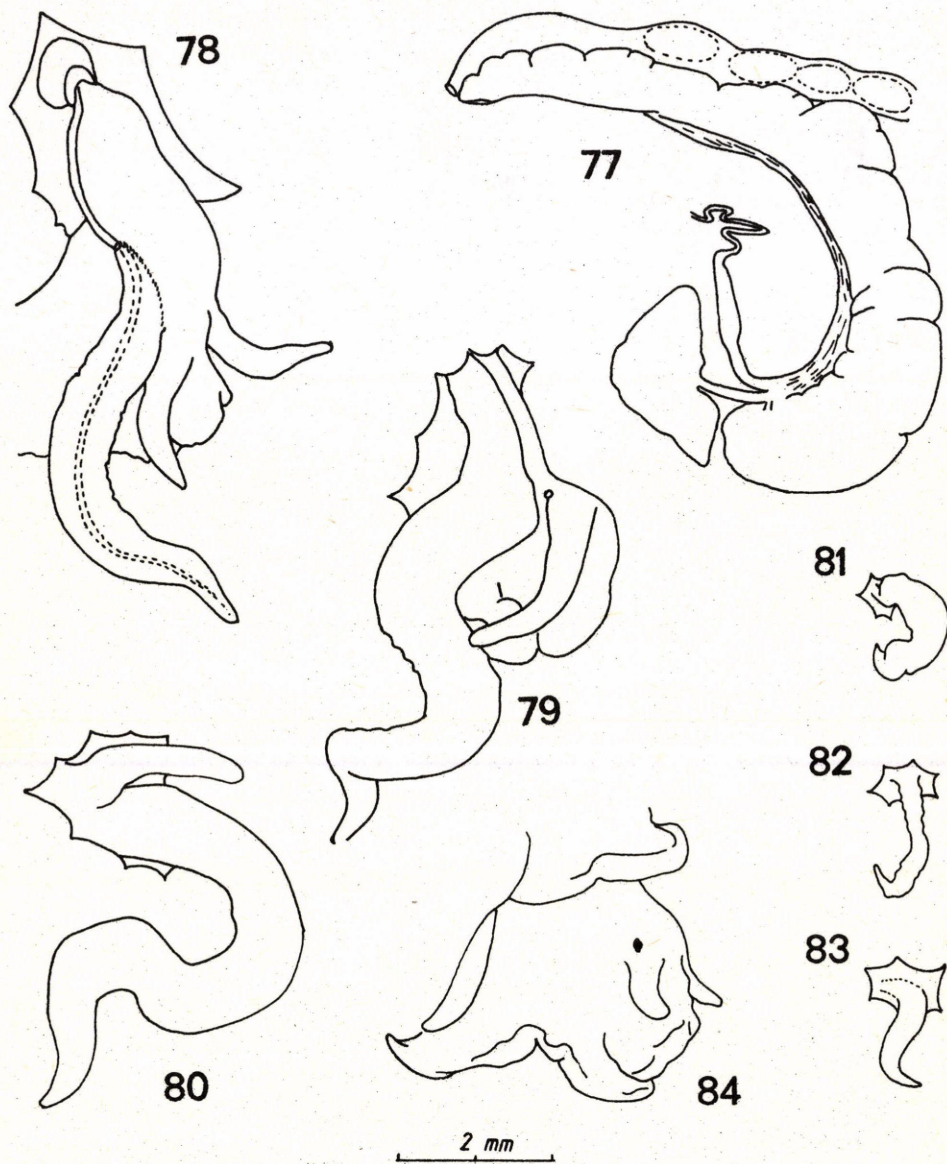
Female reproductive system (Fig. 69). Oviduct thin and undulate. SBC short, joining oviduct below apex of uterus gland. Apical part of seminal receptacle sharply distinct from oviduct. Separation diminishing towards uterus gland since seminal receptacle becoming gradually narrower. Yet, its narrowest section is twice as wide as the upper tract of oviduct. SBC funnel-shaped. Sac falling into sections A and B with their ratio being about 1:1. Uterus gland strongly developed, opening into mantle cavity at rectum.

