STUDIES ON THE FAUNA OF CURAÇAO AND OTHER CARIBBEAN ISLANDS: No. 18.

# ON SPECIMENS OF THE CORAL GENUS TUBASTRAEA, WITH NOTES ON PHENOMENA OF FISSION

by

H. BOSCHMA

(Rijksmuseum van Natuurlijke Historie, Leiden)

Among the material brought together in the West Indies by Dr P. WAGENAAR HUMMELINCK there are some coral colonies of the genus *Tubastraea* that are interesting from various points of view, in the first place because this genus of Madreporaria has but recently become known to occur in the West Indies. VAUGHAN & WELLS (1943, p. 239) note as range of distribution of the genus Panamá, Indo-Pacific, Gulf of Guinea, and the West Indies. As I did not succeed in finding data in the previous literature on the occurrence of *Tubastraea* in the West Indian area, I wrote to Dr J. W. WELLS, Cornell University, Ithaca, New York, who kindly informed me that the statement given above was based on otherwise unpublished recent finds of material from off Puerto Rico, whilst later a specimen was received from Curaçao. Moreover, the genus is mentioned in the Taxonomic Key to Genera of Living Western Atlantic Corals in SMITH (1948, p. 108).

VAUGHAN & WELLS (l. c., pp. 238/239) define the genus *Tubastraea* with the following characters: "Like *Endopsammia*, but producing small subplocoid clumps by extratentacular budding from the edge-zone, polyps remaining organically united and with corallites united by some coenenchyme and feeble costae. Columella feeble, but occasionally well developed." As the authors refer to the genus *Endopsammia*, the characters of the latter genus also may be cited here (l. c., p. 238): "Simple, subcylindrical, nonepithecate, fixed by broad base. Wall thin, costate. Septa thin, arranged according to Pourtalès plan only in early stages, later appearing normal. Columella small and spongy or scarcely developed."

The material of *Tubastraea* assembled by Dr WAGENAAR HUMMELINCK has the following data:

Curaçao, *Spaanse Baai*, N. part of beach, on root of Rhizophora, about 1 m deep (Sta. 1037A), 21.IV.1949 (one colony of $5^1/_2$ by $4^1/_2$ cm); S. side of *Knip Baai*, on limestone, about 1 m deep (Sta. 1017), 8.I.1949 (one colony in spirits, $5^1/_2$ by 4 cm); N.corner of *Plaja Djerimi*, P. VAN DER WERF leg., 1948 (several colonies on a lump of dead coral of 25 cm length and 11 cm greatest breadth; at least 7 colonies originally, but several of these have united; largest colony about 10 by 6 cm).

Aruba, on a *ship's bottom* which was cleaned two years before, about 4 m below the surface of the water, J. G. DE JONG and P. VAN DER WERF leg. in dock at Curaçao, 7.XII.1950 (two colonies, 6 by $4^1/_2$ cm, and $6^1/_2$ by 5 cm).

The material recorded above now forms part of the collections of the Rijksmuseum van Natuurlijke Historie at Leiden.

Dr HUMMELINCK kindly informed me that, moreover, two pieces of *Tubastraea* — called „rood koraal" (red coral) by the islanders — were collected by him on the North coast of Klein Bonaire, 31.VIII.1948, at a depth of about 2 m; they were given to the Curaçao Museum at Willemstad. According to him, this conspicuous species — coloured brightly red or orange-red at day time, and giving preference to shady localities — is rather well known to those who make a hobby of exploring the shallow coastal waters with diving-spectacles and spear.

Attempts to identify the colonies from Curaçao and from Aruba as one of the several described species of the genus *Tubastraea* lead to *T. tenuilamellosa* (M. E. & H.), previously known to occur from the Gulf of California to the Galápagos Islands (DURHAM, 1947). It is highly probable that at least all the other described species of *Tubastraea* are nothing but varieties of *T. aurea* (Quoy & Gaimard). Moreover it is by no means certain that *T. tenuilamellosa* is specifically distinct from *T. aurea*, because the characters on which the distinction is based are subject to variation. Provisionally the corals from Curaçao and Aruba are here indicated with the name *Tubastraea tenuilamellosa* (Milne Edwards & Haime).

In December 1950 I had the opportunity to study the material of the genus in the Muséum National d'Histoire Naturelle at Paris, where Dr G. RANSON kindly placed all the specimens at my disposal. The data of this collection are:

No. 290 h. *Coenopsammia Ehrenbergiana* Edw. H. Mer Rouge (colony of 7 by 4 cm).

No. 390 a. *Coenopsammia Ehrenbergiana* Edw. H. Iles Séchelles, Mr. L. Rousseau, 1841 (colony 6 by 5 cm).

No. 390 b. *Coenopsammia Ehrenbergiana* Edw. H. Iles Séchelles, Mrs. Péron et Lesueur, 1803 (colony 4 by $3^1/_2$ cm).

No. 390 d. *Coenopsammia Ehrenbergiana* Edw. H. Iles Séchelles. Mr. L Rousseau, 1841 (two colonies, 5 by 4 and $3^1/_2$ by 3 cm).

