



New and little-known shell-bearing heterobranch mollusks (Heterobranchia: Aplustridae and Cephalaspidea) from the bathyal zone of the northwestern part of the Sea of Japan

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ABSTRACT

Seven species of the shell-bearing heterobranch gastropods collected during Cruise 51 of R/V Akademik M.A. Lavrentyev in the northern part of the Sea of Japan represent the new data on the fauna of Heterobranchia in the bathyal zone from this area. Taxonomic descriptions of two new species, *Parvaplustrum japonicum* sp. nov., and *Retusa lata* sp. nov., are presented herein with remarks on morphology and distribution. The finding of *Toledonia* cf. *limnaeoides* (Odhner, 1913) is the first record of the genus *Toledonia* for the northern Pacific. The present records for *Diaphana hiemalis* (2693–2725 m) and *Cylichna toyamaensis* (1001–2555 m) are the deepest.

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1. Introduction

Though the deep-water opisthobranch fauna of the northwestern Pacific has been studied in research conducted by Minichev (1966, 1967, 1969), information concerning bathyal cephalaspideans from the northwestern part of the Sea of Japan remains very limited. Four ‘cephalaspid’ species, *Cylichna alba* (Brown, 1827), *D. hiemalis* (Couthouy, 1839), *Retusa toyamaensis* (Habe, 1955), and *Philine* sp. (listed as *Philine argentata* Gould, 1859), were documented in total for the entire continental slope of the northwestern part of the Sea of Japan (Derjugin, 1939; Chaban, 1996; Golikov et al., 2001; Gulbin and Chaban, 2009). The newly collected materials, comprising altogether eight species of shell-bearing heterobranch gastropods (mostly cephalaspidean), obtained during Cruise 51 of R/V Akademik M.A. Lavrentyev in the northern part of the Sea of Japan represent new data on the heterobranch fauna for the bathyal zone from this area.

Herewith, we present taxonomic descriptions for two new and two little-known species of heterobranch mollusks, accompanied with remarks on their morphology and geographic distribution. *C. toyamaensis* and *Cylichna* sp. will be described in the next paper. We regard *C. alba* and *C. toyamaensis* as

separate species, because they differ in the radula formula and shell morphology.

2. Materials and methods

The material for this study was collected in the summer of 2010 on the continental slope and in the deep-sea basin of the Sea of Japan during the Russian–German expedition SoJaBio (*Sea of Japan Biodiversity studies*) on board R/V Akademik M.A. Lavrentyev (for a list of stations see Maluytina and Brandt (2013)). For sampling of macrofauna, the newly modified camera-epibenthic sledge (C-EBS, see Brandt et al., 2013) was used. The samples were sieved using 300 µm mesh size and immediately afterwards fixed in 96% ethanol or 4% neutral formalin. The radulae and jaws were extracted from the buccal mass and cleaned with 1% sodium hypochlorite or 10% KOH. Then, they were washed in distilled water and finally treated with 70° and 95° ethanol to study them with the Scanning Electron Microscope (SEM) Hitachi-S 570N and Zeiss EVO 40. For SEM, fixed specimens dehydrated in ethanol followed by an acetone series were critical point dried and then sputter coated with platinum–palladium alloy. Male copulatory organs and radulae of some specimens were mounted in glycerol and examined under the light microscopes Leica DMLS-2 and Leica DM4500B.

The material examined here is deposited in the Zoological Institute (St.-Petersburg) (ZISP), Museum of A.V. Zhirmunsky Institute of Marine Biology (Vladivostok) (MIMB), and the Zoological Museum of Hamburg (ZMH).

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3. Results

3.1. Systematics

Clade Heterobranchia

'Lower Heterobranchia'

Superfamily Acteonoidea d'Orbigny, 1843

Family Aplustridae Gray, 1847

Genus *Parvaplustrum* Powell, 1951

Parvaplustrum japonicum sp. nov.

(Figs. 1A–K and 2A–D)

Material examined: *Holotype*, MIMB 27389, 14.08.2010, north-western Sea of Japan, 44°56.9197'N, 137°11.8947'E–44°57.0966'N, 137°12.0732'E, depth 455–465 m, R/V Akademik M.A. Lavrentyev, station A2-10. *Paratypes*: 16 specimens, ZISP 61521–61525, same data as holotype; 78 specimens, ZMN 79380 and MIMB

27390, 25.08.2010, north-western Sea of Japan, 43°13.4578'N, 135°04.3295'E–43°13.5809'N, 135°04.1939'E, depth 470–528 m, R/V Akademik M.A. Lavrentyev, station B7-7.

