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On Two Polychaetous Serpulids New to Korean Waters with Notes on the Ecological Aspects

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韓國産 多毛類 二未記錄種의 形態的 特徵과 生態에 關하여

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摘 要

한국산 多毛類 중 1980~1982년동안 남해안과 동해 울릉도 해역의 軟性底質에서 채집한 석회관갯지렁이科 (Family Serpulidae)에 속하는 2 한국 미기록종 *Protula tubularia* (Montagu, 1803)와 *Ditrupa arietina* (O.F Müller, 1776)의 형태적 특징과 생태에 관하여 기재하였다.

INTRODUCTION

Species of the family Serpulidae (Polychaeta, Annelida) are broadly and abundantly distributed generally on hard substrates in all parts of the world. The polychaetous serpulids recorded from Korean waters comprise about 11 species that occur mainly in littoral regions (Rho and Song, 1975; Paik, 1979, 1980; Rho and Lee, 1982).

Recent benthic ecological survey in Korean waters has turned my taxonomical interest to some polychaetous serpulids. The description of two species new to Korean waters, *Protula tubularia* (Montagu,1803) and *Ditrupa arietina* (O.F. Müller, 1776) is given in the present study with some ecological notes.

The materials examined herein for the description and illustration were collected from two different regions (Fig. 1); *P. tubularia* from the east coast (off Ulleung-Do) at a depth of about 180-230 m by means of a simple dredge equipped in the Japanese submersible "HAKUYO", and D. *arietina* from the shallow subtidal mud flats of the Gamagyang Bay in the southern coast of Korea.

In the respect of their natural habitats, these two cosmopolitan species can be considered somewhat different from other serpulids. In Japanese waters, Imajima (1964, 1978, 1979)

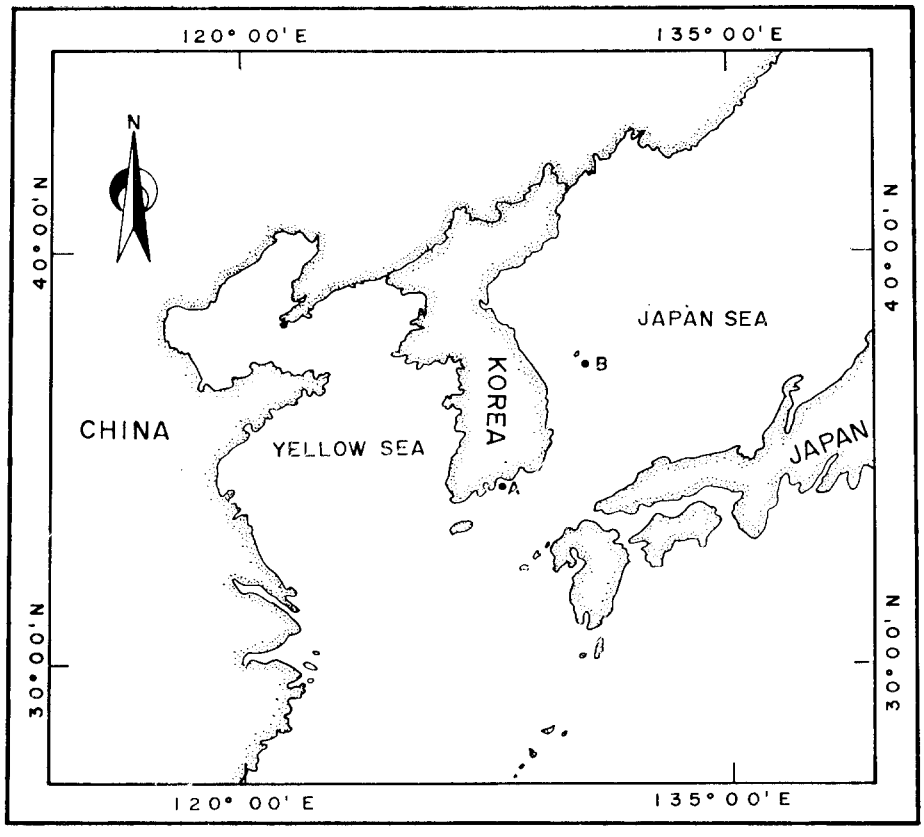

Fig. 1. Map of the sampling sites. A, Gamagyang Bay; B, Off Ulleung-Do.

and Imajima & Hartman (1964) mentioned some taxonomical and distributional notes, but little ecological informations are available.

