Zootaxa 2684: 25–35 (2010)
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

Flustrellidra armata (Bryozoa: Ctenostomatida)—a new species from the southern shoreline of Korea

ANDREI V. GRISCHENKO[1], JI EUN SEO[2,4] & BUM SIK MIN[3]

[1]*Department of Invertebrate Zoology and Aquatic Ecology, Biological Faculty, Perm State University, Bukirev Street 15, GSP, Perm 614900, Russia. E-mail: gat1971@mail.ru*

[2]*Department of Rehabilitation, Woosuk University, Samnye–eup, Wanju–gun, Jeollabuk–do 565–701 Republic of Korea. E-mail: jeseo@woosuk.ac.kr*

[3]*Department of Life Science, Graduate School,The University of Suwon, Bongdam-eup, Hwaseong-si, Gyeonggi-do 445-743 , Republic of Korea. E-mail: minbumsik@nate.com*

[4]*Corresponding author. E-mail: jeseo@woosuk.ac.kr*

Abstract

Flustrellidra armata **sp. nov.** is described from ten intertidal and four subtidal sites along the southern coast of Korea. The new species possess a series of small lateral and occasionally proximal kenozooids with simple spines; large scattered vicarious kenozooids with long, tubular, sharp or weakly ramified spines; and a marginal fringe of spiny kenozooids. Colonies of *F. armata* provide a habitat for a large number of associated benthic organisms. This species is an abundant and prominent component of rocky intertidal to upper subtidal communities and is the third species of *Flustrellidra* with low-Boreal to Subtropical distribution.

Key words: Bryozoa, Ctenostomatida, Flustrellidridae, *Flustrellidra armata*, new species, biogeography, Korea Strait

Introduction

The ctenostome bryozoan genus *Flustrellidra* Bassler, 1953 includes Recent species with encrusting or, more often, flexibly erect colonies and zooids with a bilabiate orifice interspersed with kenozooids in a strict spatial arrangement. Kenozooids develop simple or branching spines that differ among species in degree of morphology and frequency. The morphology of *Flustrellidra* species was examined by Cook (1964) and d'Hondt (1983).

To date, 10 species and one subspecies have been described (Fabricius 1780; Smitt 1872; Robetson 1900; O'Donoghue & O'Donoghue 1923; Silén 1947; Okada 1921; Mawatari 1953, 1971) from the margins of seas in the Northern Hemisphere. They are typically well represented in intertidal communities on rocky shores. *Flustrellidra* larvae are bivalved forms that disperse a short distance before settlement (Hayward 1985), leading to relatively high population densities. Much of the diversity of this genus occurs on North Pacific shores (Okada 1921; O'Donoghue & O'Donoghue 1923; Mawatari 1953, 1971; Kluge 1961, 1962, 1975; Androsova *et al*. 1974; Gontar 1978; Izyumova & Kubanin 1978; Kubanin 1997; Grischenko 2004), especially in the Asian Far East.

Inventory of the bryozoan fauna of the coastal waters of Korea began in the third decade of the 20th century and over 30 papers have been published, culminating in a recent monograph by Seo (2005). Most of these studies dealt with cheilostomes, though some indicated the appreciable role of ctenostome bryozoans in benthic and fouling communities in the region (Kim & Rho 1969; Chung & Rho 1975; Kim *et al*. 1978; Rho & Lee 1981; Rho & Kim 1981; Rho & Seo 1986; Seo 1998a, 1998b; Gong & Seo 2003, 2004; Seo 2005). Seo (2005) listed five ctenostome species for the coastal waters of Korea: *Amathia convoluta* Lamouroux, 1816; *A. distans* Busk, 1886; *Bowerbankia gracilis* Leidy, 1855; *Vesicularia harmeri* Silén, 1942; and *Mimosella*

Accepted by D. Gordon: 2 Nov. 2010; published: 23 Nov. 2010

verticillata (Heller, 1867). There has been no previous report of any species of family Flustrellidridae from Korea.

Intensive, continuous intertidal sampling along the southern shoreline of Korea, conducted from 1976 to 2002, as well as recent subtidal collections from the same area, have revealed a large number of specimens of an undescribed species of *Flustrellidra*. In this paper we present a taxonomic description of this new species and information on its ecology and distribution.

Material and methods

Specimens were collected from 1976 to 2002 at 10 sites along the southern coast of Korea, including Mipo, Samchenpo, Mijo, Sangju, Jangji, Seosang, Songgo, Cheokdo, Daechilgido, and Mokdo (Fig. 1). Most of these specimens were obtained from rocky reef flats in the middle to lower horizons of the intertidal zone, and most were preserved in 70% alcohol. Additional material was recently collected subtidally by SCUBA diving, from rocky bottoms at depths of 10–20 m from four closely spaced sites near small islands – Jisimdo, Naedo, Namyeodo, and Oedo – in the vicinity of Geojesi, the Korea Strait, and was fixed in 4% formalin.