Description. *Shell morphology*: holotype 2.2 mm high and 1.6 mm wide; paratypes from 0.8 to 2.5 mm high (sizes of 9 paratypes—2.3 mm × 1.6 mm, 2.2 mm × 1.5 mm, 2.1 mm × 1.5 mm, 2.0 mm × 1.5 mm, 1.9 mm × 1.4 mm, 1.7 mm × 1.2 mm, 1.4 mm × 1.0 mm, 1.1 mm × 0.7 mm, 0.8 mm × 0.6 mm); juvenile specimens about 0.4–0.6 mm high. Shell very thin, translucent, fragile, ovate-globose, with involuted spire and convex body whorl. Apex umbilicated, preceding whorls not visible in the apical umbilicus. Aperture lip forms a rounded wing conspicuously rising above apex and partly covers apical umbilicus so it looks semicircular. Aperture extremely wide, with convex outer lip, rounded anterior end of shell and thin parietal callus. Columella simple and thin, with no folds, with wide reflection in upper part forming deep columellar umbilicus. Sculpture consists of irregularly distributed pits 5–10 μm in diameter; some pits anastomose with each other. Operculum absent.

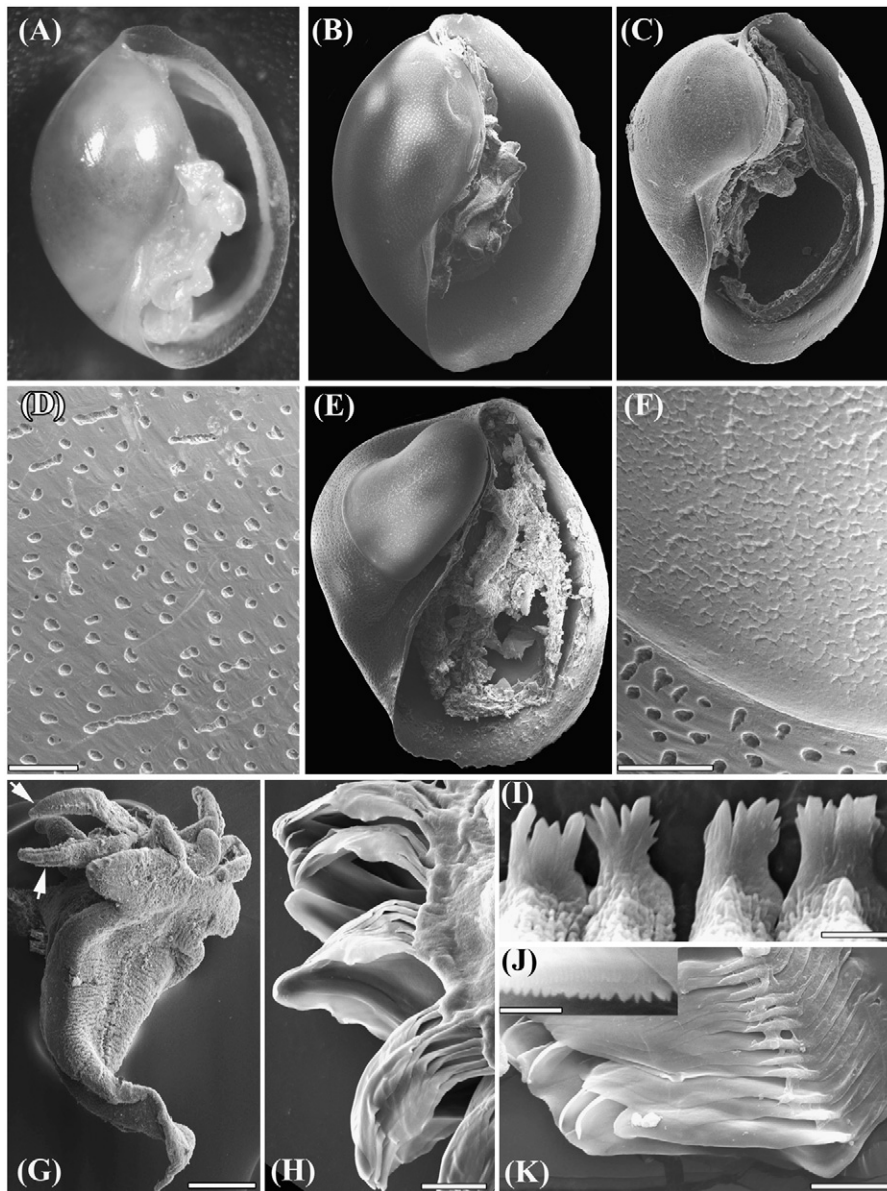


Fig. 1. *Parvaplustrum japonicum* sp. nov.: (A) holotype (MIMB 27389), 2.1 mm high; (B, C) paratypes (MIMB 27390 and ZISP 61521), 2.2 mm and 1.4 mm high; (D) shell sculpture; (E) juvenile specimen, 0.75 mm high; (F) protoconch sculpture; (G) soft body, ventral view (cephalic appendages indicated by arrows); (H, K) radula, lateral view; (I) jaw elements; (J) edge of lateral tooth; (A–I) light microscope; (B–K) SEM. Scales: (D, F), 50 μm; (G), 0.2 mm; (I), 5 μm; (J), 1 μm.

Juvenile specimens have visible protoconch; sculpture of protoconch consists of closely located flattened tubercles, visible only under SEM (Fig. 1F).

