

Opisthobranch molluscs of «*Cylichna occulta* group» (Gastropoda: Opisthobranchia: Cylichnidae) from the Chukchi Sea and adjacent waters

E.M. Chaban

Zoological Institute, Russian Academy of Sciences, St. Petersburg 199034, Russia
e-mail: echaban@zin.ru

Specimens of «*Cylichna occulta* group» which were collected during the Russian-American expedition «Rusalka-2009» in the Chukchi Sea were compared both with a specimen of the «Vega» expedition (1878) (identified as *Cylichna insculpta* var. *valida* Leche, 1878 by Aurivillius) and with syntypes of *C. insculpta* var. *valida* and identified here as *Cylichnoides validus* (Leche, 1878) **stat. nov.** The species is comprised with other species of the «*C. occulta* group» from the Chukchi Sea and adjacent waters based on the adult and sub-adult shell, penial and radular teeth morphology. Based on this comparison, *C. validus* is regarded as a valid species. Systematic position of *Cylichnoides* Minichev, 1971 as a valid genus is discussed. *C. validus* is compared with *Cylichnoides densistriatus* (Leche, 1878), *C. occultus* (Mighels et Adams, 1842) and *Cylichnoides scalptus* (Reeve, 1855) and all of them are regarded as valid species. The morphology of radular teeth of *Cylichnoides* ex. gr. *occultus* is described: denticles of the lateral teeth form closely or rarely spaced series; denticles in the series are long or short, strong or curved; they can be almost equal or different in length; the rachidian tooth has a deep notch and can be convex or almost flat; it has a vertical crest on the inner surface or lacks it, denticles are short or long and curved, triangular or threadlike. Tooth morphology can be used in taxonomic identifications of the *C. occultus* species complex as well as shell and penial morphology.

Key words: Cephalaspeida, Cylichnidae, *Cylichna*, *Cylichnoides*, *Cylichnoides validus*, morphology, taxonomy.

Заднежаберные моллюски группы «*Cylichna occulta*» (Gastropoda: Opisthobranchia: Cylichnidae) из Чукотского моря и прилегающих вод

Е.М. Чабан

Зоологический институт РАН, С.-Петербург 199034, Россия
e-mail: echaban@zin.ru

Российско-американской экспедицией «Русалка-2009» в Чукотском море были собраны несколько экземпляров раковинных заднежаберных моллюсков, относящихся к группе видов «*Cylichna occulta*», но обладающих широко-овальной раковиной с очень грубой спиральной скульптурой. Они были сравнены с синтипами *Cylichna insculpta* var. *valida* Leche, 1878, хранящимися в Шведском музее естественной истории в Стокгольме и определены как *Cylichnoides validus* (Leche, 1878) **stat. nov.** Обсуждается статус *Cylichnoides* Minichev, 1971 как валидного рода. Изучены особенности морфологии раковины, радулы и головного копулятивного аппарата *C. validus* в сравнении с *Cylichnoides densistriatus* (Leche, 1878), *C. occultus* (Mighels et Adams, 1842) и *Cylichnoides scalptus* (Reeve, 1855) – все они рассматриваются здесь как валидные виды. Показано разнообразие морфологии зубов радулы видов этой группы и ее значение в систематике цилихрид.

Ключевые слова: Cephalaspeida, Cylichnidae, *Cylichna*, *Cylichnoides*, *Cylichnoides validus*, морфология, систематика.

During the Russian-American expedition «Rusalka-2009» in the Chukchi Sea about 70 specimens and shells of cephalaspid mollusks were collected. Three species, *Retusa pertenuis* (Mighels, 1843), *Philine polaris* Aurivillius, 1887 and *Cylichna alba* (Brown, 1827), are common in the Arctic seas and make up most of the collections. Additionally, these samples contain a few empty shells and seven specimens from the «*Cylichna occulta* group».

The species from the «*Cylichna occulta* group» were described or noted for the Arctic and North Atlantic as *C. solitaria* (Say, 1822) [Gould, 1870; Herzenstein, 1885; Lemche, 1941], *C. striata* (Brown, 1827) [Friele, Grieg, 1901], *C. insculpta* (Totten, 1835) [Aurivillius, 1887; Friele, Grieg, 1901; Odhner, 1907; Gorbunov, 1946; Ushakov, 1948], *C. reinhardi* (Møller, 1842) [Leche, 1878; Aurivillius, 1887; Odhner, 1915], *C. occulta* (Mighels et Adams, 1842) [Gould, 1870; Herzenstein, 1885; Pilsbry, 1893; Knipowitsch, 1901, 1902; Minichev, 1977; Golikov, 1987, 1995; Schiøtte, 1989; Chaban, 2001, 2004, 2008, 2010; Chaban, Martynov, 2006; Martynov et al., 2006; Høisæter, 2009], *C. scalpta* (Reeve, 1855) [Leche, 1878; Aurivillius, 1887; Odhner, 1907, 1915; Derjugin, 1915; Gorbunov, 1946; Filatova, Zatsepin, 1948; Ushakov, 1948; Chaban, 2001, 2004, 2010; Chaban, Martynov, 2006; Martynov et al., 2006; Nekhaev, 2014], *C. propinqua* M. Sars, 1870 [G.O. Sars, 1878; Knipowitsch, 1902], and *C. densistriata* (Leche, 1878) [Herzenstein, 1885; Knipowitsch, 1896; Chaban, 2001, 2004, 2010; Chaban, Martynov, 2006]. All of them have the same radula formulation and close gizzard plates morphology; shell shapes are different but in the presence of abundant material, it is difficult sometimes to find the boundary that separates one form from another. According to Pilsbry [1893] and Lemche [1948], all these names (except for *C. solitaria* [now *Haminoea solitaria* (Say, 1822)] and *C. densistriata*) are junior synonyms of *C. occulta*.

The taxonomic status of *Bulla insculpta* Totten, 1835 is not resolved yet. The original description [Totten, 1835] is very brief and contains information on shell shape and spiral sculpture only. Syntypes of *B. insculpta* are unknown. Some authors regarded it as a valid species of *Cylichna* Lovén, 1846 [Aurivillius, 1887; Leche, 1878; Friele, Grieg, 1901; Odhner, 1907], but others [Gould, Binney, 1870; Pilsbry, 1893; Lemche, 1948; Rosenberg, 2009] listed *B. insculpta* as a junior synonym of *H. solitaria*. I consider *B. insculpta* as *nomina dubia*. Based on differences in shell and penial morphology, *C. occulta*, *C. scalpta* and *C. densistriata* have been shown previously to be three different species [Chaban, 1999, 2001, 2004, 2008, 2010; Chaban, Martynov, 2006; Martynov et al., 2006; Nekhaev, 2014]. But specimens of «*Cylichna occulta* group» collected during the expedition «Rusalka-2009» differ from these three species in form and thickness of the shell and in hard spiral sculpture. It can be assumed that these specimens belong to *Cylichna insculpta* var. *valida* Leche, 1878.

The syntypes of *C. insculpta* var. *valida* were examined by A. Warén in Swedish Museum of Natural History (Stockholm). Specimens collected during «Rusalka-2009» in the Chukchi Sea are compared here with the syntypes of *C. insculpta* var. *valida* from

the Swedish Museum of Natural History and with a specimen of *C. insculpta* var. *valida* from the collections of the Zoological Institute RAS (St. Petersburg). The latter specimen was collected during the «Vega» expedition (1878) and identified as *Cylichna insculpta* var. *valida* Leche, 1878 by Aurivillius (based upon data on the label). All of them are determined here to be a valid species *Cylichnoides validus* (Leche, 1878) **stat. nov.** A taxon *Cylichnoides* was established as subgenus by Minichev [1977] with the type species *C. occulta*. It is regarded here as a valid genus.

Additionally, I have studied the shell morphology of sub-adult specimens of «*Cylichna occulta* group» because *C. occulta* was very likely described by Mighels and Adams [1842] based on a sub-adult specimen (5 mm height).

One unusual specimen, which belongs to «*Cylichna occulta*» species group, was collected by P.V. Ushakov in 1924 near Wrangel Island. It has differences in shell sculpture and rachidian teeth morphology, and it is determined here as *Cylichnoides* sp. 1.

Leche [1878] designated *Cylichna insculpta* var. *valida* without a detailed description, so, the description of *Cylichnoides validus* (Leche, 1878) **stat. nov.** is presented here and compared with *C. occultus*, *Cylichnoides* sp. 1 (both from the Chukchi Sea), *C. scalptus* (from the Barents and East-Siberian seas) and *C. densistriatus* (from the Laptev and East-Siberian seas). Systematic position of *Cylichnoides* Minichev, 1971 as a valid genus is discussed.