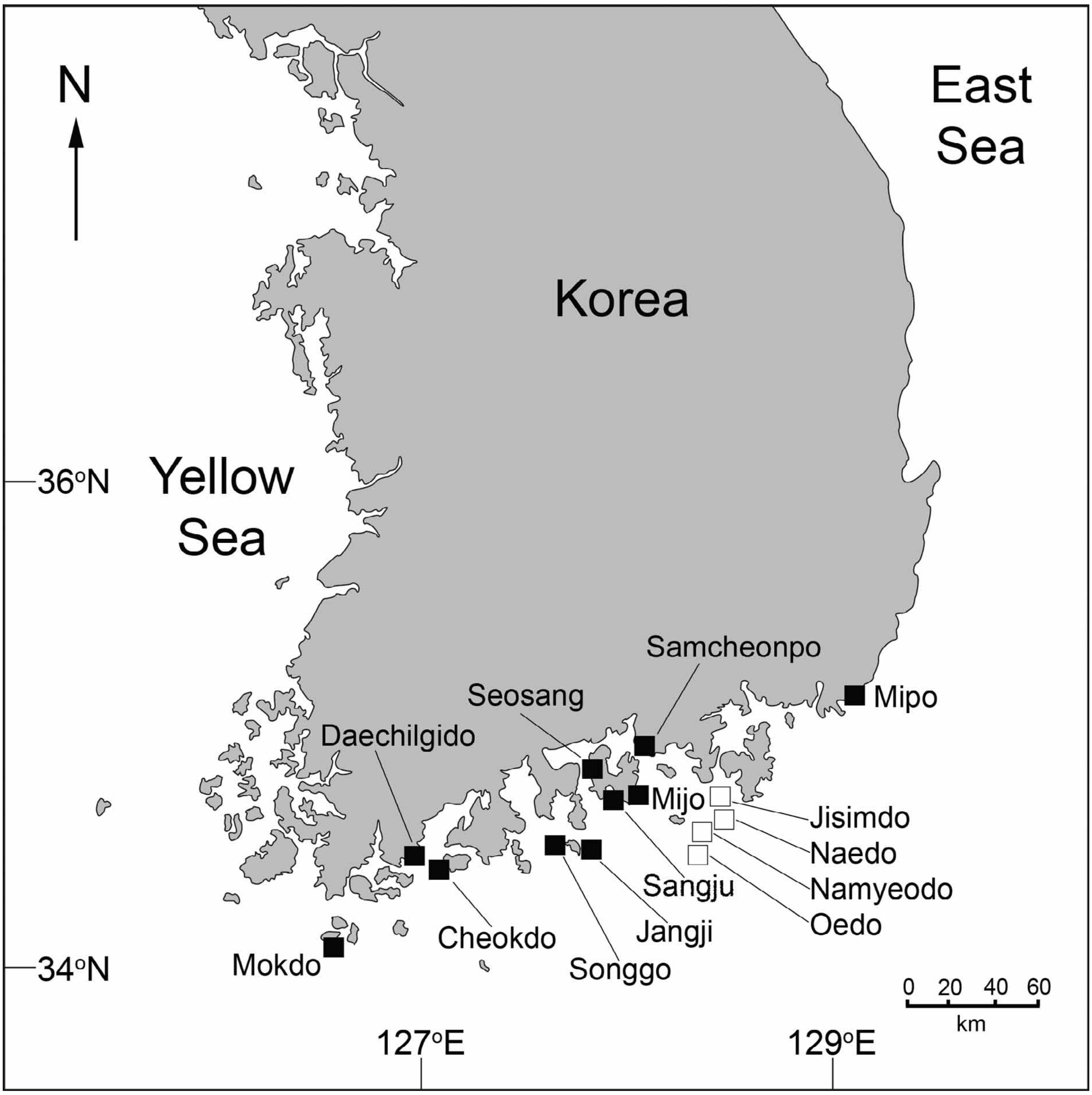

FIGURE 1. Map of the southern part of the Korean Peninsula showing sites where *Flustrellidra armata* **n. sp.** was collected, either intertidally (filled squares) or subtidally (empty squares) .

Colonies were examined with a Stemi SV6 stereoscopic microscope. The total number of specimens examined was 426 (colonies or their fragments). Measurements of zooidal characters were made at 40x magnification with an ocular micrometer and are presented in the text, in millimeters, as ranges followed in parentheses by the mean and standard deviation. The sample size for each measurement from holotype and paratype colonies was *n* = 20 zooids. Abbreviations used for measurements are as follows: ZL, zooid length; ZW, zooid width; OrL, orifice length; OrW, orifice width; Kz(s)L, kenozooid (small) length; Kz(s)W, kenozooid (small) width; Kz(l)L, kenozooid (large) length; Kz(l)W, kenozooid (large) width; Kz(m)L, kenozooid (marginal) length; Kz(m)W, kenozooid (marginal) width; Kz(bp)L, kenozooid (basal plate) length; Kz(bp)W, kenozooid (basal plate) width; Kzs(s)L, spine length of small kenozooid; Kzs(l)L, spine length of large kenozooid; Kzs(m)L, spine length of marginal kenozooid.

Holotype and paratype colonies were photographed in alcohol with a Nikon–D100 digital camera at 300 pixels inch^{-1} resolution. Selected areas of the type specimens were detached, dried in a Cressington-108 critical-point dryer, mounted with double-sided adhesive tape on aluminium SEM stubs, coated with gold in an ion–sputter coater (Hitachi E–1010), and examined under a scanning electron microscope (Hitachi–S 3000N at 25 kV accelerating voltage or Jeol JSM–5600LV at 10 kV accelerating voltage). All images were stored electronically as TIFF files at a resolution of 500 pixels inch^{-1}, using ImageCatcher software.

The classification used herein follows d'Hondt (1983). The authors of higher taxa are not included in the Reference section. The holotype and paratype specimens described here are deposited in The National Institute of Biological Resouses (NIBRI), Incheon, Korea. The remainder of the material is stored at the Department of Life Science, Woosuk University, Korea.

Taxonomy

Order Ctenostomatida Busk, 1852

Suborder Euctenostomatina Jebram, 1973

Superfamily Flustrellidroidea d'Hondt, 1975

Family Flustrellidridae Bassler, 1953

Flustrellidra Bassler, 1953

Flustrellidra armata sp. nov.

(Figs 2–4)

Diagnosis. Colony erect, branching, bilamellar, arising from an encrusting, unilaminar basal portion, the erect flabellate lobes undulating along their margins, which are lined by kenozooids with conical spines. Autozooids elongate, arranged alternately, with subterminal transversely oval bilabiate orifice; interspersed with small kenozooids with simple, pointed spines, 1–6 along each lateral margin. Mature zooids with one to three similar kenozooids separating maternal and daughter zooids. Large, vicarious kenozooids with long spines scattered throughout colony, their spines tubular, weakly branched. Encrusting basal portion composed of spineless, inflated kenozooids of irregular shape.

Type material. *Holotype*: NIBRIV0000100504, one intact colony, collected 30 August 1996 at rocky shore of Mijo by J. E. Seo, H. J. Kil and J. H. Yoo. *Paratype*: NIBRIV0000100505, one intact colony, same data as for holotype.

Additional material examined. One specimen, intertidal, Mipo, 23 December 1976, collected by J. W. Lee. One specimen, intertidal, Mipo, 10 December 1981, collected by J. E. Seo. One specimen, intertidal, Samcheonpo, 23 September 1984, collected by B. J. Rho, J. H. Park, S. Shin, and J. E. Seo. Twenty-six specimens, intertidal, Mokdo, 11 August 1995, collected by J. E. Seo. Three specimens, intertidal, Mijo, 30

August 1996, collected by J. E. Seo, H. J. Kil and J. H. Yoo. Four specimens, intertidal, Sangju, 30 August 1996, collected by J. E. Seo, J. H. Yoo, and H. J. Kil. Two specimens, intertidal, Cheokdo, 13 June 1999, collected by J. E. Seo. Twenty-two specimens, intertidal, Daechilgido, 13 June 1999, collected by J. E. Seo. Thirty-three specimens, intertidal, Jangji, 18 August 2000, collected by J. E. Seo, S. J. Seo, and Y. H. Gong. One specimen, intertidal, Seosang, 3 November 2002, collected by J. E. Seo. Three specimens, intertidal, Songgo, 18 August 2000, collected by J. E. Seo, S. J. Seo, and Y. H. Gong. Three specimens, depth 10–15 m, rocky bottom, Jisimdo, 17 October 2007, collected by B. S. Min using SCUBA. Seventy-three specimens, depth 10–15 m, rocky bottom, Naedo, 17 October 2007, collected by B. S. Min using SCUBA. Fifty-three specimens, depth 10–15 m, rocky bottom, Oedo, 17 October 2007, collected by B. S. Min using SCUBA. Seventy-five specimens, depth 20 m, rocky bottom, Namyeodo, 19 October 2007, collected by B. S. Min using SCUBA.