Anatomy. Eyes not visible, body uniformly whitish, except for brownish digestive gland. Head shield small, on each side two extensible appendages (0.4–0.5 mm in length) extend from a common base. Triangular foot lacking parapodia, with pointed posterior edge; wide anterior edge with small lateral extensions. Mantle extremely thin, pellucid and very wide, forming a hood over cephalic shield, with thickened anterior margin. Pair of jaws consists of elongate rectangular elements $15\text{--}16 \times 7.0\text{--}7.5 \mu\text{m}$ terminating into 6–8 denticles of different sizes and forms. Radular formula $50\text{--}55 \times 1:0:1$, lateral teeth very delicate. In light microscopy radula rike-like, teeth look like ‘arcuate rods’ (see Powell, 1951, p. 180) in lateral view (Fig. 2A). But according to SEM data each tooth petaliform with very narrow base and broad curved blade; tooth edge with minute denticles (Fig. 1H and K). Gizzard lack plates or any cuticle elements. Penis non-protrusible; thick-walled muscular ejaculatory duct enters penial papilla with bulbous base and long conical extension about $180 \mu\text{m}$ length; stylet absent; conical penial sheath well-developed (Fig. 2C and D).

Remarks. Powell (1951) described a new genus and species of aplustrid gastropods, *Parvapulstrum tenerum* Powell, 1951, from Subantarctica (Falkland Islands). Another species, *Parvapulstrum* sp., was described from California coast (Cadien, 1995; Gosliner, 1996). Features such as ovate-globose *Haminoea*-like shell without operculum, two extensible appendages on each side of the head

shield, and radula with a pair of petaliform lateral teeth in a row indicate that our species belongs to the genus *Parvapulstrum*. Our specimens have jaws and gizzard without plates as noted by Marcus and Marcus (1969) in their redescription of *P. tenerum*. All three species possess different shell extremely fine and dense spiral striations in *P. tenerum* (Powell, 1951), spiral lines of punctae in *Parvapulstrum* sp. (Cadien, 1995), and irregularly arranged numerous extremely small pits in *P. japonicum* sp. nov.

Etymology. The species name is derived from the name of the type locality, the Sea of Japan.

Distribution. North-western Sea of Japan (type locality).

Clade Cephalaspidea

Superfamily Diaphanoidea Odhner, 1914 (1857)

Family Diaphanidae Odhner, 1914 (1857)

Subfamily Toledoniinae Warén, 1989

Genus Toledonia Dall, 1902

Toledonia* cf. *limnaeoides (Odhner, 1913)

(Fig. 2E–H)

Material examined. Station A2-10 (1 adult and 1 juvenile); station B7-7 (2 adult and 3 juvenile specimens).

Description. *Shell morphology:* Length up to 2.5 mm, width up to 1.5 mm, shell with elevated conical spire with 2–3 convex whorls (Fig. 2F and G). Body whorl large, about 3/4 of shell length. Shell translucent, covered with brownish periostracum. Aperture 1.5 mm in length with almost straight outer lip, anterior edge of