Genus *Protula* Risso, 1826 민덮개석회관갯지렁이屬

Protula tubularia (Montagu, 1803) 민덮개석회관갯지렁이(신칭)

(figs. 2-3)

Saint-Joseph, 1894, pp. 362-369, fig. 408-413 (Mediterranean, Atlantic, English Channel), Fauvel, 1909, pp. 693-698, fig. 3-4 (English Channel); Fauvel, 1914, pp. 354-356 (Bay of Biscay); McIntosh, 1923, pp. 330-338, pl. CXV, fig. 6, pl. CXVI, fig. 2, pl. CXXI, fig. 5, pl. CXXX, fig. 7 (various regions in English coasts); Fauvel, 1927, pp. 382-383, fig. 120 a-l (English Channel, Atlantic, Mediterranean, Persian Gulf, Indian Ocean); Rioja & Lo Bianco, 1931, pp. 444-445, fig. 145-146 (Cantãbrico, Santander, Valancia, Gulf of Rosas); Fauvel, 1936, pp. 89-90 (Seto, Japan); Okuda, 1938, p. 104 (Sasaki, Izu Peninsula, Japan); Rioja, 1962, pp. 220-222, fig. 160-161 (Pacific coast of Mexico); Imajima & Hartman, 1964, p. 376 (Japan); Day, 1961, p. 553 (South Africa); Day, 1967,