Etymology. The species name derives from the Latin *armatus* (protected), referring to the armament of colony provided by numerous kenozooidal spines.

Description. Colony erect, branching, flexible, with numerous strap-shaped to flabellate lobes, rounded and undulate at growing margins (Fig. 2A, B); up to 12.5 cm in height, but usually 6.5–8.5 cm; attached to substratum by encrusting, unilaminar basal plate, up to 1.4 x 2.2 cm in size. Up to 7 closely appressed stalks arranged in parallel planes can arise from single basal plate (Fig. 2B). Branches of independent trunks mutually interlaced, giving bushy appearance to colony. Young colonies are yellowish, grayish, or pale brown, with whitish zone comprising 3–5 generations of developing zooids on periphery of terminal branches. Mature colonies brownish to flesh-coloured, with dark-brown to reddish fringing zone of marginal kenozooids along entire periphery, except for stalk. Branches slender, 5–17 mm wide, 1.1–1.8 mm thick (without spines). Lobes bilamellar without interposed medullary kenozooidal layer.

Zooids oval to rounded-rectangular, elongate, arranged alternately in distinct series. Grooves distinct between young zooids, when not occupied by kenozooids (Fig. 4A). Frontal surface smooth, inflated, semitransparent, yellowish to brownish, chitinous. Orifice (Fig. 4B) subterminal, raised, transversely elongate, bilabiate, roughly oval to rectangular in outline, with thickened, chitinous proximal labium, brown in color. Along each lateral zooidal margin are small kenozooids with circular to oval base and a sharp simple spine directed upwards or slightly tilted toward zooid. Young zooids (Fig. 4A, B) have 1–2 pairs of distal kenozooids, each with a sharp spine pointing upwards, flanking orifice; 1–3 similar kenozooids successively developing more proximally along each lateral margin (Fig. 4C, D).

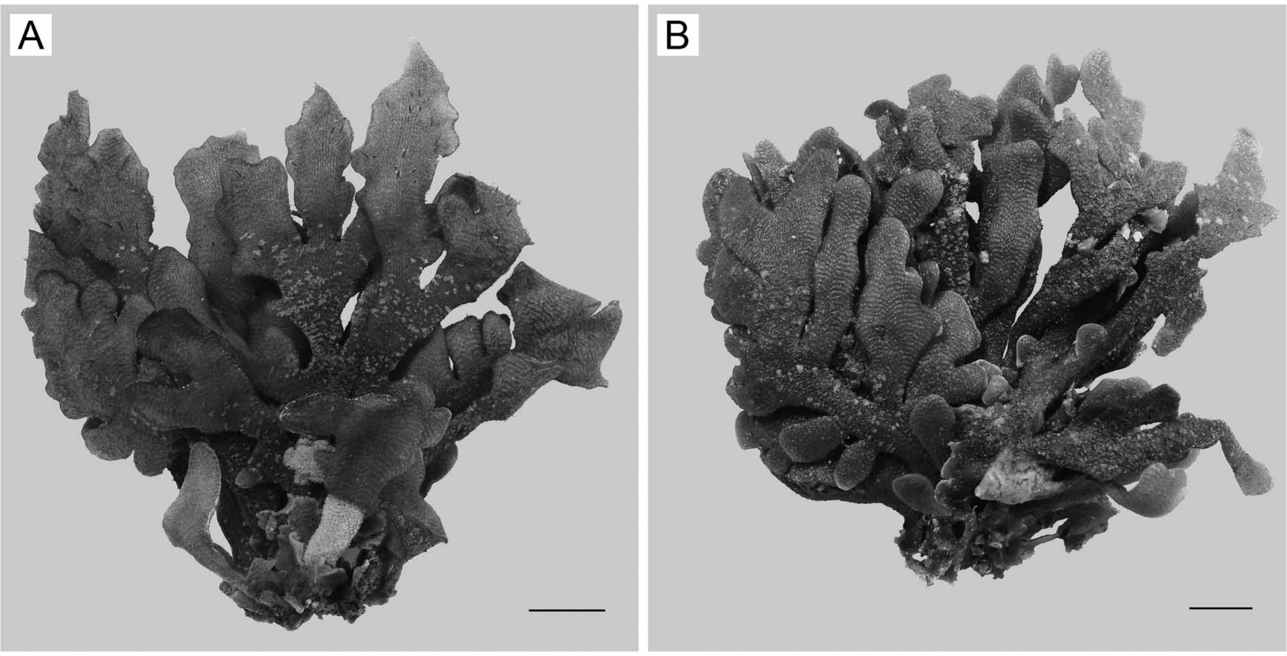

FIGURE 2. Colony morphology of *Flustrellidra armata* **n. sp.** A, holotype colony, NIBRIV0000100504. B, paratype colony, NIBRIV0000100505. Scale-bars: 1 cm.