Abbreviations: SMNH – Swedish Museum of Natural History, Stockholm, Sweden; ZISP – Zoological Institute RAS, St. Petersburg, Russia.

Material and methods

The material for this study was collected in 2009 in Chukchi Sea during the Russian-American expedition «Rusalka». The samples were fixed in 4% neutral formalin, were washed in water and kept in 70% ethanol. So, the collected material can't be used for molecular studying.

Additional samples from the ZISP collections were also studied and compared, specifically material collected during the «Vega» expedition (1879) in the Chukchi Sea and during Russian expeditions from 1901 to 1976. These samples include materials collected during the expedition of the icebreaker «Sadko» in 1937 in the Laptev Sea, the icebreaker «Fyodor Litke» in 1924 in the Chukchi Sea, collections near Wrangel Island, aboard the R/V «Persey» in 1924 and aboard the R/V «Rusanov» in 1932 in the Barents Sea, the Russian Polar expedition of 1901–1904, and the expedition of the ZISP Laboratory of Marine Research in 1973 in the Laptev Sea.

The radula was extracted from the buccal mass and cleaned with commercial bleach. The materials were washed in distilled water and finally treated with 70° and 90° ethanol to study them with the scanning electron microscope (SEM) FEI SEM Quanta-250. Male copulatory organs, radula and gizzard plates of some specimens were mounted in glycerol and examined under Opton (Zeiss) and Leica DME light microscopes.

Systematic part

Clade **HETEROBRANCHIA**

Order **CEPHALASPIDEA**

Family **Cylichnidae** H. et A. Adams, 1854

Genus *Cylichnoides* Minichev, 1977

Type species. *Bulla occulta* Mighels et Adams, 1842 (OD).

Diagnosis. Shell is oval with spiral sculpture, spire completely sunken; penial sac well developed with strong muscular folds, prostate connected with lateral side of the penial sac; radula formula is 2:1:1:2; rachidians with a deep notch and irregular denticles that are composed sometimes in group on 2–4; three large gizzard plates of equal size and form; crop absent.

The genus includes five arctic species: *C. occultus*, *C. validus*, *C. scalptus*, *C. densistriatus*, and *Cylichnoides* sp. 1. Two species of *Cylichna* from the tropical southwest Pacific have also been studied [Valdés, 2008] for penial morphology; *Cylichna biplicata* (A. Adams in Sowerby, 1850) and *C. involuta* (A. Adams in Sowerby, 1850) have penial sac and tentatively can be included in *Cylichnoides* but more studies need to clarify their systematic position.

Cylichnoides validus (Leche, 1878) **stat. nov.**

Figs 1A–L; 2A–L; 3D–F

Cylichna insculpta Totten var. *valida* Leche, 1878, p. 72; Aurivillius, 1887, p. 370–371; Odhner, 1907, p. 13.

Cylichna reinhardtii var. *insculpta* (Totten, 1835): Odhner, 1915, Taf. 1, fig. 21 (non Totten).

?*Cylichna occulta* (Mighels et Adams, 1842): Lemche, 1948, fig. 38 (det. as «*insculpta*»).

Cylichna occulta (Mighels et Adams, 1842): Chaban, 2004, fig. 5A, B.

Cylichnoides sp.: Chaban, 2010, p. 77, fig. 6.3B.

Type locality. The Kara Sea, 68°20' N, 73°53' E, 18 m (10 fannar).

Type specimens. «Type-8589, syntypes, 7 specimens, dry, Arctic Ocean, Russia, Kara Sea, off Obfjord. 73°53' N 68°20' E. Sand. Leg. Jenissej Exp. 1875 sta. 166» (SMNH) (Figs 1A, B).

Material studied. **Chukchi Sea:** 1879, «Vega» expedition, no data, identified by Aurivillius as *Cylichna insculpta* var. *valida* Leche, – 1 specimen; 09.VIII.1929, icebreaker «Fyodor Litke», station 54, Wrangel Isl., 69°19' N, 175°58' W, 53 m depth, collected by P.V. Ushakov – 2 specimens; 09.IX.1929, icebreaker «Fyodor Litke», station 55, Wrangel Il., 69°19' N, 176°56' W, 53 m depth, collected by P.V. Ushakov – 2 specimens; 09.VIII.1935, icebreaker «Krasin», station 44, Wrangel Il., 72°30' N, 178°45' W, 50 m depth, mud, clay, collected by P.V. Ushakov – 1 specimen; «Rusalka-2009»: 08.IX.2009, station 119, 44 m depth, 69.49192° N, 182.014° E – 3 specimens; 10.IX.2009, station 138, 75 m depth, 172.40068° N, 177.419° E – 1 shell; 11.IX.2009, station 136, north of

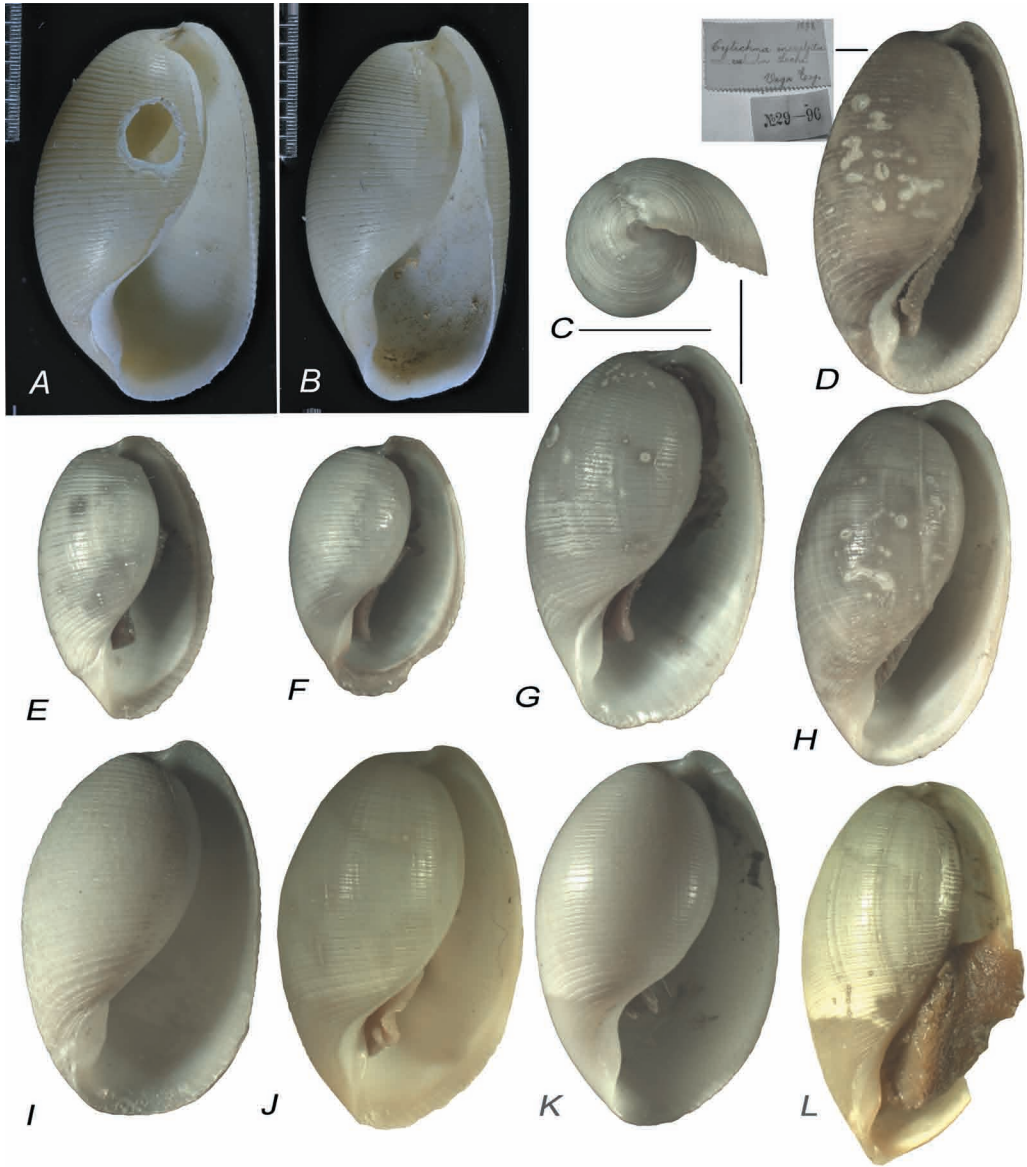


Fig. 1. *Cylichnoides validus*, shell: syntypes of *Cylichna insculpta* var. *valida*, SMNH, ventral view (A, B); «Vega» expedition, 1878, no data, 7.5 mm, (ventral view – D); R/V «Persey», Barents Sea, station 150, 8.5 mm (ventral view – H); Chukchi Sea, «Rusalka»-2009, station 119 (apical view (C) and ventral view (E – 5 mm; F – 4 mm; G – 7 mm)); R/V «Ivan Kireev», station 9/42, Laptev Sea, ventral view, 7.5 mm (I); «Fyodor Litke», Chukchi Sea, station 54, ventral view, 9 mm (J); «Krasin», Chukchi Sea, station 44, ventral view, 7.8 mm (K); «Sadko», Laptev Sea, station 21, identified by G.P. Gorbunov as *Cylichna insculpta*, ventral view, 8.5 mm (L). Scale bar: C – 2 mm.