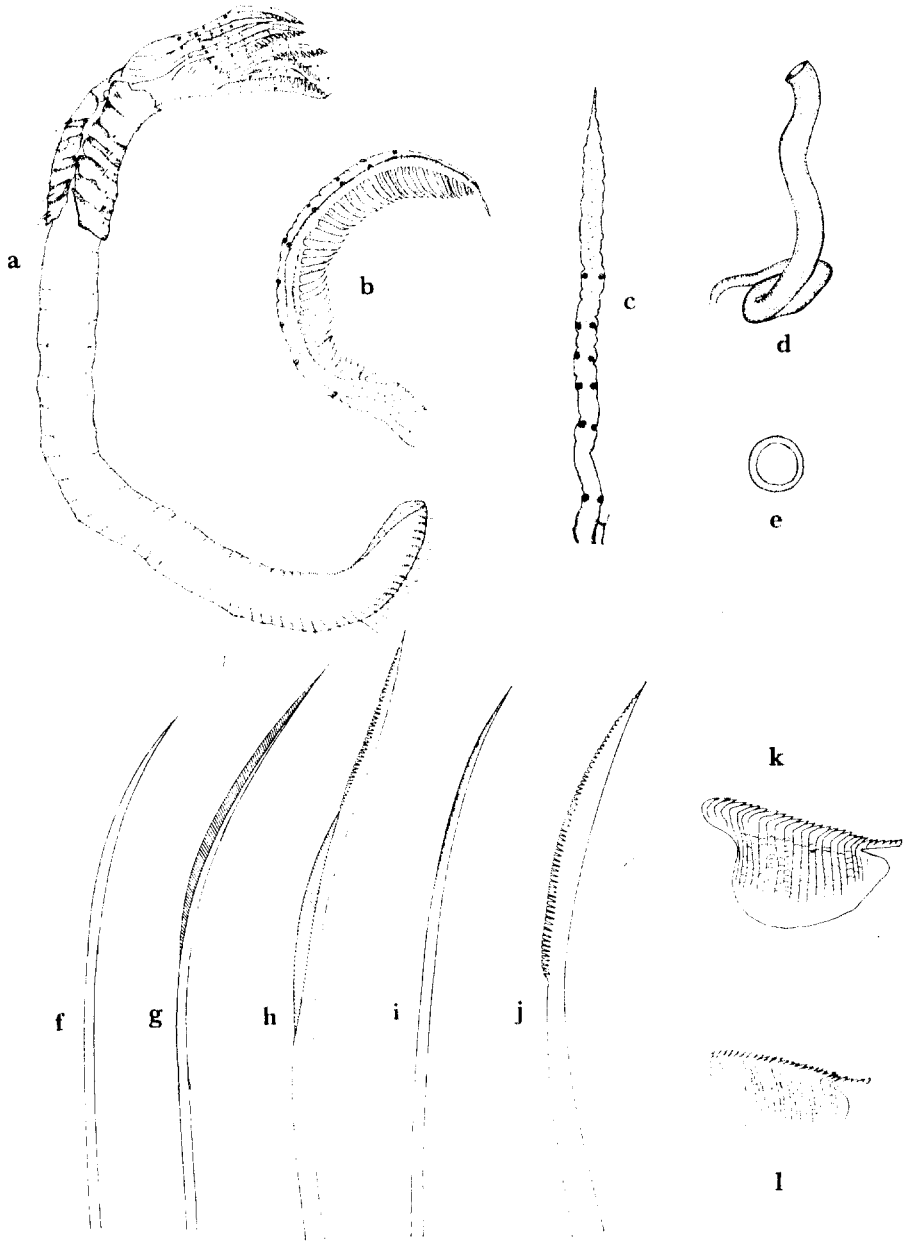

Fig. 2. *Protula tubularia* (Montagu, 1803).
a. entire worm, ×3; b. gill-radiole, ×6; c. dorsal view of gill-radiole, ×9; d. tube, ×1; e. cross-section of the tube, ×3; f. collar seta, ×262, g. thoracic seta, ×262; h. thoracic *Apomatus*-seta, ×375; i. abdominal seta, ×375; j. abdominal seta, ×937; k. thoracic uncinus, ×937; l. abdominal uncinus, ×937.

pp. 818-820, fig. 38.7. o-r (Cape, Natal region of Southern Africa); Zibrowius, 1968a, pp. 182-184, pl. 10, Fig. 13-16 (Marseille, Villefranche, Mediterranean); Pillai, 1971, p. 92 (Ceylon); Zibrowius, 1973, pp. 81-82 (West coast of Africa and the nearby archipelagos); Uchida, 1978, pp. 37-39, pl. XII (Sabiura, Japan); Day & Hutchings, 1979, pp. 148-149 (Western Australia, New South Wales, Queensland).

Material examined: more than thirty specimens from Ulleung-Do, eastern coast of Korea.

Description

Tube: cylindrical, chalky white, slightly tapered. Tubes generally consisting of an attached basal coiled portion and a nearly straight erect and free portion which are terete, smooth, and roughened by a circular fine lines of growth but lacking ridges or spines externally (Fig. 2d). The tubes of specimens examined measure about 5-10 cm in length, but sometimes reach a considerable size.

Branchiae: form two fans, each of which spirally coiled about one and a half turns. The filaments in each of which range ten to sixty, so the number of branchial filaments varies considerably according to the size of specimens. The length of the branchiae examined averages 1 cm. A branchial filament shows a pectiniform arrangement (Fig. 2b). The pinnae are arranged in a double row along the inner border (even though a single row only illustrated in the figure), the basal region of each slightly wider, and thereafter it gently tapers to the more or less blunt tip. Toward the tip of the filament the pinnae diminish in length and end in a short process. Red eye-spots on a dorsal part of the rachises in branchial filaments, and usually arranged in a double row (Fig. 2c) but their numbers vary greatly by the size of specimen as well.

Operculum: The operculum is absent. This character is an important generic criterion.

Collar and thoracic membrane: Collar entire and not incised in the median line. The thoracic collar is trilobed, deep, and continuous with the thoracic membrane. Thoracic membranes continue to the end of the thorax and they are separated ventro-laterally to form a ventral and two lateral lobes, and enclose thoracic setal fascicles of each side (Fig. 2a). The bundles of collar seta contain a few setae of two types, a simple bayonet-like seta (Fig. 2f) and a limbate seta which occurred more frequently (Fig. 2g).

Thorax: The thorax measures about 1.1 cm long and has seven setigerous segments, five of which are uncinigerous. The setae are of two types; a limbate seta as usual in collar seta (Fig. 2g) and *Apomatus*-seta which occurs from setiger 4 onwards (Fig. 2h). The thoracic uncinigerous tori and first present from the third setigerous segment onwards, arranged in a single row of teeth. The number of teeth ranges from 25 to 30, and the most anterior tooth not gouged, but slightly truncated (Fig. 2k).

Abdomen: The abdomen of specimens examined averages 3.5 cm in length. The segments variable in number, a small specimen had about 48, but a large ovigerous specimen contained 135 abdominal segments. Abdominal body somewhat flattened dorso-ventrally and

deeply furrowed by a broad flat groove along the ventral median line but more pronounced in the posterior region. The abdominal setae are of two types, which are slightly different from the thoracic ones; a narrow bayonet-like seta with minute numerous capillary buds in the posterior blade. These very long setae are particularly concentrated on the hind region (Fig. 2i). Another kind of seta is more or less geniculated and coarsely denticulated along the cutting edge (Fig. 2j). A terminal white gland present at the posterior extremity on the dorsal side of the abdomen (Fig. 2a).

