

THE CRINOID GENUS EUDIOCRINUS, WITH DESCRIPTION OF A NEW SPECIES.

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In 1868, Prof. C. Semper described a new genus of free crinoids, *Ophiocrinus*, which differed from all other comatulids in possessing five undivided arms. At the same time he described the type-species, *O. indivisus*. In 1882 Dr. P. H. Carpenter renamed the genus *Eudiocrinus* (*Ophiocrinus* being preoccupied) and described three additional species, *E. varians*, *E. semperi*, and *E. japonicus*, which were described in greater detail and figured in 1888. In 1883 Professor Perrier described *E. atlanticus*, and in 1894 Professor Bell *E. granulatus*; an additional species, *E. tuberculatus*, was described by the present author during the past year.

Among a large number of comatulids just received by the United States National Museum from Japan, as a deposit collection from Mr. Frank Springer, was a very singular specimen with but five arms, entirely different from the species of "*Eudiocrinus*" (*sensu* P. H. Carpenter), *atlanticus*, *varians*, *tuberculatus*, and *japonicus*, with which I was personally acquainted. It was obviously closely allied to the Japanese species of *Zygometra*, *Z. hartlaubii*, *Z. rubroflava*, and *Z. kohleri*, the chief difference being the possession of only five arms. Evidently, then, it could not be congeneric with the species of "*Eudiocrinus*," which I had previously studied. This led to a review of the whole matter.

The type-species of *Eudiocrinus* (*E. indivisus*) is described as follows:

Sechzehn Ranken stehen in einfacher Reihe um den flachen kleinen Knopf. Rankenglieder 18-20, sehr knotig, namentlich am Ursprung, die Verdickung entspricht den Gelenken; die zwei ersten Glieder niedrig, so hoch als breit, das 3te bis 6te die längsten, doppelt so lang als breit. Die letzten Glieder schwach comprimirt, glatt, das letzte hat ausser dem Endhaken einen starken Zahn.

Das erst Glied der direkt von Kelchknopfe entspringenden Arme trägt gleich eine Pinnula und hat ein Syzygium; das zweite ist ohne Pinnula; das dritte trägt eine solche und das vierte hat eine Pinnula und zugleich ein Syzygium. Nun

folgen sich die Pinnulae regelmässig abwechselnd, und je ein Syzygium zwischen 3-5 Gliedern. Die Glieder der Arme sind fast doppelt so lang als hoch und keilen sich namentlich in der Mitte stark an den Seiten aus.

Die zwei ersten Pinnulae sind klein, die dritte und vierte die längsten, dann folgen kürzere, die allmählich gegen das Ende der Arme zu länger und zugleich dünner werden, während die ersten mit ziemlich breiter Basis entspringen. Länge der Arme 80 mm., der Ranken 9 mm., der längsten Pinnula 8 mm. Durchmesser des Rankenknopfes 2 mm.

Die Schiebe fehlt leider an dem einzigen Exemplar. Die Pinnulae sind hell und dunkel gelbbraun gesprenkelt; der Rücken der Arme ist durch zwei geschlingelte Linie bezeichnet.

It was at once evident that my specimen, though differing in details, resembled *E. indivisus*; also that Bell's *E. granulatus* resembled both. It was also clear that the relation between these three and the other "*Eudiocrinus*" species was very remote. The differences may be summed up as follows:

Eudiocrinus indivisus, *E. granulatus*, *E.*, new species.

Eudiocrinus atlanticus, *E. japonicus*, *E. varians*, *E. semperi*, *E. tuberculatus*.

Radial facets low, the muscular fosse very narrow and crescentic.

Centro-dorsal flat, with marginal cirrus sockets.

Cirrus joints shorter proximally than distally, expanding and slightly overlapping distally, very slightly flattened.

A stout opposing spine present.

Terminal claw stout, and strongly curved.

First two joints beyond the radials united by syzygy.

The third joint beyond the radial never bears a pinnule.

Arm joints strongly overlapping.

Disk small, not extending up on the arms.

Lower pinnules with rather short joints, and very stout.

Color variegated.

Radial facets high, the muscular fosse very large.

Centro-dorsal hemispherical, nearly covered with cirrus sockets.

Cirrus joints subequal, smooth, elongate, approximately oblong in lateral view, and flattened.