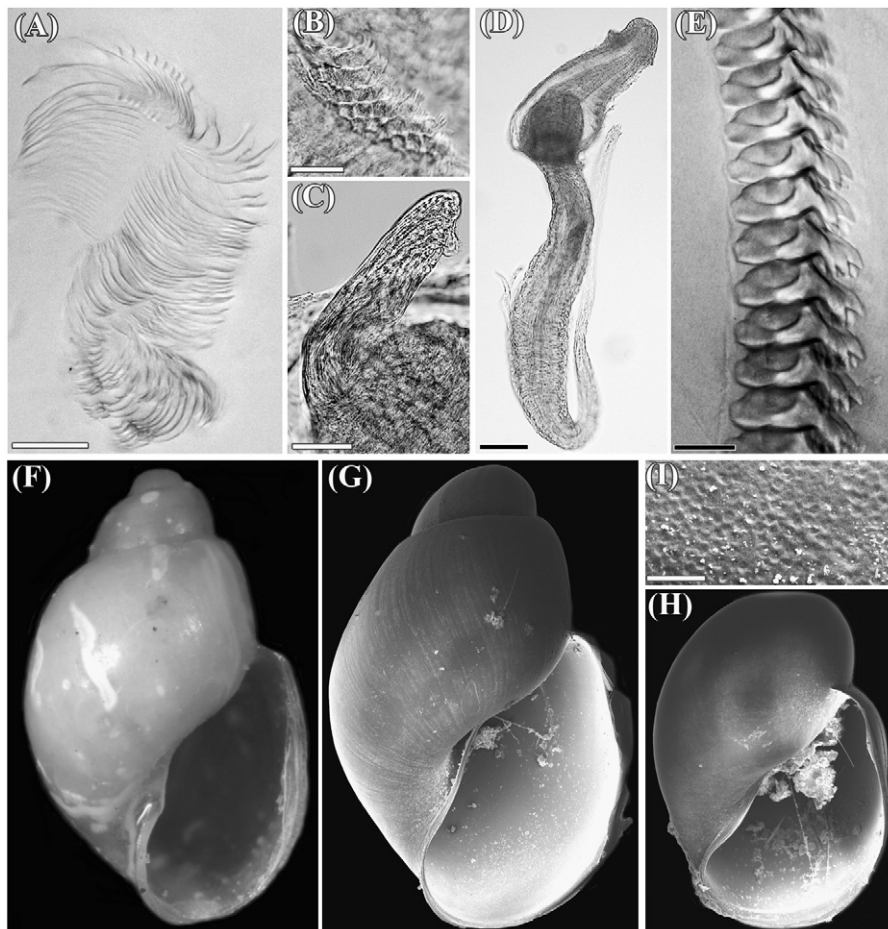


Fig. 2. *P. japonicum* sp. nov.: (A) radula, lateral view; (B) jaw elements; (C) penial papilla; (D) penis; *Toledonia* cf. *limnaeoides*: (E) radula, lateral view; (F–H) shells, 2.5 mm high (F), 1.8 mm high (G), 0.88 mm high (H); (I) protoconch sculpture; (A–F)—light microscope; G–I—SEM. Scales: (A, B, E), 20 μm ; (C, I), 50 μm ; (D), 100 μm .

the aperture rounded, inner lip with thin reflection, umbilicus narrow but deep, columella with one fold. Sculpture consists of fine growth lines. Protoconch sculpture consists of minor irregular dents. Operculum absent.

Anatomy: Body whitish, cephalic shield almost rectangular. Large eyes visible even through shell. Oval muscular foot without parapodia. Triangular buccal mass with dorsal muscular pomp continues in long thick-walled esophagus. Radular formula $30 \times 1:1:1$, rachidian tooth with 7–9 denticles.

Remarks. The specimens are assigned to the genus *Toledonia* Dall, 1902 based on their shell morphology and the morphology of the rachidian tooth. Our specimens are close to *Toledonia limnaeoides* in the sculpture and proportions of the shell (Marcus, 1976), but have more rounded aperture than Arctic specimens (Odhner, 1913). This is the first reliable record of the genus *Toledonia* in the northwestern Pacific.

Distribution. North-western Sea of Japan, depth 455–528 m.

Subfamily Diaphaninae Odhner 1914 (1857)

Genus *Diaphana* Brown 1827

Diaphana hiemalis (Couthouy 1939)

(Figs. 3A–J and 5A)

Material examined. Station A2-10 (5 specimens); station A3-10 (5 specimens); station A3-11 (9 specimens); station A6-7 (5 specimens); station A6-8 (1 specimen), station B5-8 (2 specimens), station B7-7 (25 specimens); station C1-8 (4 specimens), station C1-9 (2 specimens).

Description. *Shell morphology:* Length up to 3.2 mm, width up to 3.0 mm, shell globose, white or semi-transparent, smooth except for fine growth lines. Spire involuted, apex of shell forming small hole without rim. Apertural lip forming rounded wing conspicuously rising above apex. Aperture widest about 1/3 of its height from base. Columella almost straight, with small reflection, umbilicus wide. Protoconch brownish with 2.5 whorls, without specific sculpture. Juveniles have small, transparent, brownish operculum.

Anatomy: Body whitish, eyes very small, asymmetrical foot wide and forked posteriorly. Slightly asymmetrical radula $12 \times 1:1:1$, hook-like lateral teeth smooth, rachidian tooth with 36–38 denticles. Cephalic copulatory system with armed penial papilla; slightly curved penial stylet 130–160 μm in length. Prostate with two branches: relatively short and thick 'zigzag' branch, and longer thin branch ending in a broader appendage (Figs. 3I and 5A).

Remarks. The some eyeless turbellarians 220–280 μm length were found in mantle cavity of the specimens from the station A3-11 (Fig. 3K).