Discussion

The geuns *Protula* Risso, 1826 includes all the species without an operculum, with well-developed thoracic membranes which continue to the end of the thorax and form a free margin on the ventral side. Since the serpulid operculum have been usually used as a good criterion for identifying the members of the family Serpulidae, certain problems are raised in terms of the taxonomy of the genera of *Protula* and *Apomatus*; From the various literatures it is generally believed that these two genera are separated from each other by the presence of opercula in *Apomatus* and their absence in *Protula*. In addition, the reliable feature distinguishing respectively may be, on some occasions, the shape of collar form, thoracic and abdominal setae and uncini. However, it should be noted here that these various criteria are sometimes not constant even within the same population.

In the population of *Protula* examined in the present study, one specimen bearing the globular operculum was obtained, and a detailed examination shows exactly the same morphological aspect in all the taxonomic characters except the opercular vesicle more or less semi-transparent, which terminates a gill-radiole retaining its pinnae (Fig.3a). The observation of this phenomenon previously made in the Mediterranean population by Zibrowius (1968a) supports the specific affinity between *Protula* and *Apomatus*. Besides, Fauvel (1909, 1927, 1936) has already commented, in particular, on the morphological similarity of *Apomatus similis* Marion & Boretzky and *Protula tubularia* and has suggested that the former might be a young form of the latter. Then, in French Mediterranean coast, it was observed that *Apomatus similis* is smaller than *Protula tubularia* (Fauvel, 1927; Zibrowius, 1968). Here, the specimen found in the eastern coast of Korea and described herein measures about 1.5cm in length, and it is also relatively small in size amongst the *Protula* population examined. Moreover, after an investigation of the blood system of serpulids, Hanson (1948) concluded that the presence or absence of an operculum is not a sufficiently important character for distinguishing *Apomatus* from *Protula*, or *Filograna* from *Salmacina*; and therefore that these two pairs of genera should be fused into two genera. In addition, Zibrowius (1968a, 1973) stated that the vesicular operculum is very fragile structure, possibly even deciduous, and without any other evident particularities it may be impossible to distinguish an *Apomatus* which has lost its operculum from a *Protula* which always does not carry this organ.

Consequently, the rearing experiment with *Protula* during the life cycle in the labor-

atory will clarify certain systematic confusions between these two problematic genera, and at the same time it is necessary to study the opercular function in the genus *Apomatus* and to make the comparative detailed survey based on the abundant materials from the whole world for the revision of these genera as Zibrowius (1968a, 1970, 1973) has emphasized that the revision of the genus *Protula* is indispensable because of the variability of the morphological characters used as specific criteria.

In Japanese waters, one species and two subspecies have been recorded; *Protula tubularia tubularia* (Montagu, 1803), *P. tubularia caeca* Imajima, 1977, and *Protula magnifica* Straughan, 1967. The first cosmopolitan species, *P. tubularia*, is recognized in various regions (Fauvel, 1936, Seto; Okuda, 1938, Susaki; Uchida, 1978, Sabiura). Accordingly it seems to be widely distributed in Japanese coasts. Imajima (1977) described a new subspecies, *Protula tubularia caeca*, from the collection sampled around Chichi-jima (Ogasawara Islands). Recently, Uchida (1978) found *Protula magnifica* very common on the rocks in the depth of 3-20 m in the Sabiura region of Japanese southern coast. This species, originally described by Straughan (1967) in the Australian waters (Heron Island, Queensland), can be distinguished from the other species by the developed branchiae to form a pair of spirals each with five to six turns and in the absence of the thoracic uncini.

From the present study, Imajima's subspecies, *Protula tubularia caeca*, remains problematical, because as he mentioned it may be simply distinguished from *P. tubularia tubularia*, by the absence of red eye-spots on the gill-radioles and the form of uncini of *P. tubularia caeca* which shows a long basal process with a truncated tip distally. However, the specimens examined and described in the present paper are characterized by the presence of the red eye-spots on the gill-radioles, and the thoracic and abdominal uncini represent nearly intermediate form between the typical *Protula tubularia* and Imajima's *P. tubularia caeca* (Fig. 2c,k,l). The tube sculpture, morphology of the abdominal setae, number of the teeth of uncini are slightly different but these characters can probably be regarded as morphological parameters which are variable according to the growth, biotope or the geographic situation. In addition, even though the tube is circular in cross-section and has two slender longitudinal ridges (Imajima, 1977), the presence of the longitudinal ridges of *P. tubularia* has been also observed in some Ceylonese specimens (Pillai, 1971), and the existence of several intermediate forms in some morphological characters such as abdominal setae in this genus has been often discussed by Zibrowius (1968a, 1970). Therefore, the present investigation suggests that Imajima's subspecies *P. tubularia caeca* has possibly to be reexamined with abundant materials from the different regions or biotopes, because it can be a simple morphological variation of the *P. tubularia* (Montagu, 1803) as for the other certain cosmopolitan species.