No opposing spine.

Terminal claw slender and nearly straight, at least proximally.

First two joints beyond the radials never united by syzygy.

The third joint beyond the radial may bear a pinnule.

Arm joints smooth.

Disk very large, extending far up on the arms.

Lower pinnules slender and elongated with elongated joints distally.

Color plain grayish.

In all the characters in the above list, the *Eudiocrinus indivisus* group agrees with the Japanese species of *Zygometra*, and the sum of those characters is found in *no other genus of comatulids*. We can, consequently, find no escape from the conclusion that the two are in reality closely related, the only real difference being that the *E. indivisus* group has but five arms and *Zygometra* ten or more.

The *Eudiocrinus indivisus* group is peculiar in lacking the pinnule on the third joint ^a above the radial, while a pinnule is present on the joints on either side of it; the explanation, however, is simple; the first two joints beyond the radials represent the two costals of a ten-armed or multibrachiate comatulid; they are somewhat broader than the following, and are united by syzygy as in *Zygometra*; the third joint, therefore, represents the *first-free brachial* of a ten-armed form, and, as the first free brachial never bears a pinnule, we find it absent here also; the fourth joint (representing the second free brachial) bears a pinnule, and the fifth and sixth (i. e., third and fourth free brachials) are united by syzygy, as usual in all comatulids. Thus the species of the *Eudiocrinus indivisus* group are apparently derived by a reversion from a ten-armed type; and in this connection it is interesting to call to mind the specimen upon which Carpenter's "*Antedon clemens*" was based, which had one undivided ray, with a pinnule on the "second brachial," but none on the "third," exactly as in the *E. indivisus* group. No one can doubt that the single undivided arm in *A. clemens* is a derivation from a normally divided arm, and, as the arms in the *E. indivisus* type are similar in structure, it is reasonable to suppose that they, too, are derived from more complex arms.

Moreover, taking the type of articulation into consideration, the second and third (postradial) joints are joined in the same way as the first is joined to the radial; that is, by articulating faces made up of (dorsally) a large fossa lodging the dorsal ligament, ventral to which, on each side of the axial canal, lies a pair of fossæ lodging the interarticular ligaments, and beyond them the muscular fossæ; the third and fourth (postradial) joints are joined by an articulation consisting only of a pair of large pits lodging the interarticular ligament, separated by a ridge at right angles to the long (transverse) axis of the joint face, this constituting what has been called a synarthrial joint; the fourth and fifth joints are joined by a type of articulation first found between the second and third free brachials of most comatulids, namely, a modified form of that between the radials and next following joints, in which the transverse ridge separating the dorsal-ligament fossa from the fossæ of the interarticular ligaments is strongly diagonal, so that one end is dorso-lateral in position and the opposite end ventro-lateral; the interartic-

^a In Bell's figure of the arm base of *Eudiocrinus granulatus* (Proc. Zool. Soc. London, 1894, Plate XXIII, fig. 3) the first pinnule is omitted; he describes the species as having "the first pinnule on the left side of the second brachial;" but according to his figure it must have been on the right side, as the second pinnule (the lowest shown) is on the left. Attention should be called to the fact that there is a serious discrepancy between the size of *E. granulatus* as described and as figured.

ular and muscular fossae are similarly, to a greater or less extent, misplaced. The remaining brachial articulations are all of this type, except, of course, in the case of syzygia. This offers another means of arriving at the homologies of the joints; granting that the articulation between the fourth and fifth joints corresponds to that always found (in a ten-armed type) between the second and third free brachials, and counting backward, we find that the preceding joint is the equivalent of the first free brachial, the one before that of the costal axillary, which in this case is united to the first costal by syzygy, therefore reaching exactly the same result as we did through a consideration of the pinnule arrangement, and the arrangement of the first two syzygia.



FIG. 1.—CENTRO-DORSAL AND RADIAL FACES OF PENTAMETROCRINUS JAPONICUS.