No. 390 e. *Coenopsammia Ehrenbergiana* Edw. H. Mr. Tanaka, 1867 (colony $7^1/_2$ by $5^1/_2$ cm).

No. 390 f. *Coenopsammia Ehrenbergiana* Edw. H. Terrains récents de l'Egypte, 1844 (colony of $7^1/_2$ by $5^1/_2$ cm).

No. 390 g. *Coenopsammia Ehrenbergiana* Edw. H. Iles Séchelles, Mr. L. Rousseau, 1841 (colony of $4^1/_2$ by 4 cm).

No. 390 h. *Coenopsammia Ehrenbergiana* Edw. H. Iles Séchelles, Mr. L. Rousseau, 1841 (colony of $7^1/_2$ by 6 cm).

No. 391 a. *Coenopsammia tenuilamellosa* Edw. H. Panama (colony 4 by 3 cm).

No. 391 b. *Coenopsammia tenuilamellosa* Edw. H. Panama (colony $2^1/_2$ by 2 cm).

No. 393. *Coenopsammia coccinea* Edw. H. Borabora, Mr. Lesson, 1828 (colony 7 by 4 cm).

No. 393 a. *Coenopsammia Urvillei* Edw. H. Nlle. Zélande, Mrs. Quoy et Gaimard, 1829 (colony 8 by $5^1/_2$ cm).

No. 394 a. *Coenopsammia veneris* Val. Mr. du Petit Thouars, 1839 (three colonies, 3 by $2^1/_2$, 3 by 2, and $2^1/_2$ by 2 cm).

No. 395 a. *Coenopsammia Gaimardi* Edw. H. Nlle. Zélande, Mrs. Quoy et Gaimard, 1829 (colony 6 by 5 cm).

No. 395 b. *Coenopsammia Gaimardi* Edw. H. Nlle. Zélande, Mrs. Quoy et Gaimard, 1829 (colony 10 by 10 cm).

Except two specimens (nos. 390 e and 394 a), the corals mentioned above were studied by MILNE EDWARDS & HAIME (1848, 1860); the collection contains the type specimens of at least five of the described species. Some specimens of *Coenopsammia Ehrenbergiana* of this collection are referred to in the following pages under the name *Tubastraea aurea* (Quoy & Gaimard).

For comparison with the corals from Curaçao and Aruba a number of colonies of *Tubastraea aurea* from the material of the Danish Expedition to the Kei Islands, 1922, were examined, especially those colonies that showed calices in which phenomena of fission were to be observed. The data concerning these corals are:

Wainitu, Amboina, colony of 11 by 10 cm, diameter of the calices up to 11 mm.

Amboina, exact locality not noted, colony of $6^1/_2$ by 6 cm, diameter of the calices up to 16 mm.

Vatek, Kei Islands, colonies of 7 by $5^1/_2$, of $8^1/_2$ by $7^1/_2$, and of $9^1/_2$ by $8^1/_2$ cm, diameter of the normal calices up to 10, 10, and 12 mm respectively.

Kei Islands, exact locality not noted, two adjoining colonies on a branch or a root of a tree, together 8 by 5 cm, diameter of the calices up to 12 mm.

VAN DER HORST (1926) mentions this material in his list of localities of *Tubastraea aurea* (under the name *Dendrophyllia aurea*). He remarks (l. c., p. 48): "The two specimens from the Kei-Islands are remarkable because they grow together on a root, in such close proximity, that it is only with difficulty that they can be recognized as two separate specimens. Yet they are quite separate and have not grown together anywhere". The reason for remaining separate in all probability is the flexibility of the rather small branch or root to which the corals are attached. When growing on a more solid substratum small colonies of *Tubastraea* may easily unite to form larger colonies of a compound character, as apparently has happened in the specimens of *T. tenuilamellosa* from Curaçao collected by Mr. P. VAN DER WERF.

VAN DER HORST's Plate 2 fig. 1 (*Dendrophyllia aurea* (Q. et G.). Very large colony with large calicles) is the specimen from Wainitu of Pl. IX fig. 5 in the present paper; his Plate 2 fig. 2 (Id. Large colony with two calicles showing fissiparity) is a specimen from Vatek. When dealing with *Dendrophyllia aurea*, VAN DER HORST (1926, p. 48) writes: "Fissiparity occurs sometimes in this species. One of the specimens of *C. Ehrenbergiana* of Milne-Edwards and Haime has an oblong calicle that is about to divide into two new calicles. I found the same also in two specimens from Vatek." The peculiar calices meant by VAN DER HORST are one of the three of Pl. XII figs. 1–3, and those of Pl. XI fig. 6 and of Pl. XII fig. 4 in the present paper.