Monro (1934) studied two specimens from Amoy region of the Chinese coast and identified as *Protula* sp., but noted that structurally he could find nothing to distinguish them from *Protula tubularia* (Montagu). In addition, Ushakov (1955) reported *Protula pacifica*

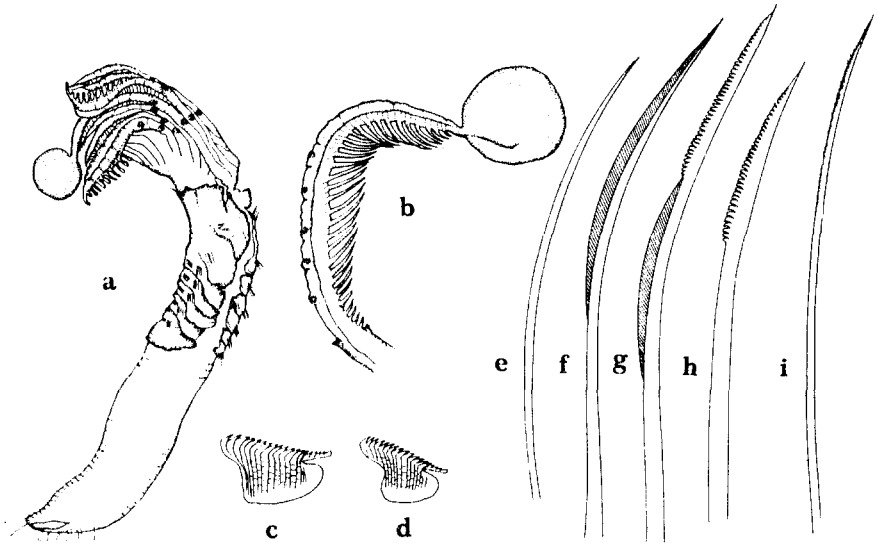

Fig. 3. Operculum-bearing individual of ? *Protula tubularia* (Montagu, 1803).
a. entire worm, ×9; b. gill-radiole with globular operculum, ×15; c. thoracic uncinus, ×1,125; d. abdominal uncinus, ×1,125; e. collar seta, ×450; f. thoracic seta, ×450; g. *Apomatus*-seta, ×1,125; h. abdominal seta, ×1,125; i. abdominal seta, ×450.

Pixell, 1912 in the Sea of Japan, west coast of south Sakhalin, southwestern part of the Sea of Okhotsk chiefly at depths exceeding 100 m. This species has been orginally described by Pixell (1912) from the Pacific coast of North America (Fairway Channel outside Departure Bay in about 55 m deep), and, as she stated, the specific character is that the collar is notched in the median ventral line and has a deep fissure on each side. However, this should be also revised by a detailed reexamination of all the possible specific criteria, since by the reference survey this species has fairly a close relationship in terms of some morphological structures with for example *P. intestinum* (Savigny), *P. capensis* McIntosh, and *P. atypha* Bush.

Ecological Remarks

The reference study from various literatures confirms that *Protula tubularia* shows the cosmopolitan distribution. Zibrowius (1968a) has noted that *P. tubularia* is frequently encountered in the submarine dark caves in the regions of Marseille and Villefranche in the Mediterranean and it may be easily obtained on the hard substrates scattered in the circalittoral soft bottom. He has also mentioned that the opercular-bearing individual has been found in the bathyal zone of the Mediterranean.

Then the species has been recorded from the Australian intertidal zones (Day & Hutchings, 1979) to the Atlantic deep sea between 100-750 m (Fauvel, 1914). Moreover, it has been found at the depth of 943 m in the northern coast of the Crete, Greece (Marenzeller, 1893).

