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Morphological Features, Ecology, and Distribution of Poorly Studied Molluscan Genera of the Colinae Subfamily (Gastropoda, Buccinidae) from the Far Eastern Seas of Russia

A. R. Kosyan

Severtsov Institute of the Problems of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia e-mail: kosalisa@rambler.ru

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Abstract—Data on the distribution of six genera of poorly studied buccinids of the Colinae subfamily (Neogastropoda, Buccinidae), namely, *Colus Röding*, 1799; *Plicifusus* Dall, 1902; *Retifusus* Dall, 1916; *Aulacofusus* Dall, 1918; *Pararetifusus* Kosuge, 1967; and *Latisipo* Dall, 1916, are presented. These mollusks are widely spread in the North Pacific region dwelling predominantly over loose sediments in a wide range of sea depths. Based on the morphology and contents of their digestive tracts, it is assumed that the representatives of the genera studied are predators with diverse diets. It is supposed that the increase in the dwelling depths had no significant influence on the feeding ecology of the species studied. Meanwhile, the lower abundance of preys at greater depths caused the lower population densities and modifications in the proboscis structure of selected taxa.

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INTRODUCTION

The most diverse group of buccinids in the waters of Russia are the representatives of the Colinae subfamily-their share is 16 of 34 genera and 116 of 263 buccinid species [5]. The best-studied representative of the Colinae is the numerous genus Neptunea Röding, 1798 [1, 3]; other species have no commercial value; therefore, they didn't attract the attention of the specialists. Among these species, the highest species diversity is characteristic of the Colus Röding, 1799; Plicifusus Dall, 1902; Retifusus Dall, 1916; Aulacofusus Dall, 1918; Pararetifusus Kosuge, 1967; and Latisipo Dall, 1916 genera. The bulk of the species of these genera are noted in the North Pacific, in particular, in the Russian waters of the Bering Sea, the Sea of Okhotsk, and the Sea of Japan. A series of previously published reviews based mostly on the initial identifications of the species contains data about the morphology of the shells and radulae [2, 8-10, 15, 18-20], as well as selected information about their anatomy [12, 13]. Meanwhile, no information about the ecology of this group is available.

In the course of an examination of museum collections, we reviewed numerous mollusk samples of the *Colus, Plicifusus, Retifusus, Aulacofusus, Pararetifusus,* and *Latisipo* genera from the region of the Bering, Chukchi, and East Siberian seas; the Sea of Japan; the Sea of Okhotsk; and off the Kuril Islands and Kuril– Kamchatka. The external morphology, anatomy, and the gut contents of the mollusks were studied, which allowed us to reach preliminary conclusions about the ecological features of selected poorly studied species.

MATERIALS AND METHODS

In this study, we used the materials of the Zoological Institute of the Russian Academy of Sciences (ZIN), the Shirshov Institute of Oceanology of the Russian Academy of Sciences (SIO), the Zoological Museum of Moscow State University (ZM MSU), the British of Natural History Museum (BNHM), as well as the materials from a private collection kindly presented by D.O. Alekseev (VNIRO). In all, about 450 specimens representing 33 molluscan species were examined (Table 1).

In the mollusks studied, we measured the shell length and the lengths of the last whorl and the aperture. The morphology of the soft body was studied with the use of a tested preparation technique [4]. The exposed radulae were cleaned of muscles and kept in a solution of liquid bleach (NaOCl) up to complete removal of the soft tissues. Then, they were dried in the open air, coated with gold, and examined with the help of a Tescan scanning electron microscope.

For 30 species (more than 200 specimens), the stomach and gut contents were studied.

RESULTS AND DISCUSSION

Distribution. The genera under consideration feature wide habitats in the boreal and higher boreal zones of the Pacific Ocean. Most of the genera dwell in the regions within 40° – 70° N and 130° E– 160° W (Table 1).