In their genus *Coenopsammia*, MILNE EDWARDS & HAIME (1848) placed the species *coccinea* Lesson, *flexuosa* Ellis & Solander, *Ehrenbergiana* M. E. & H., *Gaimardi* M. E. & H., *Urvillii* M. E. & H., *tenuilamellosa* M. E. & H., *viridis* M. E. & H., and (?) *aurea* Quoy & Gaimard; in a later work (MILNE EDWARDS & HAIME, 1860) they added the species *aequiserialis* M. E. & H., and used the name *nigrescens* Dana for their *viridis* of the previous paper. Of these species two belong to the genus *Dendrophyllia* as it is defined at present (VAUGHAN & WELLS, 1943, p. 237), viz., *nigrescens* (= *viridis*) and *aequiserialis*; the status of Ellis & Solander's *flexuosa* is uncertain; of the other species, *Tubastraea coccinea* Lesson, 1834 (= *Lobophyllia aurea* Quoy & Gaimard, 1833) is the type of the genus *Tubastraea* (cf. VAUGHAN & WELLS, 1943, p. 238), whilst the remaining species, all described by MILNE EDWARDS & HAIME, belong to the genus *Tubastraea* too: colonies of each of these are present in the collections of the Paris Museum. With the possible exception of *Tubastraea tenuilamellosa*, all the other described forms (*Ehrenbergiana*, *Gaimardi*, and *Urvillii*) are conspecific with *Tubastraea aurea* (Quoy & Gaimard).

The characters used by MILNE EDWARDS & HAIME for the specific distinction of their species as a rule are based on peculiarities that are subject to strong individual variation, often dependent upon the form of growth; many of these structures are better developed in colonies growing under favourable conditions than in colonies living under more difficult conditions. In their key, MILNE EDWARDS & HAIME (1860, pp. 126 sqq.) regard as specific characters: the columella being rudimentary or well developed, the wall being highly porous or rather solid, the septa being moderately thin or very thin, the calices being distinctly exsert or hardly exsert, the fossa being deep or shallow, the trabeculae of the coenenchyme being rather curly or more or less straight. All these characters are highly variable, definite contrasts may even be found in various parts of one colony.

Among the species arranged by DANA (1848, 1849) in the genus *Dendrophyllia* there are two that belong to *Tubastraea*. One of these, *Dendrophyllia coccinea* Dana (1849, Pl. 27 fig. 4) is conspecific with *Oculina coccinea* Ehrenberg, a species differing from *Tubastraea coccinea* Lesson; VERRILL (1872) gave the name *Dendrophyllia danae* to DANA's *D. coccinea*. The other species, *Dendrophyllia diaphana* Dana (1849, Pl. 27 fig. 3) in all probability is a young colony of *Tubastraea aurea* (Quoy & Gaimard).

KLUNZINGER (1879) regarded *Coenopsammia coccinea* (Lesson) as a synonym of *C. Ehrenbergiana* M. E. & H., because these two form subplocoid colonies in which the corallites are of varying height, whilst in the two forms the columella is of varying size. His description and figure indicate that the specimens examined by KLUNZINGER belong to *Tubastraea aurea* (Quoy & Gaimard). Under the name *Coenopsammia coccinea* Ehrenberg, KLUNZINGER records another species, the corallites of which rise much higher above the surface, so that the colony becomes subdendroid; KLUNZINGER states that this species is different from *C. coccinea* (Lesson).

The species described by GARDINER (1900) as *Coenopsammia willeyi* in all probability is not specifically different from *Tubastraea aurea* (Quoy & Gaimard).

VAUGHAN (1907) cites VERRILL's (1866) description of *Coenopsammia manni* from Hawaii, and adds some notes and figures of specimens from the same locality. These corals apparently belong to *Tubastraea aurea* (Quoy & Gaimard) or to *T. tenuilamellosa* (M. E. & H.); in all probability they belong to the former species, as VERRILL states: "The exterior of the corallites is obscurely and closely costate, and covered closely with rough granulations" (cf. VAUGHAN, 1907, p. 156). VAUGHAN adds that his specimens differ from the type of *Dendrophyllia manni* by their very exsert corallites and poorly developed columella. A colony of *D. manni* figured by EDMONDSON (1946, fig. 23c) also shows rather exsert corallites. *Dendrophyllia oahensis*, described by VAUGHAN in the cited paper, is an entirely different species, belonging in the group of *Coenopsammia coccinea* Ehrenberg as defined by KLUNZINGER (1879).

In a later publication, VAUGHAN (1918) provisionally regarded the three following forms as separate species: *Dendrophyllia willeyi* (Gardiner), *D. manni* (Verrill), and *D. diaphana* Dana. He adds, however (l. c., p. 144): "I should not be surprised if large suites of specimens showed that *D. aurea*, *D. danae*, *D. manni*, and *D. willeyi* were variants of the same species."

VAN DER HORST (1922) records four species in which the colony is of a more or less massive shape, named by him *Dendrophyllia ehrenbergiana* (M. E. & H.), *D. coccinea* (Ehrb.), *D. willeyi* (Gardiner), and *D. sibogae* van der Horst. VAN DER HORST's *D. ehrenbergiana* and *D. coccinea* have long-stalked corallites; in all probability the two forms belong to *Coenopsammia coccinea* Ehrenberg as defined by KLUNZINGER (1879). It is fairly certain that *D. willeyi* (Gardiner) is a synonym of *Tubastraea aurea* (Quoy & Gaimard); possibly *D. sibogae* also is a form of *T. aurea*.