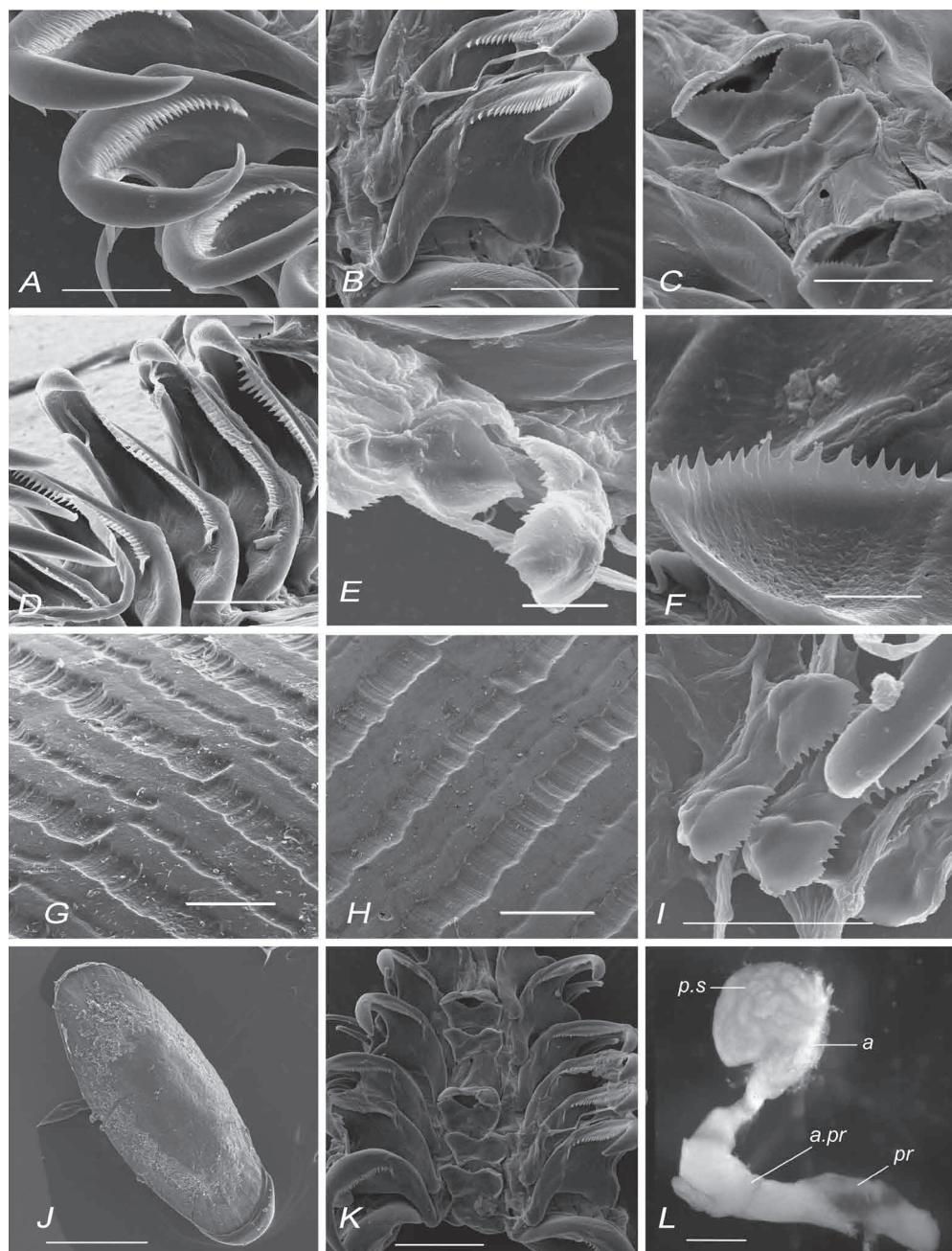


Fig. 2. *Cylichnoides validus*: radula (**K**), lateral teeth (**A**, **B**, **D**) and rachidian teeth (**C**, **E**, **F**, **I**); gizzard plate (**J**); shell sculpture (**G**, **H**); penis (**L**). **A**, **I** – Laptev sea, «Sadko», station 21; **D**, **E**, **G**, **J** – Chukchi sea, «Fyodor Litke», station 55; **B**, **C**, **F**, **H**, **K** – Chukchi sea, «Fyodor Litke», station 54; **L** – «Vega» expedition. Abbreviations: *a* – atrium, *a.pr* – additional prostate, *pr* – prostate, *p.s* – penial sheath. Scale bar: **A**, **C**, **D**, **J** – 50 μm ; **B**, **K** – 100 μm ; **G**, **H** – 200 μm ; **I** – 40 μm ; **E**, **F** – 10 μm ; **L** – 0.5 mm.

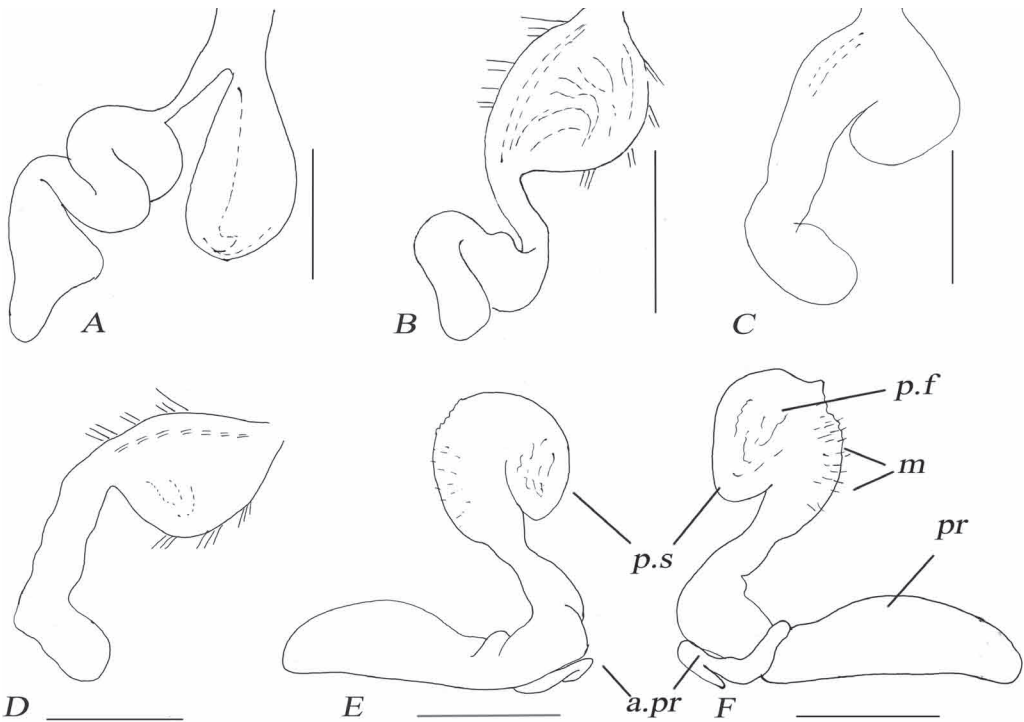


Fig. 3. Male copulatory system: *Cylichna scalptus*, Laptev Sea (A); *Cylichna densistriatus*, Russian Polar Expedition 1901–1903, no data (B); *Cylichna occulta*, Novaya Zemlya, Matochkin Strait (C); *Cylichna validus*, Laptev Sea (D) and Chukchi Sea, «Vega» expedition (dorsal view (E), ventral view (F)). Abbreviations: *m* – muscle fibers, *p.f* – folds of penial sheath, others like to Fig. 2. Scale bar: A, D–F – 1 mm; B, C – 0.5 mm.