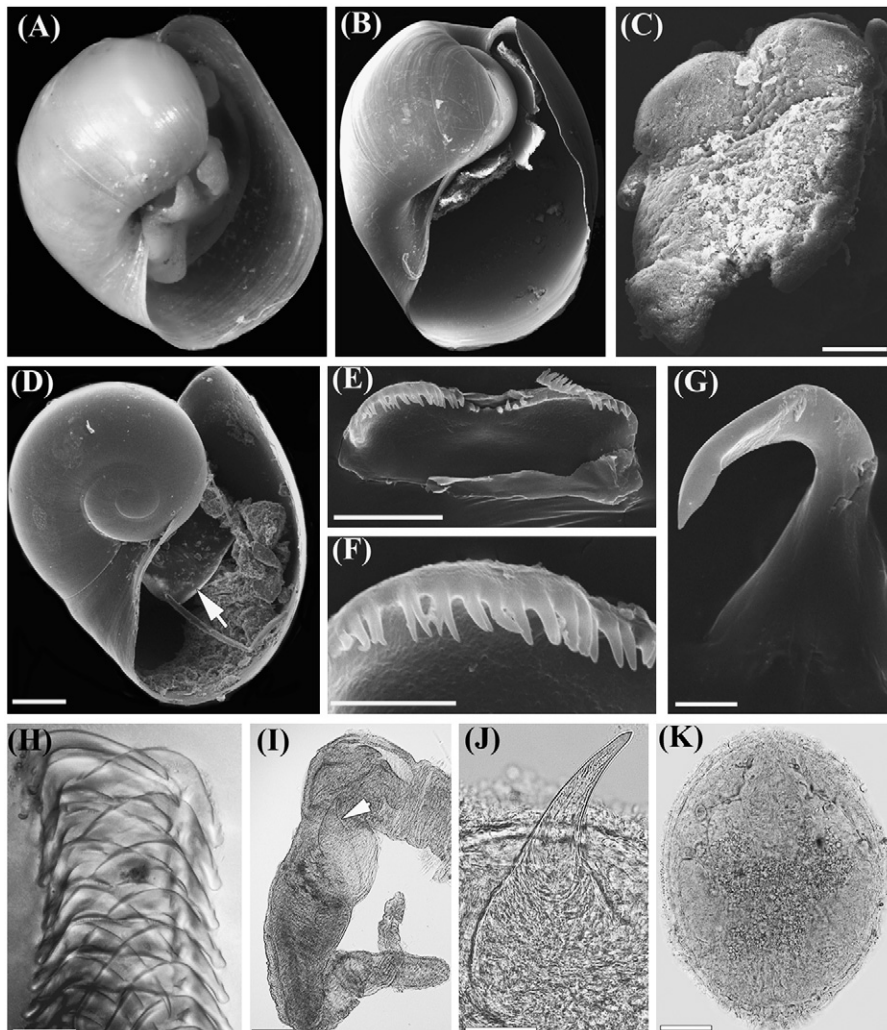


Fig. 3. *D. hiemalis*: (A, B) shell, 3.2 mm (A) and 0.75 mm high (B); (C) soft body, ventral view; (D) juvenile specimen; (E) rachidian tooth; (F) edge of rachidian tooth; (G) lateral tooth, lateral view; (H) radula; (I) penial–prostate complex (penial stylet indicated by arrow); (J) penial stylet; (K) symbiotic turbellarian (glycerol preparation); (A, H–K)—light microscope; B–G—SEM). Scales: (C, D, I), 100 μm ; (E, H), 10 μm ; (F, G), 5 μm ; (J, K), 50 μm .

Distribution. This is a circumpolar, boreal-Arctic species, recorded in the Arctic Region and North Atlantic from 5 to 2068 m (Schjøtte, 1998). In the western Pacific it has been recorded from North Kurile Islands (Chaban, 1996), the northwestern part of the Sea of Japan (Chaban, 1996; Schjøtte, 1998), and near the Pacific coast of northern Honshu Island as *Diaphana tibai* (Habe, 1976; Hori in Okutani, 2000; Hasegawa, 2009). The present record is the deepest (2693–2725 m) for *D. hiemalis*.

Superfamily Philinoidea Gray, 1850 (1815)

Family Retusidae Thiele, 1925

Genus *Retusa* Brown, 1827

Retusa lata sp. nov.

(Figs. 4A–I and 5B)

Material examined. *Holotype*: MIMB 27391, 14–15.8.2010, north-western Sea of Japan, 44°47.6338'N, 137°15.3182'E–44°47.8110'N, 137°15.3922'E, depth 1494–1525 m, R/V Akademik M.A. Lavrentyev, station A3-11. *Paratypes*: 30 specimens, MIMB 27392, ZISP 61526–61533, and ZMN 79379, same data as holotype.

Description. Shell morphology: holotype 2.1 mm high and 1.4 mm wide; paratypes from 2.8 to 1.1 mm high (sizes of 8 paratypes—2.8 mm × 1.9 mm, 2.4 mm × 1.7 mm, 1.6 mm × 1.2 mm, 1.3 mm × 1.1 mm, 1.3 mm × 1.0 mm, 1.2 mm × 1.0 mm, 1.2 mm × 0.9 mm, 1.1 mm × 0.8 mm). Shell oval-globose, with involuted spire and convex body whorl, narrowing to apex. Apex umbilicated, preceding whorls not visible in apical hole. Anterior end of shell rounded. Aperture long, wide anteriorly, narrowing gradually at about 1/3 of its length. Aperture lip forms a rounded wing conspicuously rising above apex. Outer lip convex. Columellar margin thin, almost straight. Umbilicus moderately wide and deep. Sculpture consists of numerous longitudinal, regularly spaced ribs, each rib covered with 5–7 secondary fine longitudinal riblets formed of periostracum only. Longitudinal sculpture covering entire external shell surface; spiral sculpture absent. Color uniformly whitish or yellowish.