In a later paper VAN DER HORST (1926) states that *Dendrophyllia ehrenbergiana* van der Horst, 1922, is *D. coccinea* (Ehrb.) as defined by KLUNZINGER (1879); for *D. coccinea* van der Horst, 1922, he erects the new name *D. klunzingeri*. As remarked above, in all probability the two forms are conspecific. To avoid confusion it seems best to name the species *Tubastraea klunzingeri* (van der Horst), because *Tubastraea coccinea* Lesson, 1834, and *Oculina coccinea* Ehrenberg, 1834, have been described in the same year, whilst they belong to different species: LESSON's coral to *T. aurea*, and EHRENBERG's to *T. klunzingeri*. In VAN DER HORST's (1926) paper all the subplocoid corals of the genus *Tubastraea*, described under many different names, are united as *Dendrophyllia aurea* (Quoy & Gaimard). The synonyms include, besides a number of forms that undoubtedly belong to *T. aurea* (e.g., *coccinea* Lesson, *Ehrenbergiana*, *Gaimardi*, and *Urvillii* of MILNE EDWARDS & HAIME, *manni* Verrill, *willeyi* Gardiner), *Coenopsammia flexuosa* (Ellis & Solander) that is of doubtful systematic status, and *C. tenuilamellosa* (placed by VAN DER HORST with a question mark among the synonyms of *D. aurea*) that probably represents a separate species.

THIEL (1928) studied specimens from the islands in the Gulf of Guinea; he identified these as *Dendrophyllia aurea* (Quoy & Gaimard). His description and figures (l. c., pp. 292-297, Pl. 4 figs. 37, 39–42) convincingly show that this identification is correct. In the list of synonyms, THIEL mentions *Coenopsammia flexuosa* and *C. tenuilamellosa* of MILNE EDWARDS & HAIME; as remarked above the status of the former is uncertain, whilst *C. tenuilamellosa* probably is a separate species.

DURHAM (1947, p. 39) maintains that *Tubastraea tenuilamellosa* is specifically different from *T. aurea*: "This species has been confused in some collections with *T. aurea* (Quoy & Gaimard). Superficially they are very similar, but the costal granules on *T. aurea* are much finer than those of *T. tenuilamellosa*. (See Pl. 12, figs. 5, 7.) In addition the columella averages smaller, the primary septa are not quite so wide, the calicular fossa is somewhat deeper, and the septal edges are much smoother on Quoy and Gaimard's species. On *T. tenuilamellosa* the costal grooves are about half as wide as the costae. There is a single row of fairly coarse granules on the costae (on *T. aurea* there may be 1, 2, or 3 rows of fine granules). The wall is very porous and thin".

None of the peculiarities mentioned above are sufficiently constant for real specific characters. In *T. aurea* of Pl. IX fig. 6 the costal granules are larger than in *T. tenuilamellosa* of Pl. IX fig. 2. Large calices of *T. aurea* as a rule have a well developed columella (Pl. IX fig. 5), much larger than that in most calices of *T. tenuilamellosa* (Pl. IX fig. 3). In the two species the width of the septa is subject to strong individual variation, in the specimens of Pl. IX fig. 3 (*T. tenuilamellosa*) and Pl. IX fig. 5 (*T. aurea*) the septa are of corresponding width in comparison to the size of the calices. In the rather exsert calices of *T. tenuilamellosa* the fossa is distinctly deeper than that of the far less exsert calices of *T. aurea*. In colonies of *T. aurea* with a heavy skeleton the septa have a smooth edge (Pl. X fig. 2), in colonies with a lighter skeleton the edge of the septa is much more uneven (Pl. X fig. 6). On the other hand the septa of *T. tenuilamellosa* often have a smooth edge (Pl. X figs. 1, 3–5). As a rule the costal grooves of *T. tenuilamellosa* (Pl. IX figs. 2, 4) are about half as wide as the costae, whilst in *T. aurea* (Pl. IX fig. 6) they are about as wide as the costae; this rule is not without exceptions, cf. Pl. XI fig. 1, showing calices of *T. tenuilamellosa* in which the grooves are wider than the costae. On the other hand in the specimens of *T. aurea* from the Seychelles the costal grooves often are narrower than the costae, especially in the larger calices. In *T. tenuilamellosa* there are corallites with a single row of fairly coarse granules on the costae (Pl. IX fig. 4), in other corallites, however, the whole surface of the costae is more or less regularly covered with small granules (Pl. IX fig. 2), in a similar manner as the usual structure in *T. aurea* (Pl. IX fig. 6). Even DURHAM's figured specimen of *T. tenuilamellosa* (1947, Pl. 12 fig. 5) has costae with more than one row of granules. In *T. tenuilamellosa* the wall may be very porous and thin (Pl. XI figs. 1, 3), but also in *T. aurea* the wall may be very porous and thin (Pl. XI fig. 4, Pl. XII figs. 5, 6).