In the north-west Pacific regions, little informations are available on the habitat of

Protula tubularia (Montagu, 1803) around Korean waters and even in Japanese and Chinese waters. Fauvel (1936) and Okuda (1938) found respectively several tubes attached to the aquarium tank of the laboratory. Imajima (1977, 1978) reported that *P. tubularia caeca* were collected from the underside of corals on reef around Chichi-jima (Ogasawara Islands) and that its distribution was limited to the southern Japan and up to 94 m depth from the materials collected around Izu Islands. Uchida (1978) also observed in the region of Sabiura that *P. tubularia* was very abundant on the underside of the dead madreporarian rocks between low tidal line to 2 m deep and also in the aquarium. Unfortunately there is no ecological remark on the Chinese specimens examined by Monro (1934) from the Amoy region.

The *Protula* population studied herein were collected using a simple dredge equipped in the Japanese submersible "HAKUYO" off Ulleung-Do in the eastern coast of Korea at the depth of 180-230 m. This is the first record in Korean waters, but its distributional range and some more ecological significance will be further extended through more investigations. The sediment of the habitat was composed of the coarse sand and gravels with a certain muddy fraction on the uppermost layer, and small stones to which the tubes are attached.

Distribution: cold to temperate waters of the north Atlantic, the Mediterranean, tropical eastern Atlantic, tropical American Pacific (Gulf of Panama), Indo-west Pacific (India, Ceylon, Eastern Australia), and north-west Pacific (Japan).

Genus *Ditrupa* Berkeley 1835 뿔석회관갯지렁이屬

Ditrupa arietina (O.F. Müller, 1776) 뿔석회관갯지렁이(신칭)

(fig. 4)

Langerhans, 1880, pp. 121-122, pl. 15, fig. 39a-c (Madeira); McIntosh, 1885, pp.531 (The Canary Islands); Fauvel, 1914 pp. 346-347 (The Bay of Biscay, Bay of Horta, Off Sao Antonio; McIntosh, 1923, pp. 379-383, pl. CXXII, fig. 5, pl. CXXXII, fig.1 (Shetland, N.W. coast of Ireland, West of Valentia, Plymouth, England); Fauvel, 1927, pp. 373-375, fig. 128a-g (Ireland, The Bay of Biscay, Spain, Portugal, Mediterranean); Rioja & Lo Bianco, 1931, pp. 434-435 (Valentia, Spain); Wesenberg-Lund, 1953, p. 6 (Finmark); Kirkegaard, 1959, p. 109 (The Canary Islands); Imajima, 1964, pp. 48-50, fig. 1-5 (Amakusa, Japan); Zibrowius, 1968a, pp. 169-171, pl. 9, fig. 8-13 (Marseille, Mediterranean); Zibrowius, 1968b, pp. 383-385, pl. 1, fig. 18 (Archipelago of Madeira); Zibrowius, 1973, pp. 77-79, (West coast of Africa and the nearby archipelagos, Rio de Oro, Morocco); Imajima, 1978, p. 69 (around Nii-jima and O-shima); Imajima, 1979, p. 179 (around Shionomisaki)

Material examined: more than 35 specimens from Gamagyang Bay, southern coast of Korea.

Description

Tube: calcareous, free, open at both ends (*Ditrupa* from δις, bis, and τρύπα, foramen),