Wrangel II., 27 m – 13 shells, 4 specimens; **East-Siberian Sea:** R/V «Alpha-Helix», 27.VIII.1995, station 10, 71°00' N, 170°49' E – 1 specimen; 27.VIII.1995, station 12, 70°20' N, 171°49' E – 1 specimen; **Laptev Sea:** 21.VIII.1937, icebreaker «Sadko», Laptev Sea, station 21, 76°12'9" N, 133°50' E, 47 m depth – 6 specimens; R/V «Ivan Kireev», 13.IX.1993, station 39/84, 77°08' N, 137°10' E, 30 m depth. **Barents Sea:** R/V «Persey», 11.VIII.1924, 70°11' N, 56°30' E, station 150, depth 140 m, mud.

Diagnosis. Shell widely oval, white, solid, with spiral sculpture consists of wide ribs and striae alternating (narrow and wide) in width; columellar margin with strong convexity. Outer lip much extended beyond the apex. Denticles on the lateral teeth are long, strong and closely spaced, almost equal in length, forming a plate on the base of the tooth. Rachidians bilobate, slightly convex, equipped with single regular row of very small cusps on cutting edge, lateral edges without notches, ventral surface without vertical crest.

Description. Shell. Shell thick but sometimes fragile, from 3 to 11.8 mm height, consists of one whorl, oval, narrows considerably posteriorly, widest in the middle as a rule (Fig. 1). Color milky white in recently collected specimens, but uniformly dirty

white in long preserved specimens. An edge of the outer lip with a horny brown band often present. Apex not umbilicated, outer lip higher than the apex of shell, regularly convexed. Parietal margin without callus, columellar margin with strong convexity, columellar umbilicus closed without chink. Longitudinal sculpture absent, spiral sculpture consist of deep, broad and straight grooves mostly at regular distances from each other, 8–10 grooves per one cm of shell, alternating with broad flattened ribs, which usually carry shallow striae.

Anatomy. Preserved specimen light brown, foot broad with parapodia, head shield very compressed and completely hidden under the front edge of mantle. Radula formula 10x:2:1:1:1:2. Denticles (30–32) on lateral teeth long, strong and closely spaced, almost equal in length, forming a plate on tooth base (Fig. 2A). Rachidian tooth slightly convex, asymmetrical for one studied specimen, equipped with the row of small cusps on cutting edge, and with three small additional denticles on the back of some teeth; it consists of two parts that are separated with a deep notch (Fig. 2I). Lateral edges without notches; ventral surface without vertical crest; upper-lateral ends tapering, angular (Fig. 2E, F). Outer marginal teeth with very small cusps. Gizzard plates (Fig. 2J) 2 mm long for specimen with shell height 8.4 mm, semi pellucid, yellowish, inner surface smooth, plates of some specimens with brown circle on inner surface; plates of long-preserved specimens brown. Male copulatory system with long narrow transparent prostate connected with proximal end of small penial sac which filled with muscular folds (Fig. 3D). A prostate of the specimen collected during «Vega» expedition is extraordinary: it has an additional short and narrow outgrowth in its middle part (Figs 2L, 3E, F).

Distribution. Kara Sea [Leche, 1878], Spitsbergen [Odhner, 1915, as *Cylichna reinhardtii* var. *insculpta*], Laptev Sea (ZISP collection), East-Siberian Sea [Chaban, 2010 as *Cylichnoides* sp.] and Chukchi Sea [Aurivillius, 1887 and ZISP collection].

Notes. The original description of *Cylichna insculpta* var. *valida* by Leche [1878] is very brief. Leche regarded that *valida* is a variety of *insculpta* and has «*tjocka, nästan ogenomskinliga skal*» [shell thick, almost opaque] [Leche, 1878, p. 72]. The syntypes of *C. insculpta* var. *valida* from the Swedish Museum of Natural History (Fig. 1A, B) have solid oval shells with narrowed apex, hard shell sculpture which consists of pairs of wide ribs and alternating wide and narrow spiral grooves, and columellar margin with a strong convexity. These characters show that the syntypes of *C. insculpta* var. *valida* and specimens from our material belong to the same species.

Shell variability of *Cylichnoides validus* is shown on Fig. 1. The specimen of *C. validus*, collected during «Vega» expedition in 1879 (Fig. 1D) has a more cylindrical shell, but the same columellar margin and shell sculpture as other specimens of the species. A specimen from the Laptev Sea (collected in 1937, Fig. 1L), has a more narrow shell and corresponds to *Cylichna reinhardtii* var. *insculpta* sensu Odhner [1915, Taf. 1, fig. 21]. Another specimen from the Laptev Sea (collected in 1993, Fig. 1I) has the thickest shell with a very hard spiral sculpture. A specimen that was collected in Chukchi Sea in 1935 (Fig. 1K) has a wide regularly oval shell. But all specimens have, as is typical for

C. validus characteristics: thick oval shell with narrowed apex and columellar fold, outer lip much extended beyond the apex, hard spiral sculpture with broad ribs and grooves.

The specimen collected by «Vega» has an extraordinary prostate with an additional short and narrow outgrowth (*a.pr* – Fig. 3E, F) in its middle part. This type of prostate is unknown for other members of Cylichnidae. But only one specimen with this prostate was found, and it could be a malformation as is one or four gizzard plates in the gizzard of *Cylichna alba* (unpublished data). Further study is needed for clarification of the species.

The illustration of *C. reinhardti* var. *insculpta* sensu Odhner [1915, Taf. 1, fig. 21] contradicts the description of *insculpta* given by Totten [1835]. Totten noted his *insculpta* as «impressed at the top» and having concave columellar margin (see Totten [1835, fig. 4]). According to specimens that were collected near Greenland (presumably from the collections of the Zoological Museum of Copenhagen) and labeled as «*Bulla insculpta* (= *Bulla reinhardi*)», *insculpta* has thin dark colored periostracum and very fine sculpture (Fig. 3F). If *B. insculpta* is really a synonym of *H. solitaria* (Haminoeidae) or belongs to Cylichnidae, in both cases *C. validus* and *B. insculpta* are different species.

Cylichnoides densistriatus (Leche, 1878)

Figs 3B; 6I–L; 7K–L

Utriculopsis densi-striata Leche, 1878, p. 74–75, Taf. 1, fig. 20.

Utriculopsis densistriata Leche, 1878: Herzenstein, 1885, p. 707.

Diaphana densistriata (Leche, 1878): Aurivillius, 1887, p. 371.

Cylichna densistriata (Leche, 1878): Knipowitsch, 1896, p. 300.

Cylichna occulta densistriata (Leche, 1878): Lemche, 1948, p. 79, figs 40a, 40b (paratype); Lemche, 1956, p. 236–239, pl. 1, figs 9, 10, 11; pl. 4, figs 42, 44; pl. 6, fig. 63; pl. 7, figs 82, 84; pl. 42, fig. 348.

Cylichnoides densistriata (Leche, 1878): Chaban, 2001, p. 108; Chaban, 2004, p. 83–84, fig. 5C, D; Chaban, 2010, p. 76, fig. 6.5.

Type locality. Kara Sea, 63°05' N, 73°45' E, 9–70 fms.

Type specimens. SMNH [Lemche, 1956, p. 236].

Material studied. **New Siberian Islands:** Russian polar expedition, R/V «Zarya», 1903, Kotelny Il., coll. A.V. Kolchak, det. N. Knipowitsch – 5 specimens; **East-Siberian Sea:** R/V «Ivan Kireev», 2004, station 87, 69°31'17" N, 170°25'97" E, 11 m depth – 1 specimen; station 90, 70°02'81" N, 170°04'62" E, 18 m depth – 2 specimens; station 108, 70.275° N, 168.376° E, 27 m depth – 1 specimen; station 110, 70.835° N, 162.877° E – 2 specimens; **Laptev Sea:** 24.08.1973, Kondrat'evsky Isl., 7 m depth, coll., det. by A.N. Golikov – 2 specimens; R/V «Ivan Kireev», 1993, station 31/53, 75.0000° N, 129.5730° E, 40 m depth, mud – 3 specimens; R/V «Yakov Smirnitstkiy», 1995, station 60, 74.5401° N, 135.0002° E, 23 m depth, clay – 2 specimens; station 62, 72.5501° N, 134.0003° E, 17 m depth, clay – 1 specimens.

Description. Shell (Fig. 6I–L) very thick and strong, almost globose, up to 6 mm, very wide at the top, apex umbilicated, columellar margin short, straight, often wide, almost parallel to axis of shell. Spiral sculpture (Fig. 7L) consists of alternating narrow deep wavy grooves and ribs.