The *Eudioocrinus japonicus* group, however, differs from the *E. indivisus* group in the enormous disk, which is black, and extends far up on the arms, and in the great amount of separation of adjacent radial facets (figs. 1, 2) from all other comatulids, except *Decametrocrinus*. The long, brittle, and slender, much compressed cirri, with a long, nearly straight, terminal claw, are very characteristic, though an approach to these conditions is found in *Thysanometra*. Judging from the character of the radial facets and the extensive central cavity of the centro-dorsal, the *E. japonicus* group and *Decametrocrinus* come nearest to certain genera of the Antedonidæ, such as *Thaumatometra*, *Psathyometra* (fig. 3), etc., and it is found that the general character of the pinnules, arms, and cirri also suggest the same relationship.



FIG. 2.—VENTRAL VIEW OF RADIAL FACES OF PENTAMETROCRINUS JAPONICUS.

The proximal arm structure of the *Eudioocrinus japonicus* group and of *Decametrocrinus* is, however, radically different from that of all other comatulids, except *Thaumatocrinus*, with which genus it agrees.



FIG. 3.—CENTRO-DORSAL AND RADIAL FACES OF PSATHYROMETRA FRAGILIS.

In the ordinary type of comatulid with ten arms (fig. 4) there are two costals, united by synarthrial articulation, the median ridge on the joint faces appearing externally in the middle of the line of articulation, its position being usually marked by more or less of a dorsal tubercle. On each of the distal faces of the axillary (second) costal is a first brachial, the articulation between the two being the same as that between the radial and first costal: this joint never bears a pinnule; articulating with the first brachial on its distal face is the second brachial, the articulation between the two being synarthrial, as between the two costals: but the articulation between the second and third (and all succeeding brachials, except syzygial pairs) is of the same type as that between the radials and first costals

and costal axillaries and first brachials, *except* that the transverse ridge separating the dorsal-ligament fossa from the interarticular ligament fossa is strongly diagonal, and the other elements making up the sculpture of the joint face are correspondingly misplaced. The diagonal position of the transverse ridges always alternates on succeeding joints, the external position of these ridges being marked by a series of more or less prominent alternating tubercles along the arm, the first of these tubercles being always exterior, in reference to the last axillary.

It will now be seen that, judging from the types of articulations, the two costals are *merely repetitions of the first two brachials, interpolated between them and the radials*; in the cases where the arms divide more than once, the distichals, palmars, postpalmars, etc., are really additional repetitions of the first two brachials, for we always find the first two brachials of a free arm the same, no matter how many division series may intervene between them and the radials; in the cases where the division series are 4 ($3 + 4$), there is merely a double instead of a single repetition of the first two brachials, for the first two joints are here united by synarthry into one pair, the last two united by syzygy into another pair; but the two pairs are united by an articulation resembling that found between the radials and first costals, and between all axillaries and the succeeding joints.



FIG. 5.—DORSAL VIEW OF RADIALS AND LOWER BRACHIALS OF PENTAMETROCRINUS TUBERCULATUS.



FIG. 4.—DORSAL VIEW OF THE RADIALS, COSTALS, AND LOWER BRACHIALS OF THAUMATOMETRA TENUIS, TO SHOW STRUCTURE OF AN ORDINARY COMATULID ARM.

Additional evidence that this is really the case is found in the cases where, as in *Perometra diomedea*, there is an extravagantly elongated tubercle on the articulation between the first two brachials; this is repeated between the costals; or, as in *Tropiometra*, where the first two brachials are greatly enlarged; the costals are very large also; or in various species of *Charitometra* and *Thalassometra*, where the first two brachials are highly ornamented; the costals and division series are always similarly ornamented.

In *Decametrocrinus* and in the *Eudiocrinus japonicus* group (fig. 5) we find the articulation between the first two post-radial joints to be exactly like that between the first two brachials, or the costals, in any ten-armed comatulid, i. e., a synarthry; but the articulation between the second and third and all succeeding joints corresponds to the articulations between the second and third and all succeeding brachials in the *free arms* of ordinary comatulids. Thus, then, the arms of these forms are strictly homologous to the arms of other comatulids *beyond the last axillary*; it is as if the arm of a *Heliometra*

eschrichtii or an *Antedon bifida* were cut off at the costal axillary, the costals removed, and the arm (the first brachial) grafted onto the radial. This arm arrangement occurs *only* in *Thaumatrocrinus*, *Decametrocrinus*, and in "*Eudiocrinus*" *atlanticus*, *japonicus*, *semperi*, *tuberculatus*, and *varians*.



