Vol. 65, pp. 63-70 April 25, 1952

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

TWO NEW SPECIES OF *ARTHROGORGIA* (GORONACEA: PRIMNOIDAE) FROM THE ALEUTIAN ISLANDS REGION

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Among the octocorals obtained by the U. S. Fish Commission steamer "Albatross" during the Northwestern Pacific Cruise of 1906 are two new species of primnoid corals belonging to the subfamily Calyptrophorinae. Because of the primitive characters which they possess, both are of more than usual interest and may serve to shed more light upon relationships within the Primnoidae. The members of this family, especially those native to the waters of Japan, have been studied extensively by the late Kumao Kinoshita, whose phylogenetic considerations concerning primnoids were published in the Dobutsugaku Zasshi (Tokyo) during 1908 and 1909. I am especially indebted to Mr. Hirohiko Otsuka, of Tokyo, who has translated these papers from the original Japanese, thus making their contents available to me for this and other studies in progress.

Genus *Arthrogorgia* Kükenthal

Calyptrophora (part) Kinoshita 1907, p. 234.

Arthrogorgia Kükenthal in: Kükenthal & Gorzawski 1908a, p. 625; Kükenthal & Gorzawski 1908b, p. 28; Kükenthal 1919, p. 476; Kükenthal 1924, p. 319.

Calyptrophora (*Arthrogorgia*) Kinoshita 1908, p. 59; Kinoshita 1909, p. 7.

This genus, originally proposed by Kükenthal for the species *Arthrogorgia membranacea* Kükenthal 1908 [=*Calyptrophora ijimai* Kinoshita 1907], was distinguished from *Calyptrophora* Gray on the basis of its three abaxial and two adaxial pairs of infrabasal scales and its regular pinnate branching. The two new species described below characteristically possess multiple infrabasals, but are not regularly pinnate in branching. However, since the manner of branching in this family is so diverse that it can only be considered secondary to the zooidal spiculation, these new species will fall within the limits of the genus *Arthrogorgia*, a modified diagnosis of which may read as follows:

Primnoids with zooids in whorls; zooid body enclosed by two pairs of large abaxial scales; infrabasals more than two pairs; distal adaxial

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body scales present; marginal scales (between opercular and major body scales) present in some or all longitudinal rows. Operculum high and prominent. Branching pinnate or dichotomous.

Type (by monotypy).—*Arthrogorgia membranacea* Kükenthal = *Calyptrophora ijimai* Kinoshita 1907.

Arthrogorgia kinoshitai sp. nov.

Pl. 2, figs. 1-8; Pl. 3, figs. 1-12.

Description—The colony is large and dichotomously branched in one plane. The dichotomy is not entirely regular, since one branch of a fork often fails to bifurcate when its neighbor does, continuing instead as an unbranched end twig as much as 30 cm. in length. The shorter end twigs are as little as 9 cm. long. The axis is round, longitudinally striated, 4 mm. in diameter at its lowest part. It is brown in color proximally, becoming paler distally, and with a distinct metallic sheen throughout. In the coenenchyma surrounding the axis there is a ring of primary longitudinal stem canals, about 11 in number in the twigs and increasing basally. The canal walls and the tissue surrounding the axis lack spicules. The zooids, which face downward, are arranged in whorls of six (distally) to eight or nine (proximally). In 3 cm. of axis length there are usually seven or eight whorls very closely placed (Pl. 2, fig. 1).

The zooids (Pl. 2, figs. 2, 3) show a certain degree of variation in size, fully formed individuals ranging in height (contracted) from 3.0 to 3.5 mm., measured parallel to the axis. The zooidal spiculation consists of two pairs of large, abaxial body scales, 3+ pairs of infrabasals, 4-6 pairs of distal adaxial body scales, 1 pair of inner lateral marginals (and rarely vestiges in some or all of the outer four rows), and the usual 8 operculars. The tentacles are densely packed with small, flat rods transversely disposed in the proximal half but becoming more or less longitudinal distally, and not extending into the pinnules.