Male reproductive system (Figs 70-76). Prostrate falling into two parts, which considering body size of animal is relatively small. Prostrate narrowly opening into mantle cavity at rectum, opening slightly shifted towards posterior end. Prostrate and penis connected via a short tube. Penis shape as described above. Vas deferens strongly undulate inside penis. Length-width ratio 4:1 (Fig. 70) and 4.9:1, 5:1, 4.3:1, 4.3:1 (Figs 72-75). Thickened apertural lip shown in Fig. 76 is typical, this specimen is a micropenis form.

Cochlostoma auritum auritum (Rossmässler 1837)

Material: I. Montenegro, Kotor, castle, coll. L. Pintér, P. Subai, and A. Szigethy. 24. 7. 1972 (Fig. 77). - II. Same locality, above the town, 50-450 m, in the ruins and on the rocks, limestone, coll. A. Wiktor, 1. 11. 1982 (Figs 78-81). - III. Titograd, at the highest point along the road between Titograd and Rijeka Crnojevica, 3 kms from Barutan towards Rijeka Crnojevica, coll. L. Pintér, P. Subai and A. Szigethy. 20. 7. 1972 (Figs 82-84).

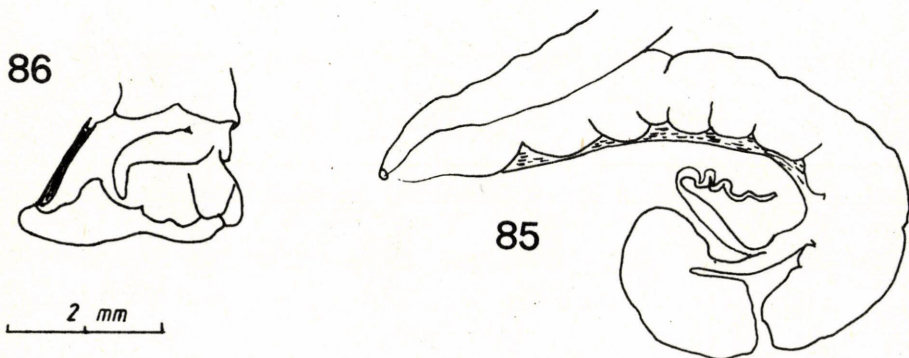
Female reproductive system (Fig. 77). Oviduct thin and undulate. SBC joining oviduct close to tip of uterus gland. Seminal receptacle positioned from this point at a distance about same as SBC length. Apical point of seminal receptacle clearly separated, but its distinction towards the uterus less obvious. Sac of bursa copulatrix approximately mushroom-shaped



Figs 77-84: *C. auritum auritum* (Rossmässler)
 (77= female genitalia; 78-79= male genitalia; 80= penis;
 81-83= penis of juvenile; 84= body of female)

with an A:B ratio of 1.3:1. Uterus gland strongly developed with a slit-like opening into mantle cavity at rectum.

Fig. 87 illustrates the body of a female specimen. Male reproductive system (Figs 78-83). Prostrate opening into mantle cavity at rectum on posterior end of animal. Prostrate and penis connected via a long tube. Penis large, widest at beginning of its free section, evenly tapered towards apex. Length-width ratios 6.8:1, 7:1, 10:1 (Figs 78-80), and 5.9:1 and 6:1 in immature specimens (Figs 80-84). Vas deferens linear inside penis. Development of penis, as in majority of Cochlostoma taxa, coinciding with thickening of apertural lip. In Figs 81-82 lip thin and translucent, but callous in Fig. 83.



Figs 85-86: *C. auritum meridionale* (Boettger)
(85= female genitalia; 86= body of female)

Cochlostoma auritum meridionale (O. Boettger 1886)

Material: southern Montenegro, valley at Stari Bar, near Bar, 700-800 m, macchia on limestone, coll. A. Wiktor, 30-31.10.1982 (Figs 85-86).

Only a single specimen was examined. The female reproductive system (Fig. 85) exhibits no substantial dissimilarities from the nominal form, the only difference being the changed A:B ratio of the sac of bursa copulatrix. Fig. 86 shown the body of this specimen.

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