FIG. 6.—CENTRO-DORSAL AND RADIAL FACES OF ZYGOMETRA HARTLAUBI.

Additional proof of the correctness of this interpretation of the arm structure of *Decametrocrinus* and the species of "*Eudiocrinus*" mentioned is found in the arrangement of the pinnules: for when a species like *Decametrocrinus naresi* or "*Eudiocrinus*" *varians* bears a pinnule on the second post-radial joint there is always one on the following joint and on all succeeding, excepting, of course, the hypozygals of syzygial pairs.

Since these five species of "*Eudiocrinus*" are really in no way related to the type-species (*E. indivisus*), but belong to an entirely different family, they require a new generic name, and for them I have proposed the name of *Pentametrocrinus* as suggesting their five-armed condition, and also their affinity to the closely related *Decametrocrinus*, with ten arms.

This involves a redefinition of two families and two genera, as follows:

Family ZYGOMETRID.E.

A family of Comatulida in which the radial faces are broad and low, in lateral apposition (figs. 6, 7), the muscular fossæ small, narrow, and crescentic, curving upward and outward from the ridge surrounding the central canal to the antero-exterior corner of the radial faces, and entirely separated from each other by a deep median cleft: the costals are united by syzygy, but the first two brachials by bifascial articulation: disk plated, but pinnule ambulacra naked; five to ninety arms.

Color variegated and usually brilliant, consisting of red, yellow, purple, brown, and white.

Habitat.—Northern Australia northward to Japan; littoral, and down to 60 fathoms.

Included genera.—*Zygometra*; *Eudiocrinus*.

Genus EUDIOCRINUS (emended.)

A genus of Zygometridæ in which the arms are five in number, the second costal not being an axillary (fig. 8); cirri short and stout, the joints swollen distally, the opposing spine stout and well developed; arm and pinnule joints overlapping.

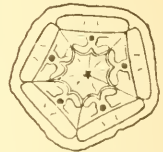


FIG. 7.—VENTRAL VIEW OF RADIAL FACES OF ZYGOMETRA HARTLAUBI.

Genotype.—*Ophiocrinus indivisus* Semper, 1868.

Habitat.—Philippines; Macclesfield Bank; Japan; 30 to 60 fathoms.

The species included in the genus *Eudiocrinus* as here emended are:

Eudiocrinus indivisus (Semper).

Eudiocrinus granulatus Bell.

Eudiocrinus variegatus, new species.

Family PENTAMETROCRINIDÆ.

A family of Comatulida in which the radial faces are very high, entirely and rather widely separated, the muscular fossæ very large, rounded-triangular, separated interiorly by a strong median ridge; the first brachials articulate directly with the radials, without the intervention of costals; orals absent: disk very large, black, extending far up on the arms, naked or more or less covered with small calcareous plates; cirri with elongate subequal compressed joints; no opposing spine; terminal claw long.

Color grayish, tinged with purplish; disk black.

Habitat.—Crozet Islands and seas south of Australia northward to the West Indies, Gulf of Gascony, Indian Ocean, Japan, and the Hawaiian Islands: 103 to 1,800 fathoms; mainly abyssal.

Included genera.—*Pentametrocrinus*; *Decametrocrinus*.

This is identical with the family for which I previously proposed the name Eudiocrinidæ, owing to a misconception of the genus *Eudiocrinus*.

Genus PENTAMETROCRINUS.

A genus of Pentametrocrinidæ in which the arms are five in number.

Genotype.—*Eudiocrinus japonicus* P. H. Carpenter, 1882.

Habitat.—West Indies; coasts of southern Europe; east coast of Africa eastward to Australia, and northward to Japan; 103 to 1,050 fathoms (mainly abyssal).

The species included in the genus *Pentametrocrinus* are:

Pentametrocrinus atlanticus (Perrier).

Pentametrocrinus japonicus (P. H. Carpenter).

Pentametrocrinus semperi (P. H. Carpenter).

Pentametrocrinus tuberculatus (A. H. Clark).

Pentametrocrinus varians (P. H. Carpenter).

The new species of *Eudiocrinus* (emended) from Japan may be known as



FIG. 8.—DORSAL VIEW OF THE PROXIMAL ARM JOINTS (COSTALS AND LOWER BRACHIALS) OF *EUDIOCRINUS VARIEGATUS*, NEW SPECIES. (THE RADIALS ARE CONCEALED BY THE CENTRO-DORSAL.)