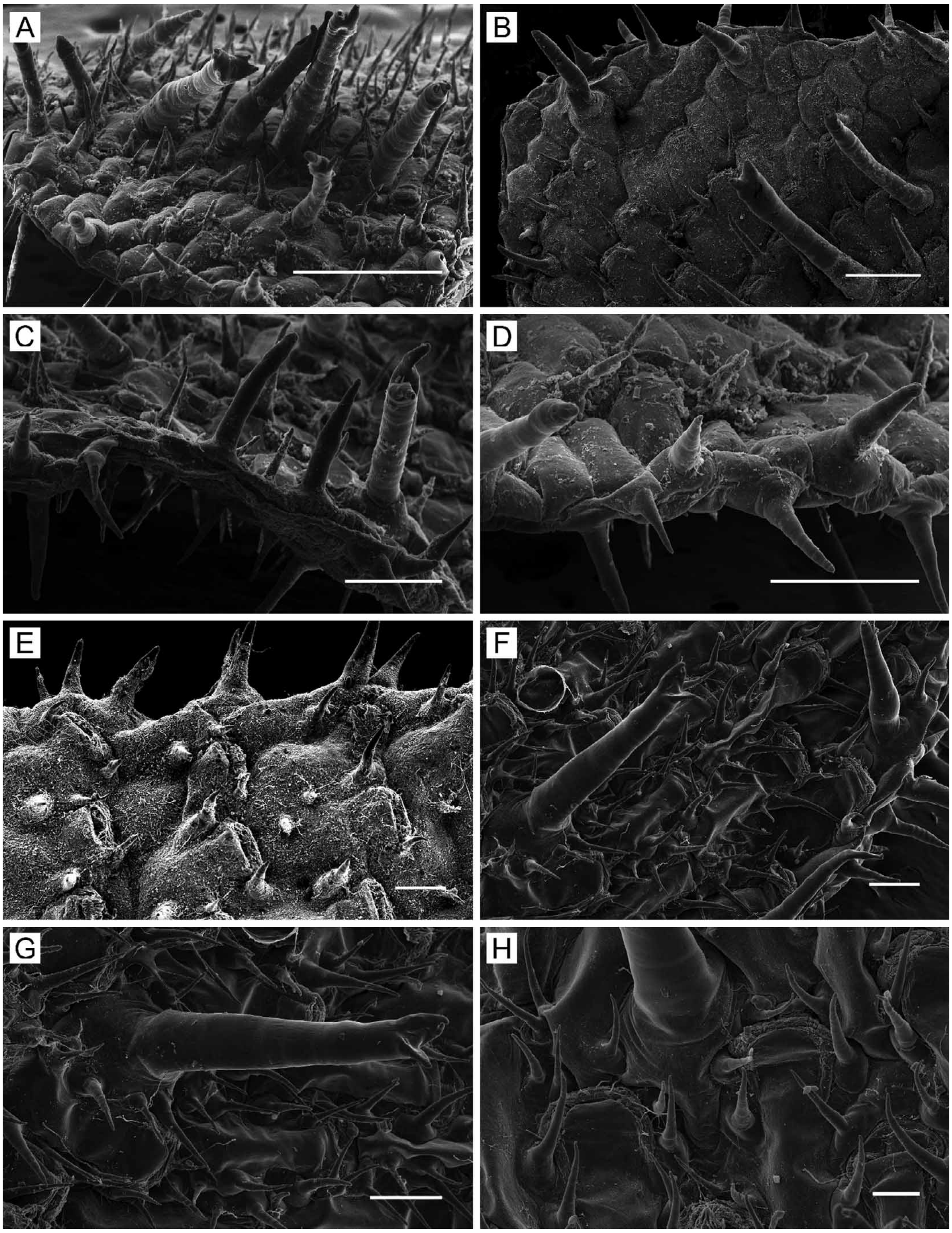

FIGURE 3. *Flustrellidra armata* **n. sp.** NIBRIV0000100504. A, distal view of terminal end of branch showing zone of developing zooids, marginal kenozooids, and a compact group of closely arranged vicarious kenozooids with long, stout tubular spines, pointed or weakly ramified at tips; B, frontal view of terminal end of branch with deep zone of developing zooids, marginal kenozooids, and two vicarious kenozooids with a long tubular spine having a blunt or forked tip; C, distal view of terminal end of branch, showing spinous marginal kenozooids and tubular kenozooidal spines in the opposite layers; D, close-up of marginal kenozooids with conical spines directed forward at various angles, fringing the zone of developing zooids; E, lateral margin of branch showing one or two distolateral pairs of spiny kenozooids between immature zooids; also evident are marginal kenozooids with pointed, conical spines; F, region of mature zooids near lateral margin of branch, showing zooids separated by two series of small spiny kenozooids; marginal kenozooids with pointed spines; and a vicarious kenozooid with a long, tubular spine, weakly bifurcate at tip; G, higher-magnification view of vicarious kenozooid in F, which bears a tubular spine with slightly forked tip and is surrounded by minute kenozooids with short, laterally directed spines; H, base of vicarious kenozooidal spine, flanked proximolaterally by minute spinous kenozooids arising from the two lateral autozooids (each indicated by the large orifice). Scale-bars: A, 1 mm; B–D, 0.5 mm. E–G, 0.2 mm; H, 0.1 mm.

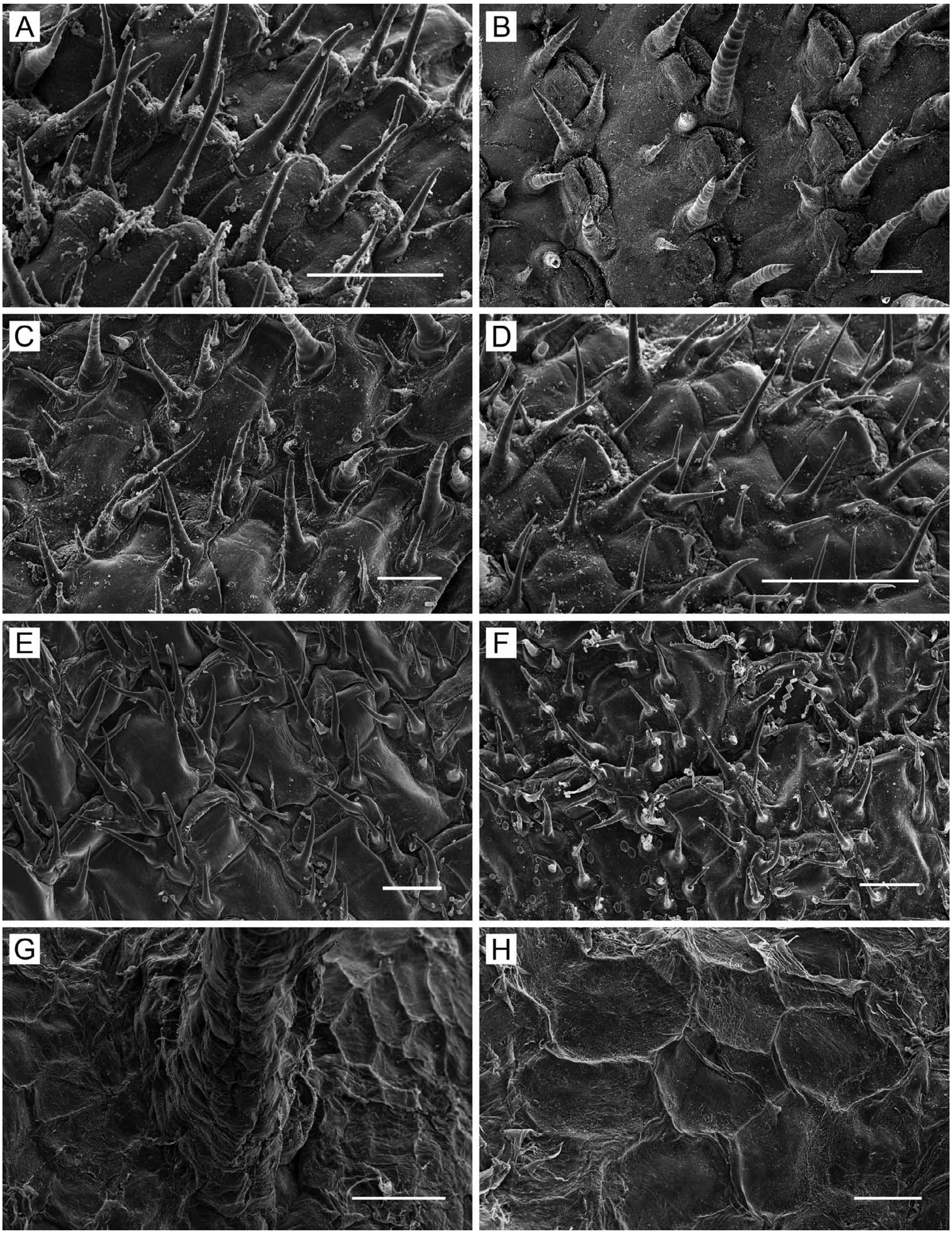

FIGURE 4. *Flustrellidra armata* **sp. nov.** NIBRIV0000100504. A, immature zooids from region near colony margin, interspersed with distolateral kenozooids flanking orifice, with long pointed spines tilted forward; B, immature zooids intercalated with one to three pairs of distal and lateral kenozooids with sharp, elongate spines; C, zooids separated by series of lateral oval kenozooids, some twinned, with sharp spines slightly tilted over frontal surface; D, zooids separated by three to four pairs of lateral kenozooids with sharp spines, with occasional minute, spiny kenozooids proximally; E, mature zooids separated laterally by double series of small kenozooids with sharp spines slightly curved over frontal surface; F, zooids from old colony region, separated laterally and proximally by single to double series of minute kenozooids with short, pointed spines; G, general view of basal plate and stalk of colony, composed entirely of kenozooids of irregular shape; H, close-up of kenozooids from encrusting basal plate. Scale-bars: A, D, G, 0.5 mm; B, C, E, F, H, 0.2 mm.