Anatomy. Studied specimens 5–5.5 mm height are adult, their narrow twisted prostate joined with a lateral side of the penial sac (Fig. 3B). Radula is 2:1:1:1;2 (Fig. 7K), bilobate rachidian teeth with straight denticles.

Distribution. White, Kara, Laptev and East-Siberian seas from 5 to 170 m [Leche, 1878; Herzenstein, 1885; Aurivillius, 1887; Knipowitsch, 1896; Chaban, 2001, 2004, 2010].

Notes. The type specimens of *C. densistriatus* have not been studied here but the specimens here described belong to this amazing species without doubt. The species is easily defined due to their almost globose thick shell and hard spiral sculpture, and according to figures given by Leche [1878] and Lemche [1956]. *C. validus* differs from *C. densistriatus* in shell shape, sculpture and columellar margin. *C. densistriatus* has a very thick shell with hard spiral sculpture. *C. occulta* from Jørgen Brønlund Fjord (North Greenland) was regarded by Schiøtte [1989, fig. 11C] as identical to *C. densistriatus* due to the shell shape, but it does not have the appropriate spiral sculpture and is determined not to be *C. densistriatus*. Radula of the type specimen was studied by Lemche and he noted that the denticulation on the rachidian tooth is continuous over the median incision [Lemche, 1956, p. 238]. This characteristic and the shell morphology distinguish *C. densistriatus* from other species of the genus. The species is not found to the east of the East-Siberian Sea.

Cylichnoides occulta (Mighels et Adams, 1842)

Figs 3C; 4A–L; 5A–I

Bulla occulta Mighels et Adams, 1842, p. 54, pl. 4, fig. 11.

Cylichna occulta (Mighels et Adams, 1842): Pilsbry, 1893, p. 292 (part.), pl. 28, fig. 36; Minichev, 1977, p. 428, fig. 1; Golikov, 1994, p. 81 (part); Golikov, 1995, p. 58 (part.); Malutin, 2006, p. 182.

Cylichnoides occulta (Mighels et Adams, 1842): Chaban, 2001, p. 108; Chaban, 2008, p. 153–154 (part); 2010, p. 74–75, fig. 6.3A.

Bulla reinhardtii Møller, 1842, p. 6; Schiøtte, Warén, 1992, p. 12, fig. 5 (syntype).

Cylichna reinhardtii (Møller, 1842): Leche, 1878, p. 73, pl. 1, fig. 21; Odhner, 1907, p. 51; Odhner, 1915, p. 227.

Cylichna solitaria (Say, 1822): Herzenstein, 1885, p. 705–706 (non Say, 1822).

Type locality. Westbrook in the vicinity of Portland, Maine, USA.

Type specimens. Lectotype of *Bulla occulta* Mighels et Adams, 1842 (fossil): MCZ 156452 [Johnson, 1949]; 2 syntypes of *Bulla reinhardtii* Møller, 1842: ZMUC GAS-84 (in alcohol) [Schiøtte, Warén, 1992, p. 12, fig. 5].

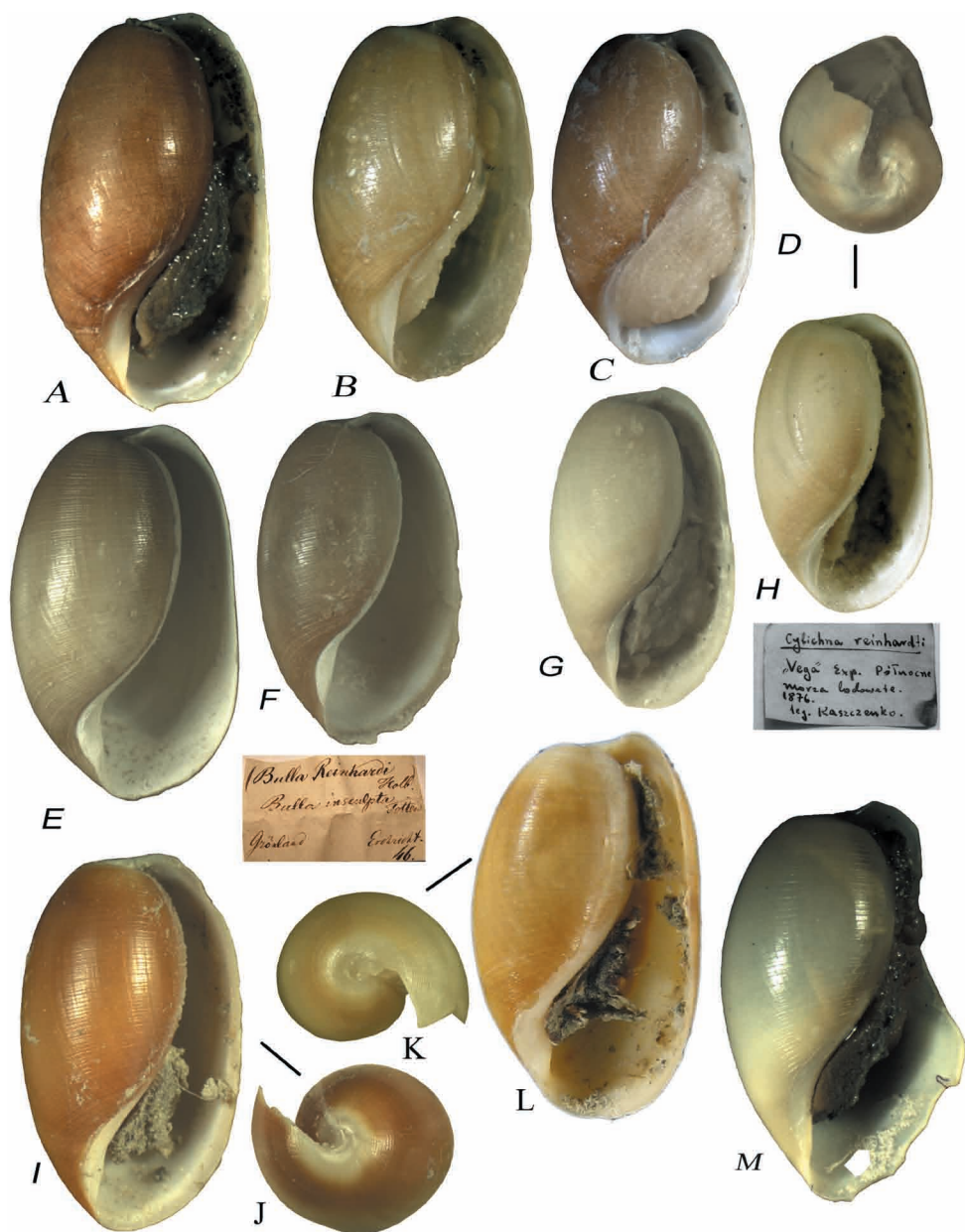
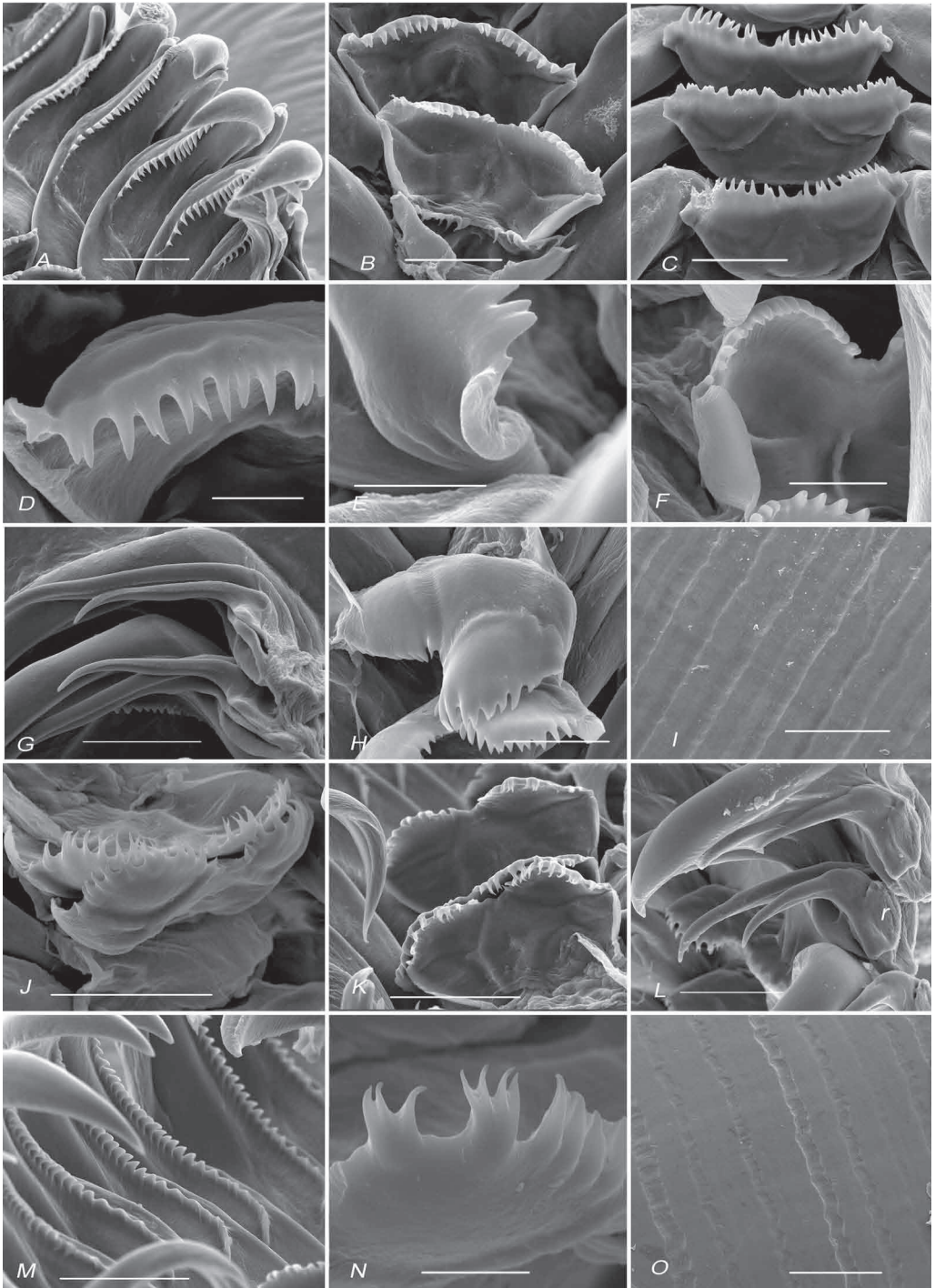