The basal and buccal body scale pairs are always open adaxially and are not fused along the abaxial suture. The basal sclerite unit (Pl. 3, fig. 10) bears a pair of pointed, marginal processes (one spine on each scale) which may occasionally be more or less reduced. The oral margin of the buccal unit is broadly expanded as a pair of rounded or somewhat pointed lobes (Pl. 3, fig. 9); rarely, the lobes are subdivided to give the buccal margin a distinctly 4-dentate outline (Pl. 2, fig. 1). The scales of both body pairs overlap where they meet abaxially, and their sutural margins, especially the concealed one, are deeply laciniated. Both basal and buccal scales are sculptured externally with low, simple, rounded granules (Pl. 2, fig. 8), particularly on the abaxial tracts; internally, the sculpture consists of rather regular, small but complicated warts (Pl. 2, fig. 7). The free margins of the buccals have a distinct border virtually free of sculpture.

Normally there are three pairs of abaxial, and several adaxial, infrabasal scales between the basal body scale pair and the rind scales, and although the actual number of scales is often greater (perhaps due to breakage), two or three transverse rows are usually distinct. When intact, the abaxial infrabasals are transversely oval scales curved to fit the zooid base.

The eight opercular scales are situated between the eight tentacle

bases and together form a tall, protruding operculum. They overlap in the abaxial to adaxial direction on both sides of the zooid, beginning with the major abaxial opercular, which overlaps both of its neighbors, and ending with the minor adaxial, which itself is more or less overlapped by both of its neighbors. The major abaxial and minor adaxial operculars are almost symmetrical: The abaxial is a tall pentagon (Pl. 3, fig. 1), the adaxial a narrow triangle (Pl. 3, fig. 4). The intermediate operculars (Pl. 3, figs. 2, 3) are slanted toward the adaxial side of the zooid. The inner keel and corresponding outer trough are very well developed, especially on the larger scales (Pl. 2, fig. 6). A major abaxial opercular may measure about 1.3 mm. in height, a minor adaxial about 0.75 mm.

Below the opercular scales of the adaxial rows lie four to six pairs of adaxial body sclerites. They are transversely oval or rounded scales decreasing in size toward the zooid base. Except for the marginal and submarginal pairs, these may be distributed in irregular order. Below these scales there is a naked area followed by a region filled with small scales extended from the infrabasals and from the rind.

There is a large, transversely oval, inner lateral marginal scale below the opercular of both inner lateral rows (Pl. 3, fig. 5); rarely there are rudimentary marginal scales in the outer lateral and abaxial rows also.

The rind scales, in a densely packed cortical layer, overlap one another by their edges. The scales of the twig rind are rounded or irregular scales 0.5-0.9 mm in diameter, sculptured with radiating ridges of fused warts (P. 3, fig. 11). Toward the base the predominant sclerites are radiately sculptured granules of much smaller size (0.05-0.2 mm.) (Pl. 3, fig. 12).

Holotype.—U. S. N. M. No. 49978. Southeast of Agattu Island, Aleutian Islands: 52° 14′ 30″ North, 174° 13′ East, 482 fathoms, fine grey sand and pebbles; bottom temperature 38.6° F. (''Albatross'' Station D 4781.)

Remarks.—In exposed parts of the colony, the zooid scales are usually much broken and the marginal ornamentation of the large body scales is suppressed. The scale fragments remain in place and obviously continue growing to form apparently perfect scales. Zooids in this condition bear a strong but abnormal resemblance to those of *Primnoa.*

It is entirely fitting that this species should bear the name of Mr. K. Kinoshita, Japanese zoophytologist who devoted much of his research on the Gorgonacea to the family Primnoidae.

Arthrogorgia otsukai sp. nov.

Pl. 2, figs. 9-12; Pl. 3, figs. 13-27.

Description.—The colony is moderately large and dichotomously branched in one plane. The dichotomy is typically irregular, some branches forming long end twigs as in the preceding species. The short end twigs are commonly about 4 cm. long, and the long ones as much as 15 cm. The axis is longitudinally striated, round, 1.5 mm. in diameter at the lowest part preserved, dark brown with slight metallic luster in the older parts and light brown with golden iridescence in the younger. The coenenchyma surrounding the axis is pierced by several large longitudinal canals, the exact number of which is indeterminable. The zooids,

which face downward, usually occur in whorls of six (Pl. 2, fig. 11). In 3 cm. of axial length there are 11-13 rather openly spaced whorls.

The zooids (Pl. 2, fig. 12) range in height from 2.5 to 2.75 mm., measured parallel with the branch axis. The zooidal spiculation consists of 2 pairs of large body scales, 2+ pairs of infrabasals, 4-6 pairs of distal adaxial body scales, and marginal scales at least in the inner lateral and adaxial rows and often in all. The tentacles contain numerous small, flat rods which apparently do not project into the pinnules.