In general appearance the two forms are different. The calices of *T. tenuilamellosa* are distinctly exsert, whilst they have a rather deep fossa; in contradistinction the calices of *T. aurea* are little exsert, and the fossa is less deep. These differences are the more striking as generally the diameter of the calices of *T. aurea* is larger than that of the calices of *T. tenuilamellosa*. Moreover, in the colonies of *T. aurea* with very large calices the coenenchyme is more strongly developed than in colonies with smaller calices, so that the calices do not rise high above the surface (Pl. IX fig. 5). But here again the difference does not hold in the same degree for all the colonies; especially young colonies of *T. aurea* may present a form of growth similar to colonies of *T. tenuilamellosa*.

Notes on specimens from the Cocos-Keeling Islands are given by WELLS (1950), who identified them as *Tubastraea willeyi* (Gardiner).

In the colonies of *Tubastraea tenuilamellosa* from Curaçao and from Aruba the diameter of the calices as a rule is not larger than 10 mm, then they have three complete cycles of septa and often some septa of the fourth cycle, the calices showing a very regular structure (Pl. IX figs. 1, 3; Pl. X fig. 1). In some colonies of *Tubastraea aurea* the majority of the calices may become much larger (to 17 mm) and still may keep their regular structure (Pl. IX fig. 5; Pl. X fig. 2). These large calices have four complete cycles of septa and a varying number of septa of the fifth cycle.

VAUGHAN & WELLS (1943) remark that in *Endopsammia*, a genus with similar characters as *Tubastraea*, only in early stages the septa are arranged according to the POURTALÈS plan. In the colonies of *Tubastraea tenuilamellosa* from Curaçao very rarely such an arrangement of the septa is to be seen. It occasionally is present in very young calices, as that above the large calice of Pl. X fig. 4. On the other hand in *Tubastraea aurea* an arrangement of a part of the septa of the higher cycles according to the POURTALÈS plan is not unfrequently to be observed in large calices, whilst in the smaller calices this arrangement then is entirely absent (Pl. IX fig. 5; Pl. X fig. 2).

The colonies from Curaçao collected by Mr. VAN DER WERF are of special interest as they show pecular phenomena of fission, next to the usual manner of asexual reproduction by budding. In connexion with the terminology used here it is appropriate to cite VAUGHAN & WELLS (1943, p. 42), who write: "*Intertentacular budding*, often erroneously referred to as "fission" or "fissiparous budding", is characterized by the development of two or more stomodaea within the same tentacular ring and of one or more couples of mesenteries between every two neighboring stomodaea (*indirect linkage*), or the neighboring stomodaea are connected by mesenterial strands (*direct linkage*)." If, however, we restrict the term "budding" to those processes in which each new individual develops in a manner altogether similar to that occurring as a result of sexual reproduction, and regard as "fission" all those processes that start with the division of one individual into component parts, each of which develops into a more or less normal individual as a result of regeneration, we have a far more principal arrangement of the phenomena than by including "longitudinal fission" as "intratentacular budding" among "budding". In any case, when dealing with abnormal phenomena, as in *Tubastraea*, where extratentacular budding is the rule, the aberrant manner of asexual reproduction may be referred to as "fission".

It is by no means unknown that asexual reproduction by fission may occur in the genus *Tubastraea*. MILNE EDWARDS & HAIME (1848, p. 68), when dealing with the genus *Coenopsammia* (this generic name is a synonym of *Tubastraea*) write of their species *Coenopsammia Urvillii*: „Cette espèce se rapproche encore de certaines Astrées par la faculté qu'elle possède de se multiplier, en outre, par fissiparité", and on page 109 of the same paper they write again: „Au mode de reproduction par bourgeonnement cette espèce réunit quelquefois celui par fissiparité."

VAN DER HORST's (1926, p. 48) notes on fissiparity in *Tubastraea aurea* are quoted on a previous page.

Fission could be observed in two colonies in the Paris Museum, viz., in no. 390a (Pl. XII fig. 1) and in the larger colony of no. 390d (Pl. XII figs. 2 and 3). In two parts of the specimen labelled *Coenopsammia coccinea* (no. 393) there are two united calices, but here apparently the common theca of two adjoining calices has partially broken off, for the two united calices have a regular structure, the septa radiating from the columella in the centre of each calice. Moreover, this colony has a few calices in which a new theca has developed inside the old, as a result of regeneration after damage. In the specimen labelled *Coenopsammia Urvillei*, the "species" that according to MILNE EDWARDS & HAIME sometimes shows asexual reproduction by fission, no instances of this mode of division could be found. Here often two calices are narrowly united, but their regular septal system shows that they cannot be the product of fission of one original calice.