Fig. 4. *Cylichnoides occultus*, shell: Chukchi Sea, Wrangel Isl., «Fyodor Litke», station 44 (A – 8.5 mm, ventral view); Wrangel Isl., Rodzhers Bay, station 4 (8.0 mm – B, 7.0 mm – C, ventral view); Greenland, identified previously as *Cylichna insculpta* (= *Cylichna reinhardtii*) (8.0 mm – E, 6.5 mm – F); «Vega» expedition, 1876 (H – 4.0 mm, G – 5.0 mm, ventral view and D – apical view); Frantz Joseph Land (I – 7.2 mm, ventral view and J – apical view); K, L – Chukchi Sea, De Long Strait (K – apical view and L – 8.0 mm, ventral view); *Cylichnoides* sp. 1: «Fyodor Litke», station 44, Chukchi Sea, Wrangel Isl. (M – 7.8 mm).



Material studied. **Chukchi Sea:** «Vega» expedition, 1876, Chukchi Sea, det. Kaszchenko as *Cylichna reinhardi* – 17 specimens; icebreaker «Vaygach», 1911, Chukchi Sea, no data, identified by G.P. Gorbunov as *Cylichna insculpta* var. *reinhardi* – 24 specimens; icebreaker «Fyodor Litke», 07.IX.1924, Wrangel II., station 44, collected by P.V. Ushakov – 3 specimens; 22.VIII.1976, Wrangel Isl., Rodzhers Bay, station 4, depth 2–4 m, collected and identified by A.N. Golikov – 20 specimens; 22.VIII.1976, Wrangel II, Rodzhers Bay, station 4, 3–4 m depth, collected and identified by A.N. Golikov – 25 specimens; **Greenland:** 4 specimens, collected near Greenland, labelled as *Bulla insculpta* (= *Bulla reinhardi*); **Franz-Iosiph Land,** Heiss Isl., station 441, depth 5–7 m, 6.VIII.1981, collected by V. Averintsev – 11 specimens.

Diagnosis. Shell ovate-cylindrical, apex not umbilicated, columellar margin without fold, spiral sculpture consist of regularly spaced weak narrow spiral grooves and ribs. Lateral teeth with 22–24 uneven denticles, which do not descend in to the base of the tooth; rachidians equipped with 9–12 denticles (on one lobe), which have triangular 1–2 tips. Lateral sides of rachidian tooth rolled, upper-lateral ends with notch, sometimes ear-shaped. Male copulatory system consists of a narrow prostate joined with lateral side of the small penial sac, which does not reach to the end of the prostate.

Description. Shell from 3 to 11.3 mm height; ovate-cylindrical, apex not umbilicated, columellar margin without fold, spiral sculpture consists of regularly alternating weak narrow spiral grooves and ribs (16–18 grooves per 1 mm of shell) (Fig. 5I). Shell variability is presented on Fig. 4A–L.

Anatomy. Inner lateral teeth with 22–24 uneven denticles, which do not form a plate on the base of the tooth; outer laterals with the fine serration. Bilobate convex rachidians equipped with 9–12 denticles (on one lobe), which have 1–2 triangular tips. Internal surface with median crest (Fig. 5F). Lateral sides of rachidian tooth rolled, upper-lateral ends with notches, sometimes ear-shaped (Figs 5A–I). Male copulatory system consists of a narrow prostate joined with lateral side of the small penial sac that is filled with muscular folds (Fig. 3D).

Distribution. Circumpolar.

Notes. Lectotype of *B. occulta* was designated by Johnson [1949] but this specimen was not figured; syntypes of *B. reinhardi* were designated and figured by Schiøtte and Warén, [1992]. Description and drawing of shell morphology, radula and male copulatory system of *C. occultus* from Frantz-Joseph Land is given by Minichev [1977]. Specimens from that locality have 26–32 denticles on rachidian tooth. *C. validus* differs from *C. occultus* in shell and radular morphology.

Fig. 5. *Cylichnoides occultus*: radula (A – internal lateral teeth, B – F, H – rachidian teeth, G – outer lateral teeth) and shell sculpture (I) of the specimens collected in the Chukchi Sea, Wrangel Isl. (A–E, I – 1976; F–H – 1924). *Cylichnoides* sp. 1: radula (J, K, N – rachidian teeth, L – outer lateral teeth, M – internal lateral teeth) and shell sculpture (O). Scale bar: A, G, K, L – 50 µm; B, C, H – 30 µm; D, E, N – 10 µm; F, J – 20 µm; I – 200 µm; M – 40 µm; O – 100 µm.

Specimens from the Chukchi Sea, collected during the «Vega» expedition (identified by Kasztczenko, as *Cylichna reinhardi*, Fig. 3D) and during the expedition of the ZISP, 1976 (identified by Golikov as *Cylichna occulta*) correspond to description of *B. occulta* by Mighels and Adams and to imaging of the syntype of *B. reinhardi*. They are represented by specimens 3–5 mm (as type of *B. occulta*) – 8–8.5 mm in height. Mighels and Adams [1842] state «this shell is the analogue of, *B. triticea* Couth. It however differs from that species in being proportionately wider». *Bulla triticea* Couthouy, 1838 has a cylindrical shell [Couthouy, 1838, pl. II, fig. 8] but *B. occulta* have been figured by Mighels and Adams [1842, pl. 4, fig. 11] as oval. Unfortunately, the lectotype of *B. occulta* is in poor condition [Clench, Turner, 1950]. Pilsbry [1893] considered *scalpta* and *reinhardi* as synonyms of *occulta*, but noted that the first may be distinct. We consider both *B. reinhardi* and *B. scalpta* to be different species and based on the illustrations of *B. occulta* [Mighels, Adams, 1842] and of the syntype of *B. reinhardi*, we regard the first as a senior synonym of the second.

Cylichnoides scalptus (Reeve, 1855)

Figs 3A; 6A–H; 7A–J

Bulla scalpta Reeve, 1855, p. 392–393, pl. 32, figs 3a, b, c.

Cylichna scalpta (Reeve, 1855): Leche, 1878, p. 73, tab. 1, fig. 22.

Cylichna (Bullinella) scalpta (Reeve, 1855): Filatova, Zatsepin, 1948, p. 394, pl. 53, fig. 8.

Cylichna occulta (Mighels et Adams, 1842): Pilsbry, 1893, p. 292 (part.), fig. 35; Lemche, 1956, p. 225, pl. 1, fig. 3, 4 (non Mighels et Adams).