Anatomy: Body whitish, eyes not visible. Foot short and rounded. Subadult specimens have small and transparent operculum (Fig. 4C). Cephalic shield with two small postero-lateral processes. Radula absent. Three oval and translucent horny gizzard plates 355–390 × 250–290 μm, with dark brown tubercles. Tubercles form a group closer to proximal end of plates.

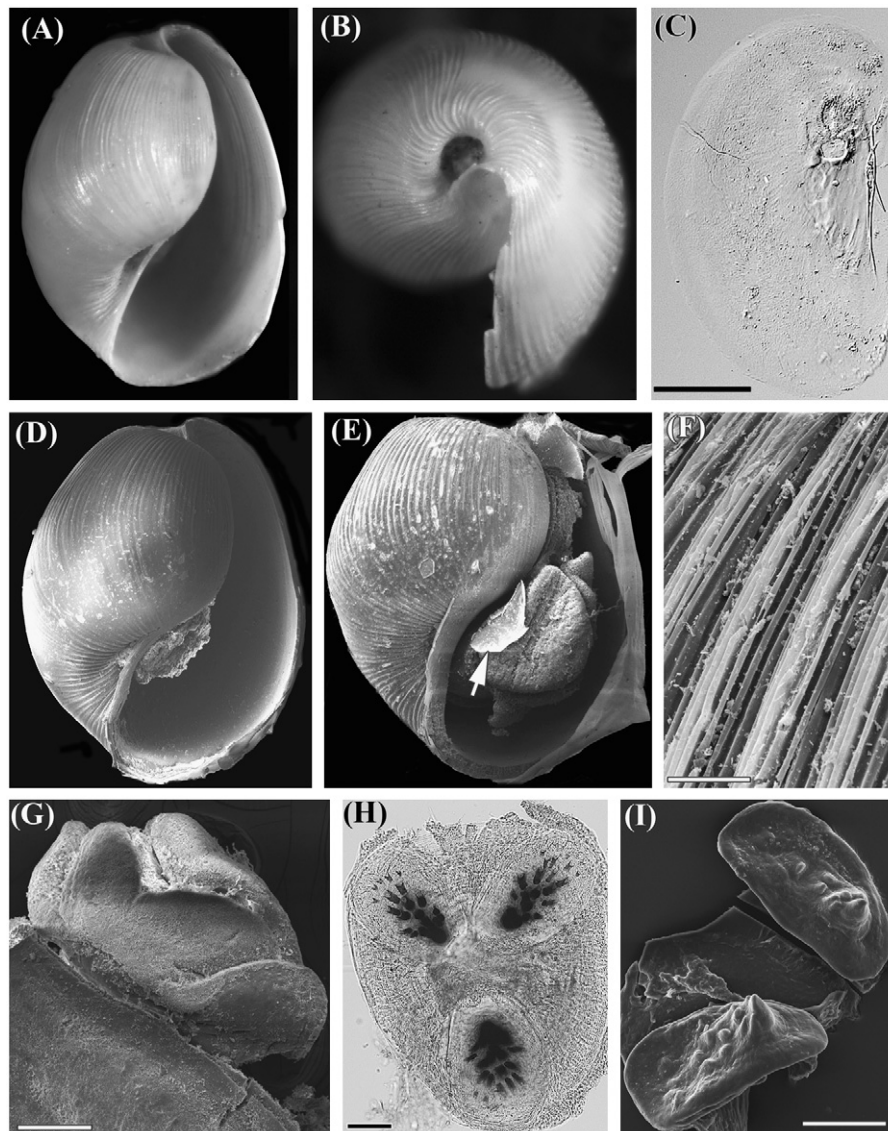


Fig. 4. *R. lata* sp. nov.: (A) holotype, ventral view (N 27391 MIMB), 2.1 mm high; (B) holotype, apical view, 1.4 mm wide; (C) operculum; (D, E) paratypes (MIMB 27392), 2.0 mm (D) and 1.56 mm high (E) (operculum indicated by arrow); (F) shell sculpture; (G) head, dorsal view; (H, I) gizzard plates; (A–C, H)—light microscope; D–G, I—SEM). Scales: (C, G, H, I), 100 μm; (F), 20 μm;

Male copulatory organ (Fig. 5B) on the right of esophagus; tubular internal part of seminal groove opens to a wide penial sac with folded walls; small penial prostate and short elongate sub-penial prostate (following Thompson (1976)) on one side of atrium, muscle-retractor attached to end of sub-penial prostate; long narrow accessory prostate on opposite side of penial sac.