Both basal and buccal body scale pairs are open adaxially and are not fused together abaxially. The opposing edges along the abaxial suture are thick and bear denticles which hold the scales together much more securely than is the case in *A. kinoshitai*. The basal pair (Pl. 3, fig. 21) carries two short, rounded, distal lobes which are scarcely noticeable in the intact zooids. The oral margin of the buccal unit projects little if at all, and is not armed with spines or processes (Pl. 3, fig. 19). The inner surfaces of the body spicules are sculptured with minute, closely set, complicated warts, whereas the outer surfaces have larger, more sparsely distributed simple granules.

There are ordinarily two, rarely three, pairs of large, curved, abaxial

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EXPLANATIONS OF FIGURES

Plate 2

Figs. 1-8: *Arthrogorgia kinoshitai* sp. nov.

1, Two zooid whorls; 2, 3, Two zooids from side; 4, View of zooid showing operculum; 5, Distal part of zooid from adaxial side; 6, Side view of outer lateral opercular scale; 7, Interior sculpture of body scale; 8, Exterior sculpture of body scale, oblique view.

Figs. 9-12: *Arthrogorgia otsukai* sp. nov.

9, Side view of abaxial opercular scale; 10, Distal part of zooid from adaxial side; 11, Two zooid whorls; 12, Zooid from the side.

Magnifications. Figs. 1-4,11,12: 9.5x; 5: 12x; 6,9: 28x; 7,8: 155x; 10: 18x.

Plate 3

Figs. 1-12: *Arthrogorgia kinoshitai* sp. nov.

1, Abaxial; 2, Outer-lateral; 3, Inner-lateral; 4, Adaxial opercular scales; 5, Inner lateral; 6, Adaxial marginal scales; 7, Abaxial; 8, Adaxial opercular scales from another zooid; 9, Buccal; 10, Basal body scale pairs; 11, Scale of twig rind; 12, Sclerites of trunk rind.

Fig. 13-27: *Arthrogorgia otsukai* sp. nov.

13, Abaxial; 14, Outer-lateral; 15, Inner-lateral; 16, Adaxial operculars; 17, Outer-lateral; 18, Adaxial marginal scales; 19, Buccal; 20, Basal body scale pairs; 21, Basal pair from front; 22, Adaxial body scales, from outside; 23, Adaxial body scales, from inside, showing accessory operculars; 24, Side view of operculum and marginal scales—AD=adaxial; IL=inner-lateral; OL=outer-lateral; AB=abaxial; O=opercular scale; M=marginal scale; SM=submarginal scale; 25, Sclerites of trunk rind; 26, Scale of twig rind; 27, Spicules of very young zooid. Top to bottom: Four of the "inner" operculars; all 8 operculars; buccal pair; basal pair; two of the infrabasal scales.

Magnifications:

Scale A: Figures 1-10; 13-21; 24. Scale B: Figures 22, 23, 27. Scale C: Figures 11, 12; 25, 26.