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Genus (total number of species)	Species studied and their dwelling depths	Geographical distribution of the representatives of the genus studied	Range of dwell- ing depths, m
Colus Röding, 1799 (18 species)	<i>C. islandicus</i> (Mohr, 1786), 5–3006 m <i>C. minor</i> (Dall, 1925), 46–260 m <i>C. kujianus</i> Tiba, 1973, 105–2000 m	Bering Sea, Kamchatka, Sea of Okhotsk, Pacific coasts of Japan	5–3006
<i>Aulacofusus</i> Dall, 1918 (6 species)	A. brevicauda (Deshayes, 1832), 21–1000 m A. herendeeni (Dall, 1899), 16–920 m A. ombronius (Dall, 1919), 35–152 m A. periscelidus (Dall, 1891), 50–200 m	Laptev Sea, Bering Sea, Sea of Okhotsk, Kamchatka, Kuril Islands	16–1000
<i>Latisipho</i> Dall, 1916 (2 species)	<i>L. hypolispus</i> (Dall, 1891), 40–930 m <i>L. hallii</i> (Dall, 1873), 2–1112 m	Bering Sea, Sea of Okhotsk, Kamchatka, Alaska	2–1112
<i>Plicifusus</i> Dall, 1902 (16 species)	P. kroeyeri (Møller, 1842), 0–225 m P. plicatus (A. Adams, 1863), 10–287 m P. croceus (Dall, 1907), 25–2000 m P. scissuratus (Dall, 1918), 49–400 m* P. elaeodes (Dall, 1907), 80–130 m P. rhyssus (Dall, 1907), 52–1530 m P. hastarius Tiba, 1980, 7–18 m P. bambusus Tiba, 1980, unknown P. olivaceus (Aurivillius, 1885), 103–318 m P. oceanodromae (Dall, 1919), 129–180 m P. obtusatus Golikov in Golikov et Scarlato, 1985, 53–142 m P. torquatus (Petrov, 1982), 142–500 m	Circumpolar, Sea of Okhotsk, eastern coast of Kamchatka, Kuril Islands, northern part of the Sea of Japan, Pacific coasts of Ja- pan	0–2000
<i>Retifiisus</i> Dall, 1916 (9 species)	<i>R. jessoensis</i> (Schrenck, 1863), 7–300 m <i>R. frielei</i> (Dall, 1891), 285–920 m <i>R. virens</i> (Dall, 1877), 18-430 m <i>R. yanamii</i> (Yokoyama, 1926), 40–100 m <i>R. roseus</i> (Dall, 1877), 42–400 m <i>R. similis</i> (Golikov et Gulbin, 1977), 50–300 m <i>R. attenuates</i> (Golikov et Gulbin, 1977), 150–414 m <i>R. iturupus</i> (Golikov et Sirenko, 1998), 660–920 m <i>R. laticingulatus</i> Golikov et Gulbin, 1977, 129–188 m	East Siberian Sea, Chukchi Sea, Bering Sea, Sea of Okhotsk, Sea of Japan, Kuril Islands, Kamchatka	7–920
Pararetifiisus Kosuge, 1967 (3 species)	<i>P. tenuis</i> (Okutani, 1966), 400–1500 m <i>P. kantori</i> Kosyan, 2006, 135–1400 m <i>P. kosugei</i> Kosyan, 2006, 130–250 m	Bering Sea, Sea of Okhotsk, Sea of Japan, Kamchatka	130–1500

Table 1. Geographical distribution and range of dwelling depths of the considered Pacific species and genera of the Colinae subfamily

Note: * The species is first recorded in the fauna of Russia.

Over the vertical, mollusks are encountered over a wide depth range from 0 to 3000 m (Table 1). The mollusks inhabit loose sediments such as broken coquina, pebbles, sands, and silts. Despite the application of a trawl capable of covering vast areas of the seafloor, the findings of the representatives of the Colinae genera considered are rare, especially as compared to other Far Eastern buccinids [6].



Fig. 1. Diversity of the shells of Colinae: A—Colus islandicus, B—Mohnia mohnii, C—Pararetifusus tenuis, D—Latisipho hallii, E—Latisipho hypolispus, F—Pararetifusus kantori, G—Aulacofusus brevicauda, H—Retifusus jessoensis, I—Plicifusus kroeyeri, J—Retifusus attenuatus, K—Plicifusus rhyssus. The length of the scale bar is 1 cm.

Morphological features. The shells of the genera studied are diverse (Table 1) and extremely variable within the same genus. Their lengths vary from 7 to 104 mm. A characteristic anatomic feature is the existence of a proboscis, at the end of which the mouth opening is located. Inside the proboscis, there is a radula with a tooth set typical of the Buccinidae: one central and two lateral teeth (Fig. 2). The lateral teeth usually have three cusps each, though sometimes their number may be as great as five. The individuals of the Latisipho, Plicifusus, Colus, and Aulacofusus genera feature lateral teeth with smaller median cusps, while those of the Retifusus and Pararetifusus genera have all cusps of equal sizes. The central teeth of the Latisipho, Plicifusus, Colus, and Aulacofusus have three cusps each; in so doing, the size of the median cusps is subjected to a strong intraspecific variability. For the genus Retifusus, two types of central teeth are noted. The first

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type found in species such as *R. jessoensis* (Schrenk, 1863), *R. virens* (Dall, 1877), *R. yanamii* (Yokoyama, 1926), and *R. okhotskanus* (Tiba, 1980) is characterized by a central tooth with five or six minor cusps arranged in a fanlike manner. The second type of radular central teeth characteristic of *R. similis*, *R. roseus*, *R. iturupus*, and *R. attenuatus*, as well as of all the *Pararetifusus* representatives, have three central cusps of equal sizes.