Zooids in mature colony regions (Fig. 4E, F) interspersed with single or double series of 4–6 kenozooids each, with parallel or alternating arrangement and with pointed, straight or slightly tilted spines; in addition, there are 1–3 small kenozooids, each with a minute, slightly curved spine, between maternal and daughter zooids. Thus, old zooids can be entirely surrounded by small kenozooids. With age and increasing chitinization, all kenozooidal spines acquire a dark-brown color that contrasts with the zooidal surface. Large vicarious kenozooids scattered throughout colony, these oval, hexagonal, or rhombic in shape with strongly convex frontal surface (Fig. 3B); occasionally arranged as compact groups in limited areas on colony surface (Fig. 3A). A hollow, tubular spine (Fig. 3A–C, F, G) , dark brown in color, sharply contrasting with brownish colony surface, originates from center of each vicarious kenozooid. Spines straight to slightly curved in middle, orientated vertically or tilted slightly distally or distolaterally. Majority of spines weakly branching terminally into 2–5 short spurs, without secondary branches; some lack distinct ramifications and have a slightly pointed or blunt tip. Most spines gradually taper from base to tip, but some are enlarged in middle and appear spindle-shaped; others are entirely elongate-cylindrical. Occasionally, a spine narrows moderately in middle and is secondary enlarged near tip, at point of ramification. Bases of large kenozooids flanked by 2–5 minute kenozooids along each lateral margin, each with short, pointed spine directed laterally and upwards. Marginal kenozooids very irregular in shape and size, arranged along entire lateral and terminal margins of branches (Fig. 3D–F). At terminal end of growing branches, kenozooids fringe the zone of developing zooids (Fig. 3B). Along margins, kenozooids of opposite layers develop complementarily, side by side (Fig. 3D), and partly overlap each other; each has a conical spine with pointed tip, oriented 20–80° from frontal plane.

Encrusting basal plate and stalk of colony (Fig. 4G, H) composed entirely of inflated kenozooids that are hexagonal, oval, roughly quadrangular, or irregular in shape, with distinct raised boundaries, not intercalated with small, spinous kenozooids. Polypide with 18 tentacles.

Measurements. ZL, 0.62–1.03 (0.81 ± 0.09). ZW, 0.32–0.51 (0.39 ± 0.05). OrL, 0.14–0.23 (0.18 ± 0.02). OrW, 0.27–0.35 (0.31 ± 0.02). Kz(s)L, 0.05–0.20 (0.12 ± 0.04). Kz(s)W, 0.04–0.15 (0.09 ± 0.03). Kz(l)L, 0.45–0.83 (0.64 ± 0.12). Kz(l)W, 0.35–0.58 (0.45 ± 0.06). Kz(m)L, 0.22–0.43 (0.31 ± 0.07). Kz(m)W, 0.18–0.35 (0.27 ± 0.06). Kz(bp)L, 0.37–0.63 (0.51 ± 0.07). Kz(bp)W, 0.26–0.43 (0.33 ± 0.05). Kzs(s)L, 0.13–0.42 (0.25 ± 0.09). Kzs(l)L, 0.67–1.62 (1.19 ± 0.27). Kzs(m)L, 0.30–0.97 (0.53 ± 0.19).

Remarks. *Flustrellidra armata* most resembles its Japanese congener *F. stolonifera* (Okada, 1921) in having a similar erect, branching, strap-shaped colony form; zooids interspersed by small lateral kenozooids with sharp, simple spines; and very large vicarious kenozooids bearing tubular branching spines. However, *F. armata* differs from the latter in the following combination of characters: (1) the number of minute, spiny kenozooids separating neighboring zooids along the lateral margins successively increases in *F. armata* with age from one or two to five or six, whereas *F. stolonifera* has only one pair of angular kenozooids flanking the orifice, and rarely one additional pair proximolaterally; (2) the double series of kenozooids between zooids in mature regions of the *F. armata* colony is absent in *F. stolonifera*; (3) the proximal kenozooids that separate maternal and daughter zooids of *F. armata* have not been reported in *F. stolonifera*; (4) branch margins of *F. armata* are fringed along their whole length with marginal kenozooids having a conical spines, while the margins are edged with spineless zooids in *F. stolonifera*; (5) spines of the vicarious kenozooids of *F. armata* are scarcely branched and only at the very tip, without secondary ramification, whereas the homologous spines in *F. stolonifera* are divided into two to six tine-like branches (see Okada 1921, text-fig. 1; Mawatari 1953, text-fig. 3).

An eastern-Pacific species, *F. spinifera* (O'Donoghue & O'Donoghue, 1923), also forms erect colonies, having strap-shaped bilamellar lobes and large kenozooids with long, sparsely branched spines (holotype specimen illustrated by d'Hondt 1983, pls 1, 2), some of which are superficially similar to those in *F. armata*. However, the spine branches are always longer and the ramification is deeper than in the vicarious kenozooidal spines of *F. armata*. In addition, all kenozooids of *F. spinifera* are of the same type, located distally to each zooid, whereas in *F. armata* large vicarious kenozooids are scattered over the colony surface and small, circular kenozooids with a simple spine are always present.

Ecology. The majority of colonies of *F. armata* collected intertidally support a diverse association of other sessile benthic forms. Most colonies observed were covered with hydroids, sponges, tubes of sabellid polychaetes, barnacles, ascidians, brachiopods, green and red algae (including articulate coralline algae), and other bryozoans, including species of *Lichenopora*, *Alcyonidium*, *Cauloramphus*, *Figularia*, *Hippothoa*, *Watersipora*, *Fenestrulina*, *Microporella*, *Pacificincola*, *Celleporaria*, and *Celleporina*. Among the bryozoans, colonies of *Celleporaria* were the most frequent and abundant, forming thick nodules around the branch stems of *F. armata*. Occasionally, errant polychaetes, pycnogonids, and the shells of juvenile gastropods and oysters were noticed between the appressed branch trunks of colonies.