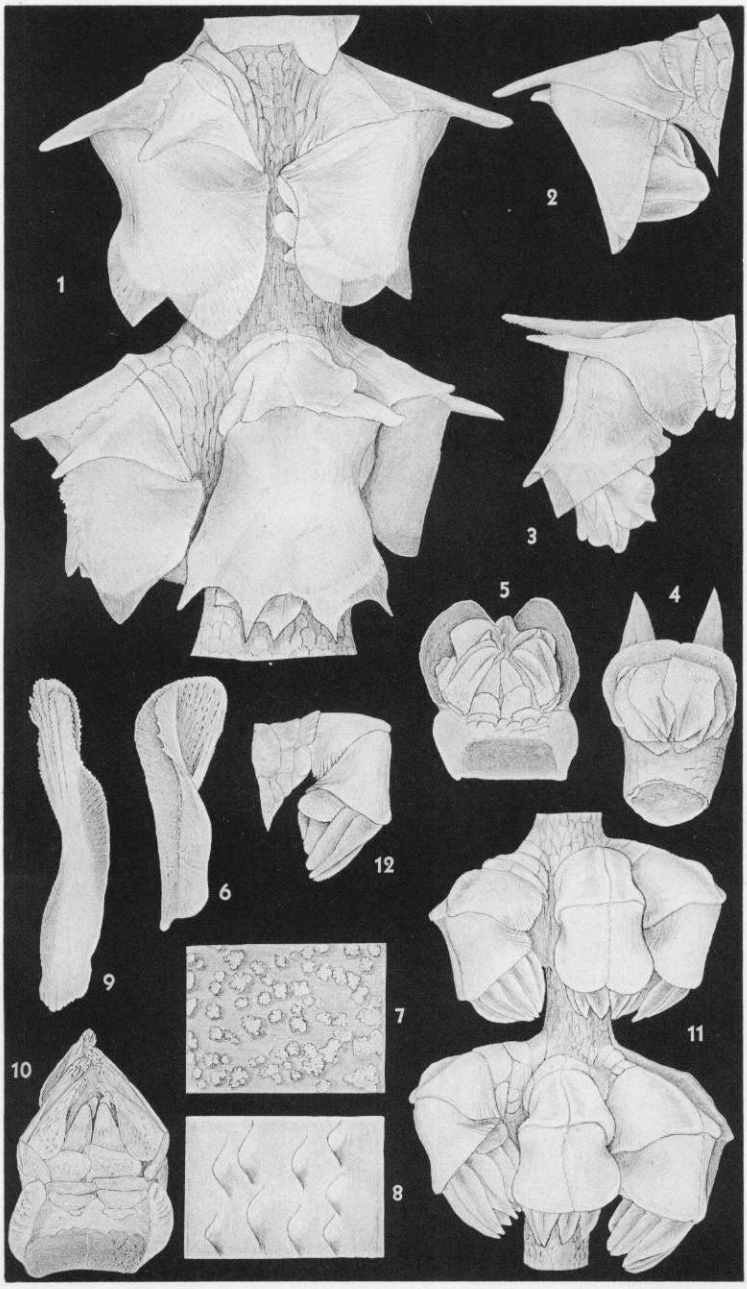
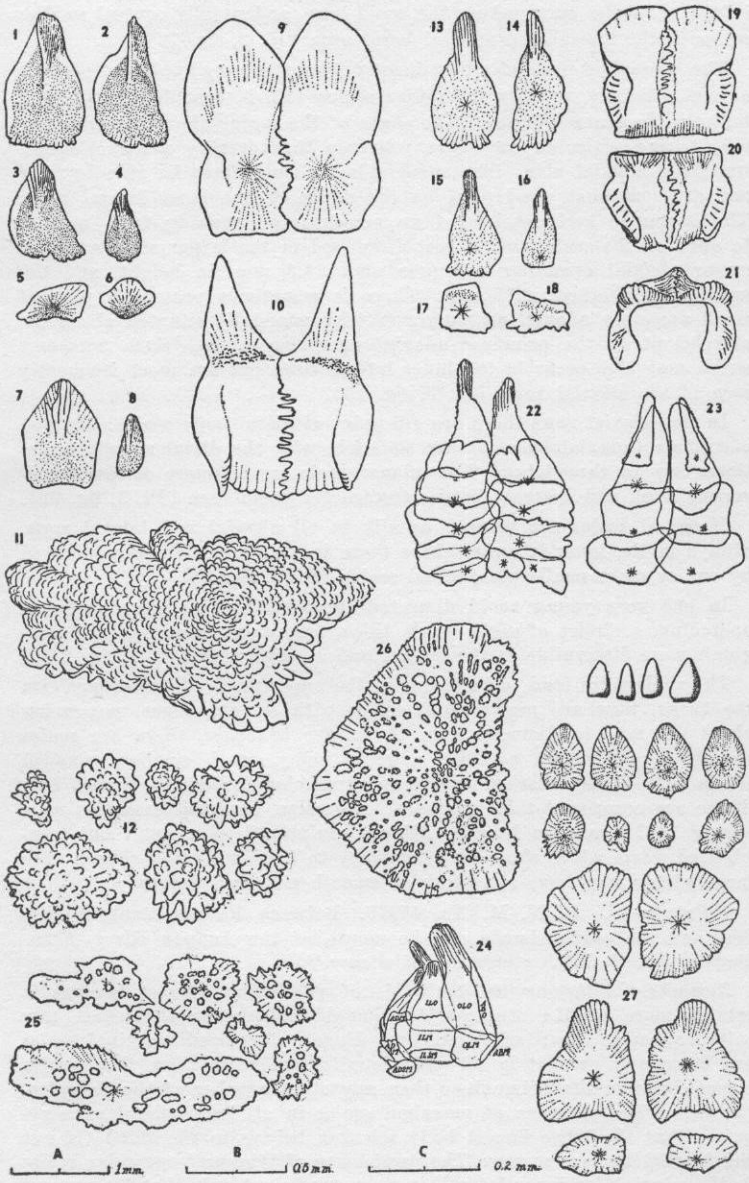