The characteristic morphological features of the shells and soft bodies of the genera studied are summarized in Table 2.

The food clots from the stomachs of the mollusks of the *Plicifusus* and *Colus* genera, along with sand and silt particles, also contained nondigested foraminifers, small intact *Trochidae*, and flat worms of the *Kalyptorhynchia* suborder, as well as fragments of rays of brittle stars, bristles of polychaets, and limbs of amphipods. This kind of diet was also described for selected



Fig. 2. Types of the radulae of Colinae: A—*Colus islandicus*, B—*Aulacofusus brevicauda*, C—*Latisipho hypolispus*, D—*Parareti-fusus tenuis*, E—*Plicifusus kroeyeri*, F—*Retifusus jessoensis*.

Pacific species of the genus *Neptunea* [17]. Most probably, the mollusks studied are predators.

The suggestion of their predatory character is proved by the morphological data. For example, for the mollusks of the Colus, Plicifusus, Latisipho, Retifusus, and Pararetifusus genera, the presence of a retractable proboscis, which is typical of predatory gastropods such as, for example, Neptunea, points to a similar feeding strategy. An extremely long proboscis that is significantly greater than the shell length is characteristic of all the species of the genus Aulacofusus and of two species of the genus Colus, namely, C. garacilis (Da Costa, 1778) and C. *jeffreysianus* (Fischer, 1868) (original observations of the author). Amphipods of the family Corophiidae found in the stomachs of a specimen of *Colus jeffreysianus* indicate that these mollusks are specialized in feeding on burrowing animals such as bivalves and amphipods.

The structure of the radulae of the representatives of the *Plicifusus, Latisipho, Colus*, and *Aulacofusus* genera is similar to that described for *Neptunea* and *Buccinum* L., 1758, which agrees with the similar diets of these species. Meanwhile, the radulae of *Pararetifusus* and *Retifusus* are significantly different. The large three-dent teeth of the radulae of *Pararetifusus* and most of the species of the *Retifusus* genus are meant, most probably, for holding their prey and tearing off large portions of it. The central teeth of the radulae of *Retifusus jessoensis, R. virens, R. yanamii*, and *R. frielei*, which are supplied with numerous fanlike sharp minor cusps, most probably are for scraping off soft tissues of their prey.

The salivary glands of most of the genera studied are large and, as in the representatives of the genus Neptunea, are capable of producing poison [7, 11, 16]. This supposition is confirmed by the fact that, among the amphipods that were found in the stomach of Colus jeffreysianus, in addition to small individuals, large individuals were found, and, in the stomach of a small P.kroeyeri specimen, fragments of rays of brittle stars were encountered. The venomous secretion of the salivary glands may help to catch prey that large and active. The presence of poison is also implied by the unusual structure of the salivary ducts of Retifusus roseus and Pararetifusus kosugei. The existence of widenings (salivary sacs) that seem to serve as temporary reservoirs for a great amount of venomous saliva, together with the location of the openings of the salivary ducts at the termination of the proboscis rather than in the rear part of the buccal cavity (as is characteristic of most of the buccinides studied), allows these mollusks to inject paralyzing poison and then consume the immobilized prey. A similar arrangement of the salivary duct openings and the same feeding type were also noted for Vasum muricatum (Born, 1778) (Neogastropoda, Turbinellidae) [14].

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Genus Feature	Colus	Aulacofusus	Latisipho	Plicifusus	Retifusus	Pararetifusus
Range of the shell size, mm	46–104	26–54	41–25	34-82	7–25	13–15
Axial sculpture of the shell	Incremental lines	Incremental lines	Incremental lines	Axial folds (10–20 on the last whorl)	Axial folds (up to 15 over the last whorl)	Incremental lines
Number of spiral ribs on the penul- timate whorl	Number of ribs strongly varies	6–16 large spiral ribs	20–30 small spi- ral ribs or up to 5 irregularly ar- ranged ridges	30–60 small spiral ribs	5–18 large spiral ribs	5–6 spiral ribs spaced very high
Central tooth of the radula	3 cusps, the mid- dle of which is either longer or shorter than the others	3 cusps, the mid- dle of which a bit longer than the others	3 cusps, the mid- dle of which is longer or shorter than the others	3 cusps, the mid- dle of which is longer or shorter than the others	5–6 small or 3 large cusps	3 large identical cusps
Lateral teeth of the radula	3 cusps, the mid- dle of which is the smallest	3 cusps, the mid- dle of which is the smallest	3 cusps, the mid- dle of which is the smallest	3 cusps, the mid- dle of which is the smallest	3 identical cusps	3 approximately identical cusps
Proboscis	Short or long	Long rolled up in rings in the rhynchocoel	Short	Short	Short	Short
Salivary ducts	Thick, twisted	Thick, twisted, with a layer of longitudinal muscles in the wall	Thin, twisted	Thin, twisted	Thick, straight, may form salivary sacs	Thick, straight, may form salivary sacs