Besides in the specimens from Dr WAGENAAR HUMMELINCK's collections and in the two colonies from the Paris Museum, fission was found to occur, by no means rarely, in colonies of *Tubastraea aurea* from Amboina and from the Kei Islands, collected during the Danish Expedition to the Kei Islands in 1922. Especially the colonies obtained at Vatek, a locality of exceptional rich animal life (see MORTENSEN, 1923, p. 67) show various stages of this manner of division.

In the colonies of *Tubastraea tenuilamellosa* from Curaçao two of the calices are much larger than normally, reaching a diameter of about 15 mm (Pl. X figs. 3 and 4). Both of these now have lost their regular structure, as some of the principal septa have become much larger than the others, and have grown out into the columella, causing a beginning of a separation of the calice into two about equal parts.

In one of the colonies from Aruba there is one calice with a similar irregular structure. At its widest part this calice has a diameter of 19 mm. Next to this large calice there is one of an elongated shape comparable to the specimen of Pl. XI fig. 1.

In another calice of *T. tenuilamellosa* the long axis has become much larger than generally, so that the calice has an elliptical shape (Pl. X fig. 5). Here again some of the principal septa have become larger than normally, leading to a partial division of the calice. A more or less corresponding case is that of the small elliptical calice of *T. aurea* (Pl. X fig. 6), in which two opposite septa have joined to form a transverse barrier that later might have developed into a theca separating the two halves of the corallite.

A further stage of this process is that of the calice of *T. tenuillamellosa* of Pl. XI fig. 1. In this ellipitical calice there are two opposite septa causing a partial division of the calice into two halves; these septa have become much thicker than the other septa and appear as parts of the theca grown inward. A similar structure is that of the more or less panduriform calice of *T. aurea* of Pl. XI fig. 2. Here the skeletal elements partially dividing the two components do not differ in any respect from the normal theca. As in this compound calice the columella forms one uninterrupted mass from one end of the calicular fossa to the other, it is evident that it has developed as a result of fission of one original calice.

Compound calices as those of Pl. XI figs. 1 and 2 in further growth might develop as that of *T. tenuilamellosa* of Pl. XI fig. 3. A double calice of this kind might arise as a result of stronger development of the ingrowing parts of the theca in the short axis. In the specimen of Pl. XI fig. 3, however, in all probability the compound calice is not a result of fission, but the outcome of partial fusion of two calices that were in such a close contact that parts of their thecae formed one common calcareous plate. If then for some reason or other a part of this common wall became lost (instances of this kind are referred to above, as occurring in the specimen labelled *Coenopsammia coccinea* in the Paris Museum) the two polyps became rather closely united. The structure of the opening in the common theca of the double calice of Pl. XI fig. 3 proves that this opening was present during life. Here each of the two calices has a separate columella, and each of the two calices has a regular set of septa, the six primary septa occupying an entirely normal position, so that undoubtedly this double calice has originated by fusion.

Some cases of fission in large calices of *Tubastraea aurea* are shown in figs. 4–6 of Pl. XI. In one (Pl. XI fig. 4) a few of the larger septa have grown out towards the centre in such a manner that they are more or less radiating from two centres. Moreover the columella, that has become somewhat narrower in its central part, here is growing upward, joining in the tendency to form a partition between the two halves of the calice. In the specimen of Pl. XI fig. 5 this process has further developed, as the septa in each of the two halves have a far more radiating structure, and the irregular central mass of the columella has become much higher than the parts forming the centre of each half of the calice. On the other hand the specimen of Pl. XI fig. 6 does not show any other irregular feature but a pronouncedly oval shape, the columella does not show a division into two parts, and among the larger septa there is not a distinct tendency to form a boundary between the two halves of the calice.

Among the material in the Paris Museum two colonies of *Tubastraea aurea* from the Seychelles (labelled *Coenopsammia Ehrenbergiana* Edw. H.) are interesting as they show advanced stages of division, one in one calice (Pl. XII fig. 1), the other in two calices (Pl. XII figs. 2 and 3). In the specimen of Pl. XII fig. 1 the columella is partially divided into three parts, the central part on each side being connected with a strongly developed septum, one of which by its enormous thickness having obtained a structure corresponding with that of the theca, whilst the other parts of the columella each form the centre of a half of the calice in which the septa have a tendency for a radiating arrangement from this new centre. The calice of Pl. XII fig. 2 has nearly divided into two parts, separated on one side by a large septum that completely appears as an ingrowing part of the theca, and on the other side by two septa that are distinctly thicker than the others. Here the columella is inconspicuous, in each part of the calice composed of a few irregular trabeculae. In the two parts of the calice the septa, especially their central portions, show an arrangement leading towards a radiation from the centre. In the calice of Pl. XII fig. 3 the columella consists of two parts united in the centre of the calice by an irregular narrow mass of trabeculae. Each of the two parts of the calice has a nearly complete radial arrangement of the septa with the exception of the region of the division, where there is the irregular mass of trabeculae belonging to the columella.