Cylichnoides scalpta (Reeve, 1855): Chaban, 2001, p. 108; Chaban, 2004, p. 82–83, fig. 5E, F; Chaban, 2010, p. 75–76, fig. 6.4; Chaban, Martynov, 2006, p. 254, pl. 126, fig. F; Nekhaev, 2014, p. 110, fig. 15D.

Type locality. Spitsbergen.

Type specimens. Lost [Lemche, 1948].

Material studied. **Barents Sea:** R/V «Persey»: station 862, 22.IX.1927, 73°59' N, 63°25' E, depth 79 m – 2 specimens; station 866, 22.IX.1927, 75°21' N, 65°10' E, depth 340 m – 1 specimen; **Kara Sea:** icebreaker «Rusanov», 1932, station 20, 70°47' N, 63°59' E, depth 130 m, mud – 7 specimens; icebreaker «Sedov», 1934, station 51, 77°28' N, 86°32' E, depth 112 m, mud and sand – 20 specimens; icebreaker «Fyodor Litke», 29.IX.1948, station 183, 80°30' N, 90°03' E, depth 174 m, mud – 11 specimens; **Laptev Sea:** R/V «Polarstern», 07.IX.1993, station 43, 77°24' N, 133°32' E, depth 55 m – 16 specimens; **East-Siberian Sea:** R/V «Ivan Kireev», 2004, station 87, 69°31' N, 170°25' E, depth 11 m – 1 specimen; station 106, 70°28' N, 171°36' E, depth 31 m – 1 specimen.

Description. Shell wide-cylindrical, up to 11.5 mm height, spiral striations very narrow, engraved, apex impressed and wide, mostly umbilicated, columellar margin narrow, oblique (Figs 7G–J).

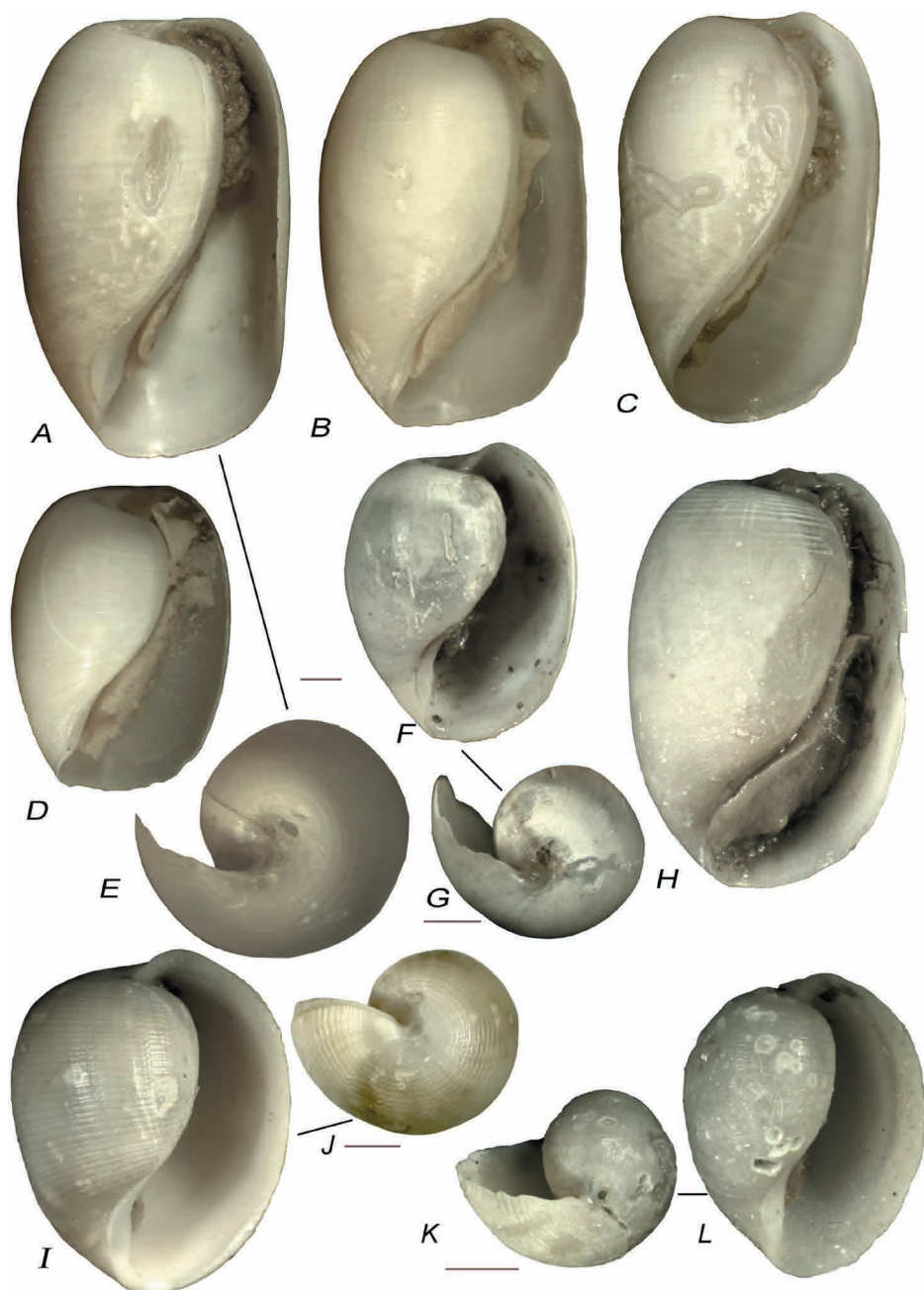


Fig. 6. *Cylichnooides scalptus*, shell: Kara Sea, «Fyodor Litke», station 183 (A–E); Barents Sea, R/V «Persey», station 862 (F, G) and station 866 (H) (ventral view: A – 10.2 mm, B – 9.9 mm, C – 9.5 mm, D – 5.3 mm, F – 5.0 mm, H – 10 mm; apical view: E, G). *Cylichnooides densistriatus*, shell: Kotelny Isl., New Siberian Islands, 1903 (I, J); Laptev Sea, Kondrat’evsky Il., 1973 (K, L), ventral view (I – 5.6 mm, L – 4 mm), apical view (J, K). Scale bar: E, G, J, K – 1.0 mm.