We observed in the field that populations of *F. armata* are patchy in the upper subtidal zone but have a high of coverage of substrata on rocky bottoms at depths of 10–20 m at some sites. These deeper colonies likewise provide a habitat for a variety of subtidal benthic organisms. We saw dozens of caprellid and other amphipod crustaceans associated with colonies of *F. armata*. The majority of colonies were densely covered by hydroids, green and red algae (both encrusting and articulate coralline algae), sponges, barnacles, tubes of sabellid polychaetes, and other bryozoans, including species of *Crisia*, *Lichenopora*, *Alcyonidium*, *Cellaria*, *Beania*, *Catenicella*, *Escharoides*, *Pacificincola*, *Celleporaria*, and *Celleporina*. In some cases, we found juvenile mytilids, oysters, decapods, errant polychaetes, and pycnogonids between branches of of *F. armata* colonies, and groups of small scleractinians attached to the basal region of colonies.

Distribution. *Flustrellidra armata* is currently known along more than 300 km of the southern shoreline of the Korean Peninsula, facing the western passage of the Korea Strait, between Mipo (35°36' N, 129°27' E) in the northeast and Mokdo (34°10' N, 126°34' E) in the southwest. Accordingly, *F. armata* can be categorized as a Pacific-Asian, low-Boreal to Subtropical, intertidal to upper-subtidal species.

Discussion

The discovery of *F. armata* increases the known diversity of the genus *Flustrellidra* to eleven species and one subspecies. The genus includes two Boreal-Arctic, seven Boreal, and three Boreal-Subtropical species (Table 1). *Flustrellidra corniculata* (Smitt, 1872) and *F. hispida* (Fabricius, 1780) occur in the Boreal zones of both the Atlantic and Pacific oceans (Hincks 1880; Prenant & Bobin 1956; Kluge 1962; Ryland 1974; Hayward 1985; Mawatari 1971; Kubanin 1997). The distributions of the ten other taxa of *Flustrellidra* are restricted mostly to the North Pacific. Four species (*F. gigantea* Silén, 1947; *F. cervicornis* (Robertson, 1900); *F. vegae* Silén, 1947; and *F. kurilensis* (Mawatari, 1953)) are widely distributed within the Boreal zone, occurring on both sides of the Pacific and, presumably, along the Aleutian Archipelago (Osburn 1953; Kluge 1961; Cook 1964; Androsova *et al*. 1974; Izyumova & Kubanin 1978; Kubanin 1997; Grischenko 2002, 2004). *Flustrellidra spinifera* (O'Donoghue & O'Donoghue, 1923), described from Vancouver Island, seems to be the only species endemic to the Eastern Pacific, occurring from the Gulf of Alaska to California (Cook 1964; d'Hondt 1983). *Flustrellidra filispinia* Mawatari, 1971, and *F. akkeshiensis* Mawatari, 1971, were for a long time not known outside their type locality, Akkeshi Bay, on the Pacific coast of Hokkaido. However, the latter has been reported occurring on carapaces of the red king crab *Paralithodes camtschaticus* (Thilesius, 1815), in the western Kamchatka shelf of the Sea of Okhotsk (Grischenko 2001). This record changed of the status of *F. akkeshiensis* from low- to wide-Boreal.

Only one species and one subspecies, *Flustrellidra stolonifera* (Okada, 1921) and *F. stolonifera aspinosa* (Mawatari, 1953), both described from Sagami Bay, are known to occur in the vicinity of the boundary between the Boreal and Subtropical zones of the Asian Pacific (~35.7° N, Inubo Cape, Pacific coast of Honshu), and these species may be considered to be low-Boreal to Subtropical in distribution. Despite a contradictory interpretation of the boundary between the Boreal and Subtropical zones in the Western Pacific (Horikoshi 1981; Nishimura 1981; Masahi 1985; Kafanov 2005), a biogeographical study in Korean waters (Seo 1996) clearly demonstrated that the southern coast of Korea and Jeju Island are strongly influenced by the warm Tsushima current (a branch of Kuroshio current) and that the bryozoan fauna in these areas includes Subtropical elements. For this reason, and on the basis of the distributional data for *F. armata*, we consider this species as the third low-Boreal to Subtropical species of *Flustrellidra*.

The majority of records of *Flustrellidra* species is from the upper subtidal and intertidal zones (Kluge 1962; Ryland 1974; Hayward 1985; Kubanin 1997). *Flustrellidra inarmata* Hayward, 1978, was an apparent being exception, originally described from deep water in the Norwegian Sea (69°38.4’ N, 10°28.6’ E; depth range 2939–3213 m); this species is now the type species of the abyssal genus *Haywardozoon* d’Hondt, 1983 (Haywardozoidae).

TABLE 1. Geographical distributions of *Flustrellidra* species.

Species	Distribution	Biogeographical status
F. corniculata	Barents Sea, Spitzbergen, Western Greenland, Jan Mayen Island, Sweden, Norway, White Sea, Kara Sea, Canadian Arctic Archipelago, Beaufort Sea, Bering Sea, Commander Islands, Aleutian Islands, Sea of Okhotsk, Kuril Islands, Hokkaido Island, Gulf of Alaska, British Columbia, Vancouver Island	Boreal-Arctic circumpolar
F. gigantea	Beaufort Sea, Bering Sea, Kamchatka Peninsula, Sea of Okhotsk, Kuril Islands, Sakhalin Island, Hokkaido Island, Commander Islands, Gulf of Alaska	Boreal-Arctic Pacific
F. hispida	Gulf of St Lawrence, Woods Hole, Western France, Britain, North Sea, South-Western Baltic Sea, Norway, Barents Sea, White Sea, Bering Sea, Kamchatka Peninsula, Commander Islands, Aleutian Islands, Pribilof Islands, Kuril Islands, Gulf of Alaska, British Columbia	Amphi-Boreal
F. cervicornis	Kuril Islands, Sea of Okhotsk, Kamchatka Peninsula, Bering Sea, Commander Islands, Pribilof Islands, Gulf of Alaska	Pacific high-Boreal
F. vegae	North Kuril Islands, Sea of Okhotsk, Kamchatka Peninsula, Bering Sea, Commander Islands, Aleutian Islands	Pacific high-Boreal
F. kurilensis	North Kuril Islands, Bering Sea, Commander Islands, Gulf of Alaska	Pacific high-Boreal
F. spinifera	Eastern Bering Sea, Gulf of Alaska – California	Eastern Pacific low-Boreal
F. filispinia	Hokkaido Island, Sea of Okhotsk	Pacific Asian Boreal
F. akkeshiensis	Hokkaido Island	Pacific Asian low-Boreal
F. stolonifera	Sagami Bay, Honshu Island	Pacific Asian low-Boreal-Subtropical
F. stolonifera aspinosa	Sagami Bay, Honshu Island	Pacific Asian low-Boreal-Subtropical
F. armata	Southern shoreline of Korea	Pacific Asian low-Boreal-Subtropical