A nearly complete case of fission is that of the calice of *Tubastraea aurea* from Vatek, Kei Islands, of Pl. XII fig. 4. In the region of division the two components still show some irregularities, but on the whole the separation of the two halves is nearly complete. There is some complication here as apparently on a part of the calice the soft parts have undergone some damage, resulting into a regeneration by the development of a new theca inside the old.

Regeneration of a similar kind was observed in many calices of *Tubastrea aurea* from the same locality. This may result into the formation of an entirely new theca inside the old (Pl. XII fig. 5), then it stands to reason that the regenerated calice at first is rather irregular, as the newly formed septa are much smaller than the older.

If the damage to the soft parts is so severe that only small fragments of the soft parts remain alive, regeneration may give rise to budding, as in the specimen of Pl. XII fig. 6. Here on the marginal region of the theca of one polyp five small new individuals have grown out, three of which are narrowly joining each other, the other two occurring separately. In each of these the septal arrangement is as regular as in young buds developing in the coenenchyme between the calices.

A short preliminary note on the phenomena dealt with above appeared in a previous paper (BOSCHMA, 1951).

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## EXPLANATION OF THE PLATES

### PLATE IX

1–4 *Tubastraea tenuilamellosa* from Spaanse Baai, Curaçao (1, colony; 2, costae of one calice), and from Plaja Djerimi, Curaçao (3, colony; 4, costae of one calice).

5–6 *Tubastraea aurea* from Wainitu, Amboina (5, colony; 6, costae of one calice).

1, 3, and 5, natural size; 2, 4, and 6, × 5.

### PLATE X

1, and 3–5 *Tubastraea tenuilamellosa* from Curaçao.

2, and 6 *Tubastraea aurea* from Amboina (2), and from Vatek, Kei Islands (6).

All figures × 3.

### PLATE XI

1, and 3 *Tubastraea tenuilamellosa* from Curaçao.

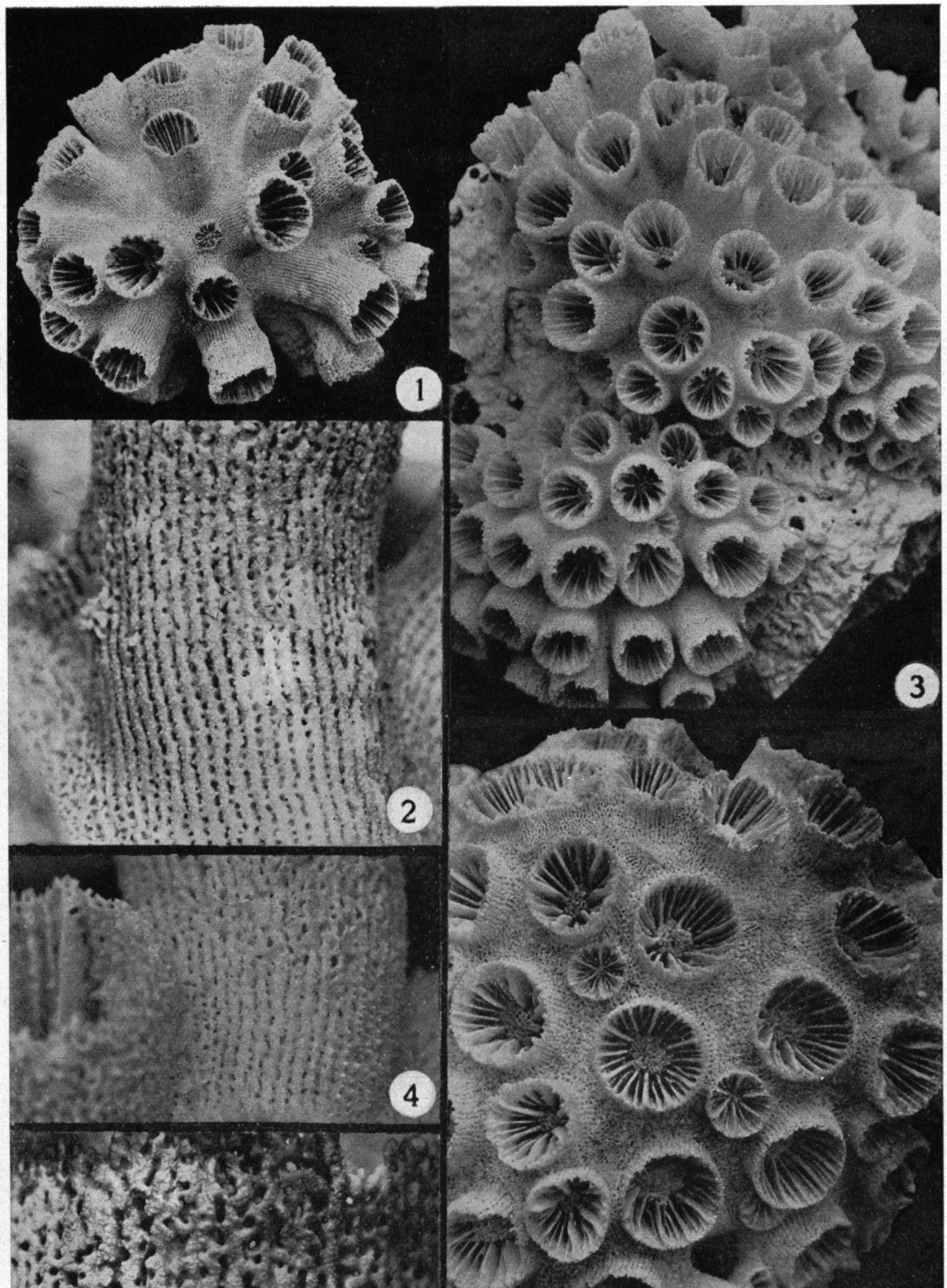
2, and 4–6 *Tubastraea aurea* from Vatek, Kei Islands (2 and 6), from Kei Islands, exact locality unknown (4), and from Wainitu, Amboina (5).