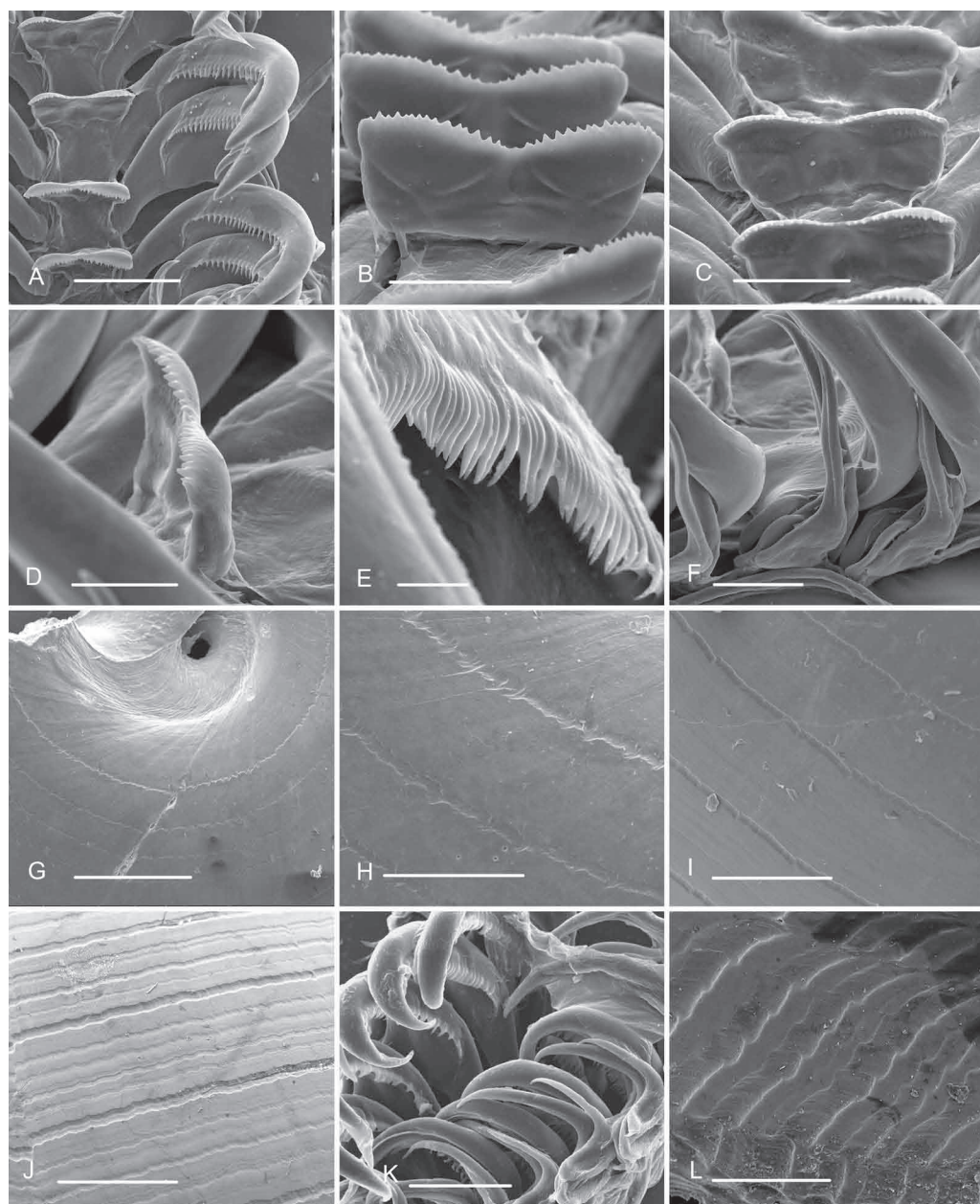


Fig. 7. *Cylichnoides scalptus*: Kara Sea, 1948: radula (A–F), shell sculpture (G–J), (B–D – rachidian tooth, denticles of the internal lateral tooth, E – denticles of the internal lateral tooth, F – outer lateral teeth). *Cylichnoides densistriatus* (K, L): radula (K), shell sculpture (L). Scale bar: A – 100 μm ; B – 40 μm ; C, F, K – 50 μm ; D – 30 μm ; E – 10 μm ; G – 500 μm ; H, I, L – 200 μm ; J – 400 μm .

Anatomy. Male copulatory system consists of the narrow prostate and long penial sac, which is joined with prostate by a narrow proximal part (Fig. 3A). Lateral teeth have uneven denticles, which do not form a plate on the base of the tooth (Figs 7A, E). Rachidians bilobate, slightly convex, equipped with short widely spaced denticles on cutting edge, upper-lateral ends without notches (Figs 7B–D).

Distribution. Arctic species, distributed from Baffin Bay eastward to the East-Siberian Sea.

Notes. *C. scalptus* differs from both *C. occultus* and *C. validus* in shell, penial and radular morphology (see Table 1). It is not found to the east of the East-Siberian Sea.

Cylichnoides sp. 1.

Figs 4M; 5J–O

Material studied. **Chukchi Sea:** Wrangel Isl., icebreaker «Fyodor Litke», 01.IX.1929, station 44 – 1 specimen, collected by P.V. Ushakov.

Description. This shell has an almost straight columellar margin (Fig. 4M), very fine spiral sculpture, pale yellow periostracum and unusual rachidians. Spiral sculpture (Fig. 5O) consists of the weak straight striae equally close over the whole shell, mostly at regular distances from each other. These striae alternate with two more weak striae, which can be seen more clearly at the electron microscopy images. The height of the shell is 7.8 mm. Radula (Fig. 5J–N) has formula 10x2:1:1:1:2, lateral teeth with 20–24 regularly spaced curved denticles, which descend to the base of the tooth. Rachidian teeth equipped with the long curved denticles tapering with 1–4 filiform ends. Cutting edge is a simple rounded form. Lateral edges not rolled.

Notes. The species differs from other species of *Cylichnoides* in shell sculpture and rachidian teeth morphology. Rachidian tooth is equipped with long curved denticles tapering with 1–4 thread ends.

Discussion

Cylichna occulta sensu Pilsbry [1893] and Lemche [1948] is a group of related species that have: an oval or oval-cylindrical shell with spiral striation; the male copulatory system consists of prostate and penial sac with muscular folds; radula with two marginal teeth. Scanning electron microscopy images demonstrate significant differences in morphology of rachidian teeth of the «*C. occulta* species group». Rachidian tooth can be convex or almost flat, with rolled or tapering lateral ends; the cutting edge can be equipped with simple small denticles or long curved composed denticles; the back surfaces of rachidian tooth can be smooth or equipped with additional very small cusps and their inner surface can carry strong vertical crest. Differences in rachidian morphology help to separated species together with shell and penial morphology (see Table 1).

Table 1

Comparison of characters of *Cyllichnoides occultus* complex

Characters	<i>C. occultus</i>	<i>Cyllichnoides</i> sp. 1	<i>C. scalptus</i>	<i>C. densistriatus</i>	<i>C. validus</i>
Height of the shell (mm)	Up to 11.3	7.8 mm	Up to 11.5	Up to 6.0	Up to 11.8
Color of periostracum	Red, yellow, white, yellow with red ends	Pale yellow	White	White	White
Spiral sculpture	Weak, narrow ribs and grooves alternate almost regularly	Very fine grooves, alternate with two more weak	Spiral striations very narrow, engraved	Alternating deep grooves and strong ribs	Broad ribs alternating with wide grooves
Number grooves per 1 mm (in the middle of the shell)	16–18	6–7	4–5	6–7	6–7
Columnella	From direct and oblique to concave, without fold	Direct, without fold	Oblique without fold	Direct without fold	With strong fold
Apical umbilicus	Closed	Closed	Often open	Often open	Closed
Radula	Rachidians strongly convex with large cusps and upper-lateral notches	Rachidians with long curved denticles which tapering with 1–4 threadlike ends	Rachidians equipped with short widely spaced denticles	Denticles on the laterals rarely spaced, don't descend to the base of the lateral tooth; rachidian teeth with straight denticles	Denticles on the laterals closely spaced, descend to the base of the lateral tooth; rachidians slightly convex, equipped with row of small cusps, lateral ends without notches
Height/width of the shell	1.6–1.9	–	1.3–1.5	1.1–1.3	1.5–1.7
Penis sac	Short	Not studied	Long	Short	Short
Distribution	Circumpolar	Chukchi Sea	Baffin Bay, east to East-Siberian Sea	White Sea – East-Siberian Sea	Spitsbergen east to Chukchi Sea

Remarks on the genus *Cylichnoides*

Minichev [1977] established the subgenus *Cylichnoides* with the type species *C. occulta* based on the shell and male copulatory morphology. The subgenus was separated later into a valid genus [Chaban, 2004; Chaban, Martynov, 2006], but in WoRMS it is listed as a junior synonym of the genus *Cylichna* [Bouchet, 2015]. According to Minichev, *C. occultus* has a penial sac in contrast with *Cylichna cylindracea* (Pennant, 1777), the type species of the genus *Cylichna*. He noted that the prostate of *C. cylindracea* is connected directly with an external seminal groove [Minichev, 1977], but this is now considered incorrect. Lemche [1956] showed that a proximal part of the male copulatory system of *C. cylindracea* possesses muscular folds and a penial sac. Moreover, according to Amorim et al. [2013], the penial sac (vestibulum, atrium) of opisthobranchs can be everted during copulation if a penial papilla is not free, and it is used as a penis. The penial morphology of *C. occultus* and *C. cylindracea* differ in the locality of connection of prostate with the penial sac and in the degree of the penial sac development. The prostate of *C. cylindracea* is connected with a distal end of the penial sac, the latter is a vestibulum with a weak fold only. The prostate of *C. occultus* (Fig. 3D) is connected with an antero-lateral side of the penial sac, the latter is well developed and separated from the vestibulum. The latter character can be interpreted as a synapomorphy of *Cylichnoides* and I regard this taxon as a valid genus. Additional characters of *Cylichnoides* (Table 2) are large gizzard plates, an absence of the crop and bilobate rachidian tooth

Table 2

Characters of *Cylichna* and *Cylichnoides*

Characters	<i>Cylichna</i>	<i>Cylichnoides</i>
Shell	Cylindrical	Oval
Penis	Penial sac not separated, prostate with numerous parallel longitudinal folds	Penial sac separated, prostate with one longitudinal or mixed folds
Radula	3–7:1:1:1:3–7, rachidians arched, shallow median notch	2:1:1:1:2, rachidians bilobate with deep median notch
Crop	Present	Absent
Gizzard plates	Short	Long
Source	Lemche [1956], own data	Minichev [1977], this study

with a deep notch. Once more character noted by Minichev is in larval morphology. However, differences in the larval shell morphology of *C. cylindracea* and *C. occultus* can be a result of the ecological environment [Minichev, 1977, p. 432].

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