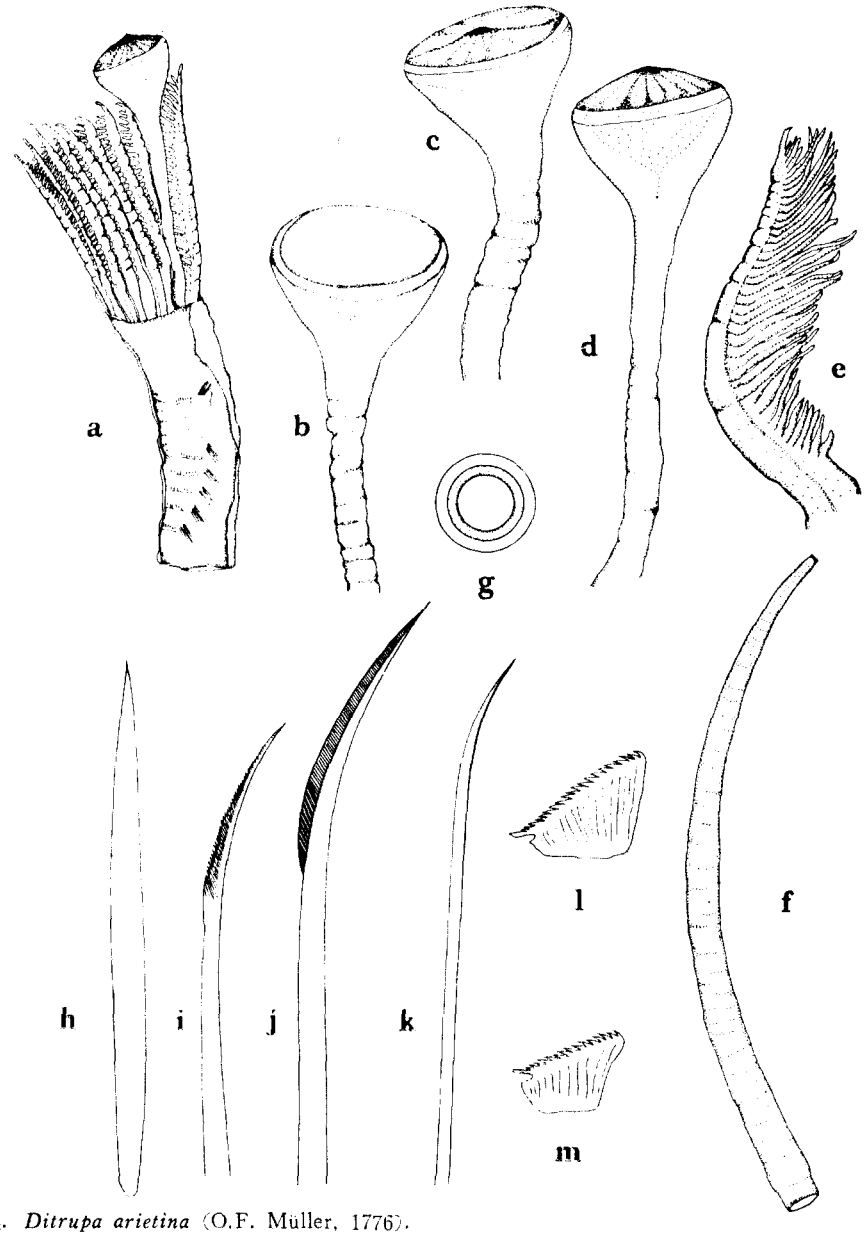

Fig. 4. *Ditrupa arietina* (O.F. Müller, 1776).
a. anterior end with operculum and thorax, × 28; b,c,d. various views of operculum, × 30; e. branchial filament, ×30; f. tube, ×6; g. cross-section of the tube, ×12, h. thoracic seta, ×675; i. thoracic seta, ×937; j. thoracic seta, ×937; k. abdominal capillary seta, ×937; l. thoracic uncinus, ×1,335; m, abdominal uncinus, ×1,315.

Dentalium-shaped like a slender tusk of an elephant, obliquely thinned, and usually slightly constricted at the aperture. The tubes of specimens studied measure from 12 mm to 18 mm

in length, and its wider region in front has a diameter of 1 to 1.5 mm. The cross-section of the tube shows two kinds of calcareous layer; the outer layer is vitreous but the inner lining is opaque white (Fig. 4f, g).

Branchiae: They measure about 2 mm long, and are arranged in two semicircles of about ten filaments in each, usually nine on the right side and ten on the left. The filaments tapering from base to apex ending in a short process which is largely a little longer than the adjoining pinnae. The pinnae of a gill-radiole are more or less long, disposed in a double row, and they are so arranged distally that they form a nearly even series and these give a character to the tip of the branchiae (Fig. 4 a,e).

Operculum: The peduncle of the operculum is long and rounded without any projection but often folded, and springs from the left branchial fan. It remains nearly cylindrical to the tips of the branchiae, where it delates into the long and sharp vase with the yellowish brown or dull yellow plate of some calcareous incrustation, approximately 1 mm in diameter at its tip (Fig.4b,c,d,). The operculum is also vesicular with its distal plate convex, sometimes flat, and occasionally sculptured with a concentric striation.

Collar and thoracic membrane: transparent, very thin and fissured in the mid-dorsal line, but thereafter continuous from side to side across the ventral surface (Fig. 4a). Fauvel (1927) described that upper edge of the collar was denticulate, but no collar membrane was visible. Collar setae absent.

Thorax: The thorax of the specimens studied averages about 3.5 mm in length and 0.9 mm in width. Six pairs of setigers laterally and the first thoracic segment achaetous. The first setiger in front is provided by a bundle of directed forward setae which are simple and large but very stout and not-curved (Fig. 4h); Compared with the other five subsequent thoracic setae and uncini, fiirst anterior thoracic tuft is placed in the isolated position possessing the thoracic uncini. The 2-6 segments contain thoracic ventral uncini and two types of dorsal setae; a small seta with minutely serrated blade and another type of limbate capillary seta (Fig. 4 i,j). Thoracic uncini may be described as a trapezoid structure with a score of sawteeth at the upper edge, but the number of teeth varies a little with the size of uncini. It should be noted that the terminal tooth is particularly longer than the others(Fig. 4l).