Remarks. *R. lata* is undoubtedly a member of the genus *Retusa*, since it possesses three tuberculate gizzard plates and lack radula. *R. lata* sp. nov. is clearly distinguished from all species of the genus in the almost globose shell (ratio of the shell width to height is about 0.7), involuted spire and ribs of the longitudinal shell sculpture. Abyssal *Retusa operculata* Minichev, 1966 has

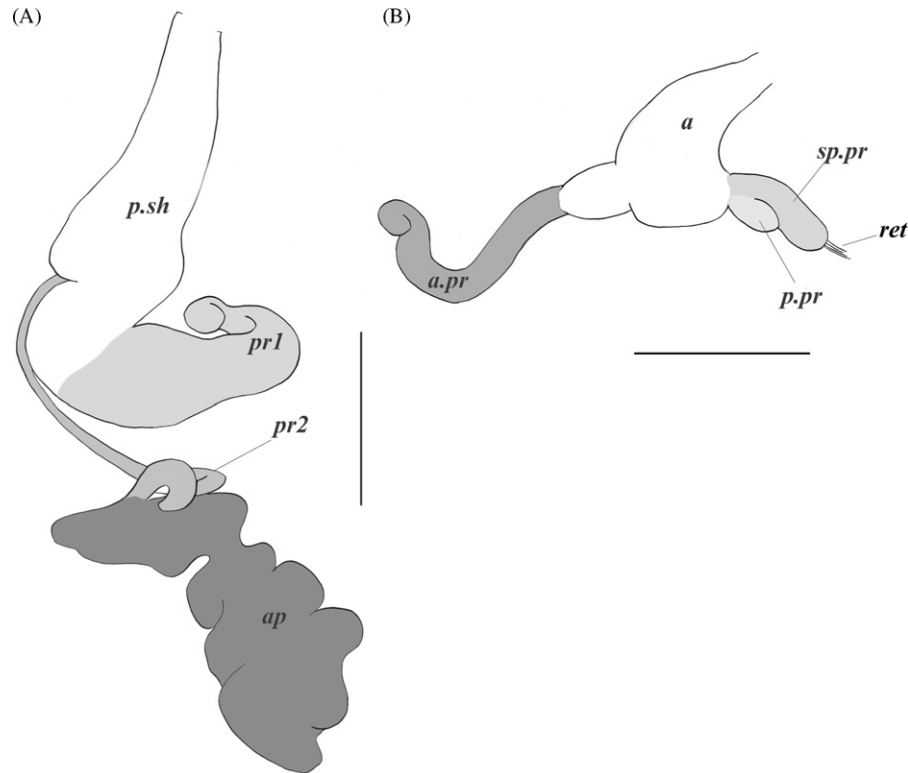


Fig. 5. Penial-prostate complex of *D. hiemalis* (A) and *R. lata* (B). Abbreviations: *a*—atrium, *ap*—appendage of the thin prostate, *a.pr*—accessory prostate, *p.pr*—penial prostate, *pr1*—thick prostate, *pr2*—thin prostate, *p.sh*—penial sheath, *ret*—penial retractor, *sp.pr*—sub-penial prostate. Scales: 0.5 mm.

Table 1

Station data for 41 voyage of RV Akademik Lavrentyev with heterobranch gastropods.

Station	Date	Position haul start	Position haul end	Depth (m)	Species	Specimens
A2-10	14.08.2010	44°56.9197'N, 137°11.8947'E	44°57.0966'N, 137°12.0732'E	455–465	<i>P. japonicum</i> <i>Toledonia</i> cf. <i>limnaeoides</i> <i>D. hiemalis</i>	17 2 5
A3-10	14.08.2010	44°49.8620'N, 137°13.9974'E	44°50.0210'N, 137°14.0932'E	1354–1356	<i>D. hiemalis</i> <i>C. toyamaensis</i> <i>Cylichna</i> sp.	5 1 shell 1 sp. + 1 shell
A3-11	14–15.08.2010	44°47.6338'N, 137°15.3182'E	44°47.8110'N, 137°15.3922'E	1494–1525	<i>D. hiemalis</i> <i>Cylichna</i> sp. <i>R. lata</i>	9 21 31
A6-7	16.08.2010	44°19.4270'N, 137°24.1964'E	44°19.2650'N, 137°24.1206'E	2511–2534	<i>D. hiemalis</i>	5
A6-8	16.08.2010	44°18.6270'N, 137°24.4079'E	44°18.4712'N, 137°24.3985'E	2545–2555	<i>D. hiemalis</i> <i>C. toyamaensis</i> <i>Cylichna</i> sp.	1 3 sp. + 2 shells 1
B5-8	23.08.2010	43°01.3064'N, 135°05.9562'E	43°00.9363'N, 135°06.5366'E	2609–2655	<i>D. hiemalis</i>	2
B6-7	25.08.2010	43°10.3999'N, 135°00.9751'E	43°10.2513'N, 135°00.9239'E	1001–1011	<i>C. toyamaensis</i> <i>Cylichna</i> sp.	36 4
B7-7	25.08.2010	43°13.4578'N, 135°04.3295'E	43°13.5809'N, 135°04.1939'E	470–528	<i>Toledonia</i> cf. <i>limnaeoides</i> <i>D. hiemalis</i> <i>C. toyamaensis</i> <i>P. japonicum</i>	5 25 13 78
B7-8	25.08.2010	43°13.5215'N, 135°04.3071'E	43°13.6778'N, 135°04.4447'E	532	<i>C. alba</i>	1
C1-8	27.08.2010	42°26.5832'N, 133°09.1471'E	42°26.6230'N, 133°09.3740'E	2670–2681	<i>D. hiemalis</i>	4
C1-9	27.08.2010	42°26.4275'N, 133°08.6525'E	42°26.4636'N, 133°08.8737'E	2,693–2,725	<i>D. hiemalis</i>	2

Table 2

Species list of the benthic shell-bearing heterobranch mollusks from bathyal zone of the northwestern part of the Sea of Japan (NW SJ).