PLATE II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23
24
25
26
27
A
1 mm.
B
0.5 mm.
C
0.2 mm.

infrabasal scales surrounding the zooid base, and usually several smaller scales in the lateral and adaxial basal area (Pl. 2, fig. 12).

The operculum protrudes prominently from the buccal pair and consists of eight narrow, roughly triangular scales (Pl. 3, figs. 13-16) situated between the tentacle bases. The edges of the major abaxial overlap the neighboring scales on each side, which in turn overlap one another toward the adaxial side. The small, adaxial operculars lie side by side and are somewhat overlapped by the scales of the inner lateral rows. The opercular keel consists of an aculeate rod running from nucleus to apex of the scale, and is best developed in the larger sclerites. The major abaxial opercular measures about 1.3 mm. in height, and the small adaxial about 0.75 mm. There is sometimes present a pair of small accessory adaxial operculars (0.4-0.5 mm. tall) situated above the attachment of the principal adaxial opercular scales. Such accessory scales may also occur in the inner lateral rows but are most frequently seen in the adaxial rows (Pl. 3, fig. 23).

In the adaxial rows there are 4-6 pairs of distal body scales: the two marginals (adaxial buccals) are squarish, with the distal margin sometimes two- or three-lobed. The submarginals are all more or less transversely oval, and decrease in size toward the zooid base (Pl. 3, fig. 22).

Marginal scales are present usually in all abaxial and lateral rows, always in the inner laterals, where there is a large scale often followed by one or more small submarginal scales (Pl. 3, fig. 24).

In one very young zooid dissected there was within the functional operculum a circlet of eight small, thick, triangular sclerites. No marginals were discernible in the lateral and abaxial rows (Pl. 3, fig. 27).

The rind scales tend to be larger in the upper parts of the colony. On the twigs, they are mostly thin scales with serrate edges, measuring about 0.5 mm. in diameter. On the larger branches, there are scales equally large, but in addition a great many, much smaller, rounded scales with deeply toothed edges, and irregular forms (Pl. 3, fig. 25). There are occasional thick plates of large size, observed examples measuring 1.0-1.3 mm. in length. All are sculptured with small but complicated warts which show little tendency to form radiating ridges. The large plates may have a number of smooth marginal spines.

Holotype.—U. S. N. M. No. 49979. Between Bowers Bank, Bering Sea, and the codfish banks off the mouth of the Aangan River, Kamchatka. (U. S. F. C. steamer "Albatross.")

Remarks.—*Arthrogorgia otsukai* is of particular interest because it retains more of the "normal" primnoid spiculation than does any calyptrophorine described heretofore. Since well-formed marginal scales are frequently present in all eight longitudinal scale rows, this species comes closer to the Primnoinae than any other member of the Calyptrophorinae. The presence of marginal scales in all longitudinal rows requires that the large buccal body sclerites belong to the third (if not the fourth) transverse row. The persistence of "inner" opercular scales in the adaxial (or inner lateral) rows suggests not only that the present opercular scales are actually circumoperculars, but also that the process of elimination of the distalmost transverse scale row may have commenced on the abaxial side. The assumption of opercular function by the marginal (circumopercular) scales is taking place elsewhere in the

family, namely in both *Thouarella* and *Primoella,* where the opercular scales are reduced in size on the adaxial side.

Arthrogorgia kinoshitai represents a condition intermediate between *A. ijimai* (marginals never in any but the adaxial rows) and *A. otsukai* (marginals always present in the adaxial and inner lateral, often also in outer lateral and abaxial rows). These connect the Primnoinae with the highly modified Calyptrophoras and may justify the older grouping of the calyptrophorine genera with the Primnoinae.

It is a pleasure to name this species in honor of Mr. Hirohiko Otsuka, whose careful translations of Kinoshita's articles in the Japanese language have put otherwise unavailable information at my disposal in the preparation of this paper.

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