The species diversity and abundance of *Flustrellidra* are highest along the North Pacific rim, occurring on shelves in the vicinity of Hokkaido, the Kuril Islands, the Kamchatka Peninsula, the Commander–Aleutian Ridge, the Gulf of Alaska, and British Columbia, where species of *Flustrellidra* are conspicuous components of a variety of benthic and fouling assemblages (O’Donoghue & O’Donoghue 1923; Osburn 1953; Mawatari 1953, 1971; Kluge 1961; Androsova *et al*. 1974; Izyumova & Kubanin 1978; Gontar 1978, 1989; Kubanin 1996, 1997; Grischenko 2002, 2004; Grischenko *et al*. 2007). For instance, in Lower Cook Inlet, Gulf of Alaska, *Flustrellidra* spp. were found associated with the red king crab *P. camtschaticus* (Sundberg & Clausen 1977). As mentioned above, *F. akkeshiensis* has also been recorded as an epibiont of red king crab on the shelf of western Kamchatka (Grischenko 2001). Furthermore, in the region of the Commander Islands, *F. gigantea* and *F. cervicornis* attain considerable biomasses (76 $g.m^{-2}$ and 1040 $g.m^{-2}$, respectively) at depths of 0–15 m in kelp communities (Grischenko 1997). These ctenostomes provide a habitat for a number of sessile organisms, including other bryozoans. During a study of intertidal cheilostome bryozoans of Akkeshi Bay, Pacific coast of Hokkaido (Grischenko *et al*. 2007), colonies of *F. corniculata* were found occurring at high densities in exceptionally dense aggregations on some genera of red algae in the middle horizon of the rocky intertidal zone, covering dozens of square meters and affording a biotope for various associated animals and algae (A. V. Grischenko, unpubl. data). *Flustrellidra armata* shows similarly high abundance in the rocky intertidal and upper subtidal zones, also harbors a high diversity of associated organisms, and is a prominent component of benthic communities along the southern shoreline of Korea.

Acknowledgements

We are grateful to Professor Shunsuke F. Mawatari and Dr Matthew H. Dick of Hokkaido University, Sapporo, Japan, and also to Dr Dennis P. Gordon of the National Institute of Water and Atmospheric Research, Wellington, New Zealand, for comments and critical reading of the original manuscript. Ms D. Y. Jeoung of Chonbuk National University, Jeonju, Jeollabuk–do, Korea, is thanked for assistance with SEM. This work was supported by a Korea Research Foundation Grant funded by the Korean Government (MOEHRD) (KRF–2007–210–C00005) and Woosuk University (2010).

References

Androsova, E.I., Gostilovskaya, M.G. & Izyumova, E.A. (1974) Phylum Podaxonia, Class Bryozoa. Faunal list of the Kuril Islands intertidal zone. *In*: Zhirmunsky, A.V. (Ed), *Plant and Animal World of the Intertidal Zone of the Kuril Islands*. Nauka Press, Novosibirsk, pp. 368–369. (In Russian.)

Cook, P.L. (1964) Notes on the Flustrellidridae (Polyzoa, Ctenostomata). *The Annals and Magazine of Natural History, ser. 13*, 7, 279–300.

Dick, M.H., Grischenko, A.V. & Mawatari, S.F. (2005) Intertidal Bryozoa (Cheilostomata) of Ketchikan, Alaska. *Journal of Natural History*, 39, 3687–3784.

Dick, M.H. & Ross, J.R.P. (1988) *Intertidal Bryozoa (Cheilostomata) of the Kodiak vicinity, Alaska*. *Centre for Pacific Northwest Studies Occasional Paper*, 23, 1–133.

Fabricius, O. (1780) *Fauna Groenlandica, systematice sistens animalia Groenlandiae occidentalis hactenus indagata*. Hafniae et Lipsiae, I.G. Rothe. 452 p., 1 pl.

Gong, Y.H. & Seo, J.E. (2003) Fouling Bryozoans from the East Sea. *Journal of HRDEC*, 4, 1–22. (In Korean.)

Gong, Y.H. & Seo, J.E. (2004) A taxonomic study on fouling bryozoans from Korea. Preliminary report. *Underwater Science and Technology*, 5, 11–16. (In Korean.)

Gontar, V.I. (1978) Bryozoa of the Iturup Island coastal waters. *Biologiya Morya*, 1, 10–16. (In Russian).

Gontar, V.I. (1989) Phylum Bryozoa. The list of macrophytes and invertebrates of macrobenthos of the Avacha Inlet. *In*: Kussakin, O.G. (Ed), *Hydrobiological Explorations in Avacha Inlet*. Far East Division of the Academy of Sciences of USSR Press, Vladivostok, p. 113. (In Russian).

Grischenko, A.V. (1997) Bryozoans (Ctenostomida, Cheilostomida) of the Commander Islands shelf zone. *In*: Rzhavsky, A.V. (Ed), *Benthic Flora and Fauna of the Shelf Zone of the Commander Islands*. Dalnauka Press, Vladivostok, pp. 153–192. (In Russian, with English summary.)

Grischenko, A.V. (2001) Red king crab as a mobile substratum for Bryozoa in the Western Kamchatka shelf. *In*: Tokranov, AM. (Ed), *Conservation of Biodiversity of Kamchatka and Coastal Waters*. Materials of 2nd scientific conference. KamchatPress, Petropavlovsk-Kamchatsky, pp. 46–47. (In Russian.)

Grischenko, A.V. (2002) History of investigations and current state of knowledge of Bryozoan species diversity in the Bering Sea. *In*: Wyse Jackson, P.N. & Spencer Jones, M.E. (Eds), *Annals of Bryozoology*: *Aspects of the History of Research on Bryozoans*. International Bryozoology Association, Trinity College, Dublin, pp. 97–116.

Grischenko, A.V. (2004) Intertidal Bryozoa of the Commander Islands. *In*: Tokranov, A.M. (Ed), *Conservation of Biodiversity of Kamchatka and Coastal Waters*. Materials of 5th scientific conference. KamchatNIRO Press, Petropavlovsk-Kamchatsky, pp. 38–43. (In Russian.)

Grischenko, A.V., Dick, M.H. & Mawatari, S.F. (2007) Diversity and taxonomy of intertidal Bryozoa (Cheilostomata) at Akkeshi Bay, Hokkaido, Japan. *Journal of Natural History*, 41, 1047–1161.

Hayward, P.J. (1978) Two new species of Ctenostomata (Bryozoa) from the Norwegian Sea. *Sarsia*, 63,159–162.

Hayward, P.J. (1985) Ctenostome Bryozoans. Keys and notes for the identification of the species. *Linnean Society Synopses of the British Fauna, n.s.*, 33, 1–169p.

Hincks, T. (1880) *A History of the British Marine Polyzoa*. Van Voorst, London, 2 vols.

Hondt, J.L. d' (1983) Tabular keys for identification of the Recent ctenostomatous Bryozoa. *Mémoires de l'Institut* *océanographique, Monaco*, 14, 1–134p.