EUDIOCRINUS VARIEGATUS, new species.

Centro-dorsal discoidal, rather thick, with somewhat sloping sides, the broad polar area flat, the cirrus sockets arranged in two crowded, more or less irregular, rows.

Cirri about twenty-five in number, 7 mm. long, with fifteen joints, the first not so long as broad, the remainder squarish (fig. 9); the fourth and fifth joints have their distal ends expanded and projecting somewhat dorsally, this character gradually becoming less and less marked distally: there are no dorsal spines, but the opposing spine is prominent, arising from the entire surface of the joint, the apex opposite the middle of the joint: terminal claw rather stout and well curved, about as long as the penultimate joint.

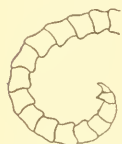


FIG. 9.—CIRRUS OF EUDIOCRINUS VARIEGATUS.

Radials even with the centro-dorsal: first costal short, about four times as broad as long, united to the second by syzygy; there is a well-marked rounded median tubercle; second costal slightly longer than the first, but similar to it, and not an axillary: it bears a pinnule. Five arms 75 mm. long, of overlapping joints: the first two brachials, like the two costals, have their lateral edges slightly turned outward, forming a slight narrow lateral border: first and second brachials slightly over twice as broad as long, the distal edges rather prominent, with a rounded median tubercle: third and fourth brachials (syzygial pair) not quite so long as broad, slightly longer on one side than on the other, with a low rounded median keel: following two brachials wedge-shaped, not so long as broad, then becoming triangular, about as long as broad, soon becoming obliquely wedge-shaped, and longer than broad and distally less obliquely wedge-shaped and elongate; the brachials up to the sixth or seventh have a low rounded median keel, marked by a series of longitudinally elongate tubercles, one on each joint: from this point onward the keel becomes less marked (only faintly visible) and assumes a peculiar zigzag form, owing to its oblique position on each joint; it is traceable to at least the distal third of the arm; the distal ends of the joints in the lower part of the arm project somewhat, but this dies away after about the middle.

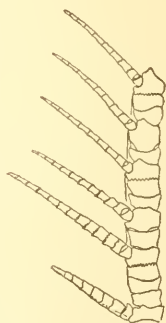


FIG. 10.—LOWER PINNULES OF EUDIOCRINUS VARIEGATUS ON THE INNER SIDE OF THE ARM; I. E., THE SIDE ON WHICH THE COSTAL PINNULE (REPRESENTING THE MISSING ARM) OCCURS.

Costal pinnule 4 mm. long, stout, triangular, with nine squarish joints; pinnule on second brachial similar (the first brachial has no

pinnule); pinnule on fourth (epizygal) brachial 6 mm. long, much stouter than the costal pinnule, with twelve joints, the first three approximately squarish, the remainder longer than broad, but not elongated; the pinnule is rounded, and all the joints overlap strongly, and have serrate distal ends (figs. 10, 11); following pinnules about 4.5 mm. long, but much more slender than the pinnules on the fourth (epizygal) and fifth brachials, with about twelve joints, the first very short, the next two squarish, the remainder elongate, the articulations somewhat swollen; the lower joints have overlapping and spinous distal edges; the distal pinnules are 9 mm. long, slender, the first joint short, the second squarish, the remainder much elongated, with expanded articulations.

Color (in formalin) purplish brown, the skeleton lighter, the cirri white, the enlarged lower pinnules (on the fourth and fifth brachials) purple, the arms and pinnules banded with purple and whitish.

Type.—Cat. No. 25326, U.S.N.M. (Owston Coll. No. 6931), from 34° 59' north latitude, 139° 34' east longitude (Sagami Bay, Japan); 60 fathoms.

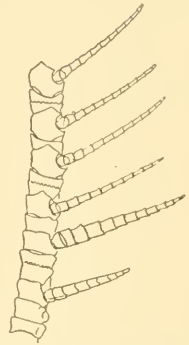


FIG. 11.—LOWER PINNULES OF *EUDIOCRINUS VARIEGATUS* ON THE OUTER SIDE OF THE ARM; I. E., THE SIDE OPPOSITE TO THE COSTAL PINNULE.