Table 2. Morphological features of the Colinae genera studied

Thus, we can conclude that the mollusks of the genera studied dwell within a significant depth range from the sublittoral to the bathyal zones and prefer loose sediments; they are predators with a diverse diet. No changes in the feeding strategy were observed over the entire vertical range of dwelling depths

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REFERENCES

- 1. A. N. Golikov, "Gastropod Mollusks of the *Neptunea* (Bolten) Genus," in *Fauna of the USSR. Mollusks* (Nauka, Leningrad, 1963), Vol. 5, Issue 1 [in Russian].
- A. N. Golikov and B. I. Sirenko, "Prosobranchia Gastropod Mollusks of the Continental Slope of the Kuril Island Range," Ruthenica 8 (2), 91–135 (1998).
- 3. V. N. Goryachev, *Gasteropod Mollusks of the Neptunea Röding Genus of the Bering Sea* (Nauka, Moscow, 1978) [in Russian].

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- 4. Yu. I. Kantor, *Gasteropod Mollusks of the World Ocean: Volutopsiinae Subfamily* (Nauka, Moscow, 1990) [in Russian].
- Yu. I. Kantor and A. V. Sysoev, *Catalogue of Mollusks of* Russia and Adjacent Countries (KMK, Moscow, 2005) [in Russian].
- A. I. Piskunov, "Summertime Distribution of the Mass Species of Gastropod Mollusks of the Buccinidae Family off the Eastern Sakhalin," Studies in the Fish Biology and Fishery Oceanography, No. 10, 52–59 (1979).
- U. Anthoni and L. Bohlin, C. Larsen, P. Nielsen, N. H. Nielsen, and C. Christophersen, "The Toxin Tetramine from the 'Edible' Whelk *Neptunea antique*," Toxicon 27 (7), 717–723 (1989).
- P. Bouchet and A. Waren, "Revision of the Northeast Atlantic Bathyal and Abyssal Neogastropoda Excluding Turridae (Mollusca, Gastropoda)," Bollettino Malacologico, Supplemento 1, (1985).
- A. N. Golikov, B. I. Sirenko, V. V. Gulbin, and E. M. Chaban, "Checklist of Shell-Bearing Gastropods of the Northwestern Pacific," Ruthenica 11 (2), 153–174 (2001).
- S. Higo, P. Callomon, and Y. Goto, *Catalogue and Bibliography of the Marine Shell-Bearing Mollusca of Japan* (Elle Scientific Publications, Osaka, 1999).
- Y. Kawashima, Y. Nagashima, and K. Shiomi, "Toxicity and Tetramine Contents of Salivary Glands from Carnivorous Gastropods," Shokuhin Eiseigaku Zasshi 43 (6), 385–388 (2002).

- 12. A. R. Kosyan, "Anatomy and Taxonomic Composition of the Genus *Latisipho* Dall (Gastropoda: Buccinidae) from the Russian Waters," Ruthenica **16** (1-2), 17–42 (2006).
- A. R. Kosyan, "Two New Species of the Genus *Parareti-fusus* Kosuge, 1967 (Buccinidae: Colinae), with Notes on the Morphology of *Pararetifusus tenuis* (Okutani, 1966)," Ruthenica 16 (1-2), 5–15 (2006).
- A. I. Medinskaya, M. G. Harasewych, and Yu. I. Kantor, "On the Anatomy of *Vasum muricatum* (Born, 1778) (Neogastropoda, Turbinellidae)," Ruthenica 5 (2), 131– 138 (1996).
- 15. T. Okutani, *Marine mollusks of Japan* (Tokai University Press, 2000).

- A. J. Power B. F. Keegan, and K. Nolan, "The Seasonality and Role of the Neurotoxin Tetramine in the Salivary Glands of the Red Whelk *Neptunea antiqua* (L.)," Toxicon 40 (4), 419–425 (2002).
- R. Shimek, "The Diets of Alaskan Neptunea," Veliger 26 (4), 274–181 (1984).
- R. Tiba and S. Kosuge, North Pacific Shells. 7. Genus Plicifusus Dall, 1902 (Occasional Publication of the Institute of Malacology of Tokyo, 1980).
- 19. R. Tiba and S. Kosuge, *North Pacific Shells.* 8. *Genus Colus Röding, 1798* (Occasional Publication of the Institute of Malacology of Tokyo, 1981).
- 20. R. Tiba and S. Kosuge, *North Pacific Shells. 18. Genus Mohnia Friele, 1877* (Occasional Publication of the Institute of Malacology of Tokyo, 1992).