Species	Vertical distribution in NW SJ (m)	Frequency of occurrence in bathyal zone of NW SJ	References
<i>T. stimpsoni</i> Dall, 1919	10–520	Single finding	Gulbin and Chaban (2009)
<i>P. japonicum</i> sp. nov.	455–465	Two findings	Present study
<i>B. augusta</i> Martynov and Schrödl, 2009	200–540	6 Findings	Martynov and Schrödl (2009)
<i>D. hiemalis</i> (Couthouy, 1839)	190–2725	Uncommon	Derjugin (1939), Chaban (1996), Gulbin and Chaban (2009) and present study
<i>Toledonia</i> cf. <i>limnaeoides</i> (Odhner, 1913)	455–528	Two findings	Present study
<i>C. alba</i> (Brown, 1827)	5–2750	Uncommon	Derjugin (1939) and Gulbin and Chaban (2009)
<i>C. toyamaensis</i> Habe, 1955	1001–2555	4 Findings	Present study
<i>Cylichna</i> sp.	1001–2555	4 Findings	Present study
<i>Philine</i> sp.	1000–1200	Single specimen	Gulbin and Chaban (2009), as <i>P. argentata</i> Gould, 1859
<i>R. lata</i> sp. nov.	1494–1525	Single finding	Present study
<i>R. toyamaensis</i> (Habe, 1955)	13–500	4 findings	Gulbin and Chaban (2009)

cylindrical shell with spiral striations (Minichev, 1966, 1971). Deep-sea *Retusa sakuraii* Habe, 1958 from the Pacific side of Honshu has a thin and polished shell without expressed longitudinal sculpture (Habe, 1958; Hasegawa and Okutani, 2011).

Fragments of the calcareous foraminifers were found in the esophagus and gizzard of *R. lata*.

Etymology. *R. lata* has been so named because it has wide oval-globose shell.

Distribution. North-western Sea of Japan (only type locality).

4. Discussion

Shell-bearing heterobranch mollusks are relatively rare in the bathyal zone of the northwestern Sea of Japan, but, in the collections taken during the SoJaBio cruise (Table 1), their species diversity exceeds that of other microgastropods. Ten species of shell-bearing Heterobranchia are currently known from depths over 300 m in the northwestern Sea of Japan (Table 2), and five of them (*Turritellopsis stimpsoni*, *P. japonicum* sp. nov., *Toledonia* cf. *limnaeoides*, *R. toyamaensis*, and *Boreoberthella augusta*) have not been recorded from depths below 500–600 m. One of the greatest interest is *P. japonicum* sp. nov., the third described species of a rare and little-known genus *Parvaplustrum*. The type species *P. tenerum* Powell, 1951 from the Falkland Islands is found at depths from 71 to 320 m (Powell, 1951; Marcus and Marcus, 1969); *Parvaplustrum* sp. from California coast is recorded at depths of 8–345 m (Gosliner, 1996; Cadien, 1995); and *P. japonicum* sp. nov. is believed to live at the greater depths (455–528 m). The type of feeding of *Parvaplustrum* is still unknown, since only detritus was found in the digestive tract of *P. japonicum*. It is particularly remarkable that specimens of *P. japonicum* were collected in considerable numbers, but just in two samples. Another new species, *R. lata*, was collected only once, but also in abundance. Such a peculiar distribution was mentioned for some Antarctic deep-sea gastropods, too (Schwabe et al., 2007).

Of the six species occurring in the northwestern Sea of Japan at depths over 600 m, *C. alba* and *D. hiemalis* are eurybathic, as they penetrate to the upper sublittoral zone. It should be noted that *D. hiemalis* is registered in the Sea of Japan at the greatest depth of its vertical distribution (up to 2725 m). The same is true for *C. toyamaensis*, which inhabits depths from 240 to 1533 m along the Pacific coast of Japan, and depths from 1001 to 2555 m in the Sea of Japan. Some findings of the other invertebrates (foraminifers, polychaetes, bryozoans, isopods, cumaceans) in the Sea of Japan are also known from very deep sites (Fursenko et al., 1979; Alalykina, 2013; Brandt et al., 2013; Golovan et al. 2013;

Grischenko, 2013; Malyutina et al., 2013). Most likely depths below 2000 m, including the abyssal zone, in the Sea of Japan are inhabited by both eurybathic and bathyal species. Two new and apparently endemic species were unexpectedly found in the bathyal zone of the Sea of Japan.

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