Horikoshi, M. (1981) On the locations of mangroves and coral reefs within a tropical regional ecosystem, with discussions on the marine bioclimatic zones in the West Pacific. *Kaseki*, 30,105–120. (In Japanese.)

Izyumova, E.A. & Kubanin, A.A. (1978) Phylum Podaxonia, Class Bryozoa. A list of the animal species from the intertidal zone of the eastern Kamchatka and western coast of Bering Sea. *In*: Kussakin, O.G. (Ed), *The Intertidal Zone of the Bering Sea and Southeastern Kamchatka*. Nauka Press, Moscow, pp. 170–171. (In Russian.)

Kafanov, A.I. (2005) Oleg Grigoryevich Kussakin as a biogeographer. *Biologiya Morya*, 31, 148–153. (In Russian.)

Kim, H.K. & Rho, B.J. (1969) A report on the floral and faunal survey of Chuja Island. VI. *Fauna of Chuja Islands 3. Marine Invertebrates of Chuju Islands*. The Cultural Property Preservation Bureau, pp. 67–108. (In Korean.)

Kim, H.K, Rho, B.J, Hong, S.Y., Kim, I.H., Shin, S. & Han, C.H. (1978) The marine invertebrate fauna in the southern part of Geoje Island and its adjacent five islands. *The Korean Association for Conservation of Nature*, 14, 103–126. (In Korean.)

Kluge, G.A. (1961) Species list of Bryozoa of the far eastern Seas of the USSR. *Issledovaniya Dal'nevostochnih Morei SSSR*, 7, 118–143. (In Russian.)

Kluge, G.A. (1962) Bryozoa of the northern Seas of the USSR. *Opredeliteli po Faune SSSR*, 76, 1–584. (In Russian.)

Kluge, G.A. (1975) *Bryozoa of the Northern Seas of the USSR*. Amerind Publishing, New Delhi. 711 p. (English translation of 1962 Russian volume.)

Kubanin, A.A. (1996) Phylum Bryozoa. *In*: Kussakin, O.G. & Kostina, E.E. The intertidal biota of volcanic Yankich Island (middle Kuril Islands). *Publications of the Seto Marine Biological Laboratory*, 37, 201–225.

Kubanin, A.A. (1997). Phylum Tentaculata, subphylum Bryozoa. *In*: Kussakin, O.G., Ivanova, M.B. & Tsurpalo, A.P. (Eds), *A Check-list of Animals, Plants and Fungi from the Intertidal Zone of the Far Eastern Seas of Russia*. Dalnauka Press, Vladivostok, pp. 119–125. (In Russian.)

Masashi, Y. (1985) Tropical and subtropical zones in marine biogeography. *Kayo to Seibutsu*, 7, 410–416. (In Japanese.)

Mawatari, S. (1953) Studies on Japanese Ctenostomatous Bryozoa, I. On some species of Carnosa. *Publications of the Seto Marine Biological Laboratory*, 3, 213–220.

Mawatari, S.F. (1971) Three species of *Flustrellidra* (Bryozoa, Ctenostomata) from Hokkaido. *Journal of the Faculty of Science, Hokkaido University, Series 6, Zoology*, 18, 227–234.

Nishimura, S. (1981) *Sea and Life of the Earth*: *An introduction to marine biogeography*. Kaimeisha, Tokyo. 284 p. (In Japanese.)

O'Donoghue, C.H. & O'Donoghue, E. (1923) A preliminary list of Polyzoa (Bryozoa) from the Vancouver Island region. *Contributions to Canadian Biology, n.s*, 1, 145–201, pls 1–4.

Okada, Y. (1921) Notes of some Japanese chilostomatous Bryozoa. *Annotationes Zoologicae Japonenses*, 10(3):19–32.

Osburn, R.C. (1953) Bryozoa of the Pacific Coast of North America. Part 3, Cyclostomata, Ctenostomata, Entoprocta and Addenda. *Allan Hancock Pacific Expeditions*, 14, 613–841.

Prenant, M. & Bobin, G. (1956) Bryozoaires. 1. Entoproctes, Phylactolèmes, Cténostomes. *Faune de France*, 60, 1–398.

Rho, B.J. & Chung, H.B. (1975) A Taxonomic Study on the Marine Bryozoans in Korea. *Journal of Korean Research Institute for Better Living*, 14, 47–62. (In Korean.)

Rho, B.J. & Lee, K.H. (1981) The marine invertebrate fauna in the Gogunsan Islands and Bian Island. *The Report of the KACN*, 18, 115–124. (In Korean.)

Rho, B.J. & Kim, H.K. (1981) A Study on the marine bryozoans in Korea 3. Stenolaemata and Gymnolaemata. *Journal of Korean Research Institute for Better Living*, 27, 57–72. (In Korean.)

Rho, B.J. & Seo, J.E. (1986) A systematic study on the marine bryozoans in Cheju-do. *Korean Journal of Zoology*, 29, 31–60.

Robertson, A. (1900) Papers from the Harriman Alaska Expedition. 6. The Bryozoa. *Proceedings of the Washington Academy of Sciences*, 2, 315–340.

Ryland, J.S. (1974) A revised key for the identification of intertidal Bryozoa (Polyzoa). *Field Studies*, 4, 77–86.

Seo, J.E. (1996) On the geographical distribution of cheilostomate Bryozoa in Korean waters. *In*: Gordon, D.P., Smith, A.M. & Grant-Mackie, J.A. (Eds), *Bryozoans in Space and Time*. NIWA, Wellington, pp. 299–304.

Seo, J.E. (1998a) Marine Vryozoans from Geojedo Island in Korea. *The Korean Journal of Systematic Zoology*, 14, 207–217.

Seo, J.E. (1998b) Taxonomy of the marine bryozoans from Namhaedo Island and Its adjacent waters, Korea. *The Korean Journal of Systematic Zoology*, 14, 415–424.

Seo, J.E. (2005) *Illustrated Encyclopedia of Fauna and Flora of Korea. Volume 40. Bryozoa*. Ministry of Education and Human Resources Development, Daehan Printing and Publishing, Seoul. 596 p.

Silén, L. (1947) On the spines of *Flustrella* (Bryozoa). *Zoologiska bidrag fran Uppsala*, 25, 134–140.

Smitt, F.A. (1872) Kritisk förteckning öfver Skandinaviens hafs-Bryozoer. Part 5. *Öfversigt af Kongliga Vetenskaps-Academiens Förhandlingar*, 28, 1115–1134, pls 20–21.

Sundberg, K.A. & Clausen, D. (1977) Post-larval king crab (*Paralithodes camtschatica*) distribution and abundance in Kachemak Bay, Lower Cook Inlet, Alaska, 1976. *In*: Trasky, L., Flagg, L. & Burbank, D. (Eds), *Environmental studies of Kachemak Bay and Lower Cook Inlet*, *5*. Alaska Department of Fish and Game, Anchorage, p. 36.