Abdomen: The abdomen of the materials examined averages about 6-7 mm in length possessing some thirty abdominal segments, but varies considerably according to size. Many of the segments located in the anterior part are devoid of abdominal bristles, while the posterior region presents well one or two simple long tapering capillary setae (Fig. 4k). On the other hand, all the abdominal segments are recognized by the presence of abdominal uncini, which are smaller than those of the thoracic segments and shows the same morphological aspect (Fig. 4m).

Discussion

Recent representatives of the genus *Ditrupa* Berkeley, 1835 are known in the N-E

Atlantic, Indian Ocean, Philippines, Indonesia, Australia, Japan, etc... and then show a world-wide distribution. However, the distribution range of *Ditrupa arietina* (O.F. Müller, 1776) must be reconsidered after the taxonomical revision by examining plenty of specimens from the various regions of the world, because the identification of this species has been generally based on the external morphology of the tube, which resembles very closely that of *Dentalium* belonging to the Scaphopods of the Mollusca (Bretnall, 1921; Dew, 1959). This is the reason why the naturalists in the 18th and in the beginning of the 19th century confused these polychaetous serpulids with the Molluscan tusk shell.

In the present study the specimens were identified as *D. arietina*, since the general characteristics of the tube, operculun, and uncini correspond quite well with those described by Fauvel (1927), Imajima (1964), and Zibrowius (1968 a). However, some morphological features in terms of the thoracic and abdominal setae set certain problem, since I found a bundle of the rod-like, simple, and stout setae (Fig. 4h) in the first setigerous thoracic segment, and the other setae thoracic or abdominal are not always in accord exactly with the descriptions made by certain authors. Then the trouble in systematics of this genus *Ditrupa* may also be solved by the detailed examination of these various characters with abundant materials.

Ecological remarks

D. arietina is completely isolated from all the other sessile serpulids due to its free-living habitat on soft substrates. Furthermore, with regard to the feeding habitat, the serpulids in general are usually considered as filter-feeders using their complex tentacular crowns, which consist of a varying number of gill-radioli carrying pinnules (Fauchald & Jumars, 1979). However, it seems that the *D. arietina* in Korean waters is probably surface deposit feeders because they are found in the clayey silty bottom and then a ciliary current through the branchial filaments of the worm helps to capture the deposited material in bedload. Additionally, *Ditrupa arietina* in the Mediterranean has been considered by Picard (1965) as a characteristic species of the Coastal Detritic Biocoenosis; This biocoenosis mainly occupies the upper part of the circalittoral zone, and the sediment is composed of organogenous gravel arising from present-day organisms, with an admixture of sand and silt.

In Japanese coast, as pointed out by Imajima (1964) this species was, for a long time, in confusion with Molluscan scaphopods (Tokunaga, 1906; Yokoyama, 1920; Miyadi and Habe, 1947) and inhabits the muddy bottom in certain Japanese bays, but further informations on the ecology are not yet available. Imajima (1979, 1978) remarked that they were found in 19-85 m in depth.

In Korean waters, they have been dredged, for the moment, in the Gamagyang Bay, southern coast of Korea (Fig. 1). The bottom sediment was consitituted by a clayey silt in the shallow subtidal mud flats. The similar faunistic survey using grab-sampling in a certain parallel communities of the western and eastern coasts could not add new localities,

It is also interesting to note that the specimens found in Korean waters were all alive and there is a discrepancy in the biotope between Mediterranean and Korean populations.

The aspect of an epibiosis of two small hydrozoans was found on the opercular calcareous plate by Zibrowius' observation from the specimens of the archipelago of Madeira (Zibrowius, 1968b), where a bryozoan (*Bugula ditrupae* Busk, 1858) and a foraminiferan (*Cibicides refulgens* Montfort) were very regularly associated to alive *Ditrupa*'s opercula.

SUMMARY

Two unrecorded polychaetous serpulids found in Korean waters, *Protula tubularia* (Montagu, 1803) and *Ditrupa arietina* (O.F. Müller, 1776), were described. Taxonomical criteria and morphological characteristics of these cosmopolitan species were also discussed. In addition, some ecological aspects were noted together with distributional ranges in the world ocean.

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