All figures × 3.

### PLATE XII

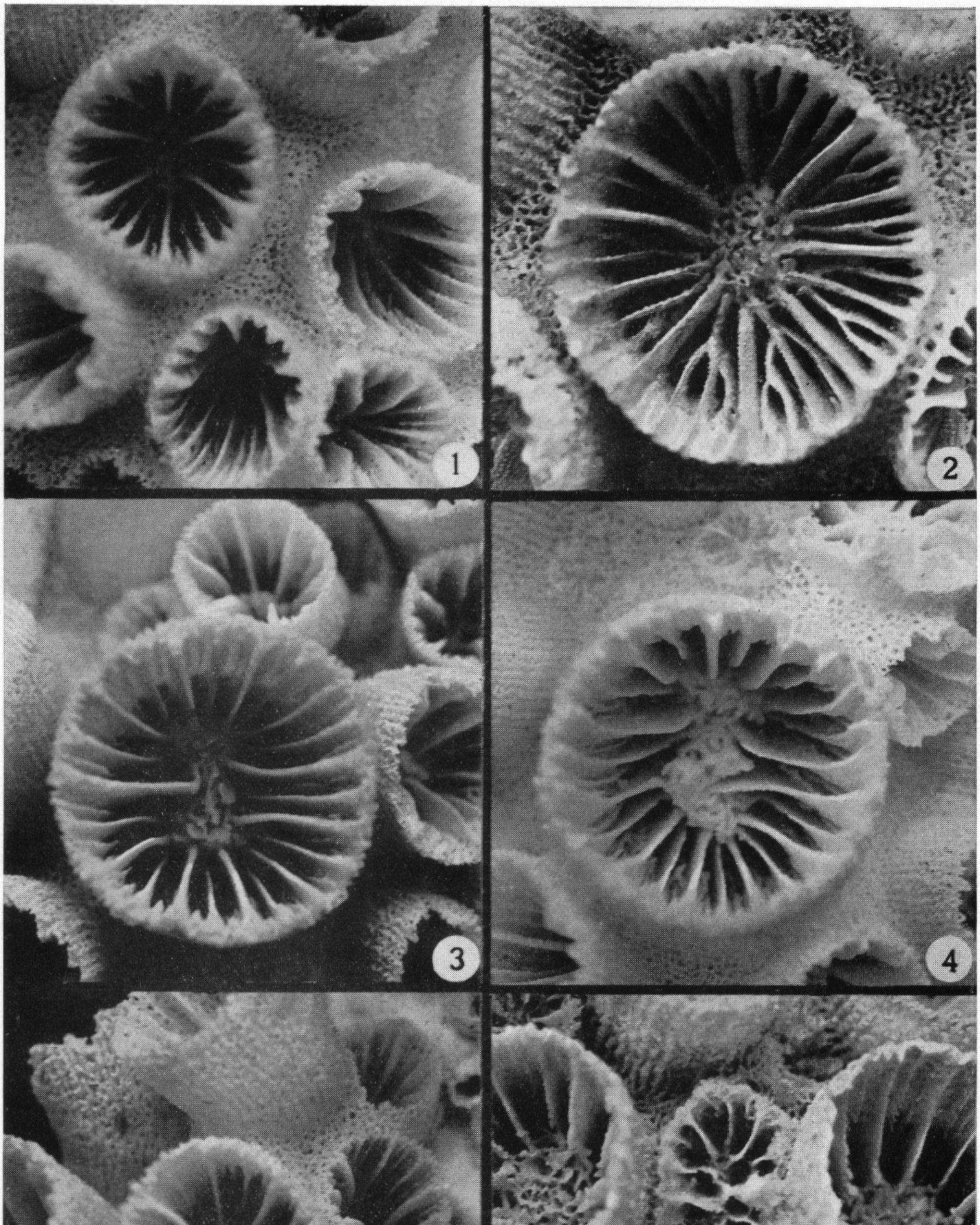
1–6 *Tubastraea aurea* from the Seychelles (1, Paris Museum, no. 390a; 2–3, Paris Museum, no. 390 d), and from Vatek, Kei Islands (4–6).

All figures × 3.

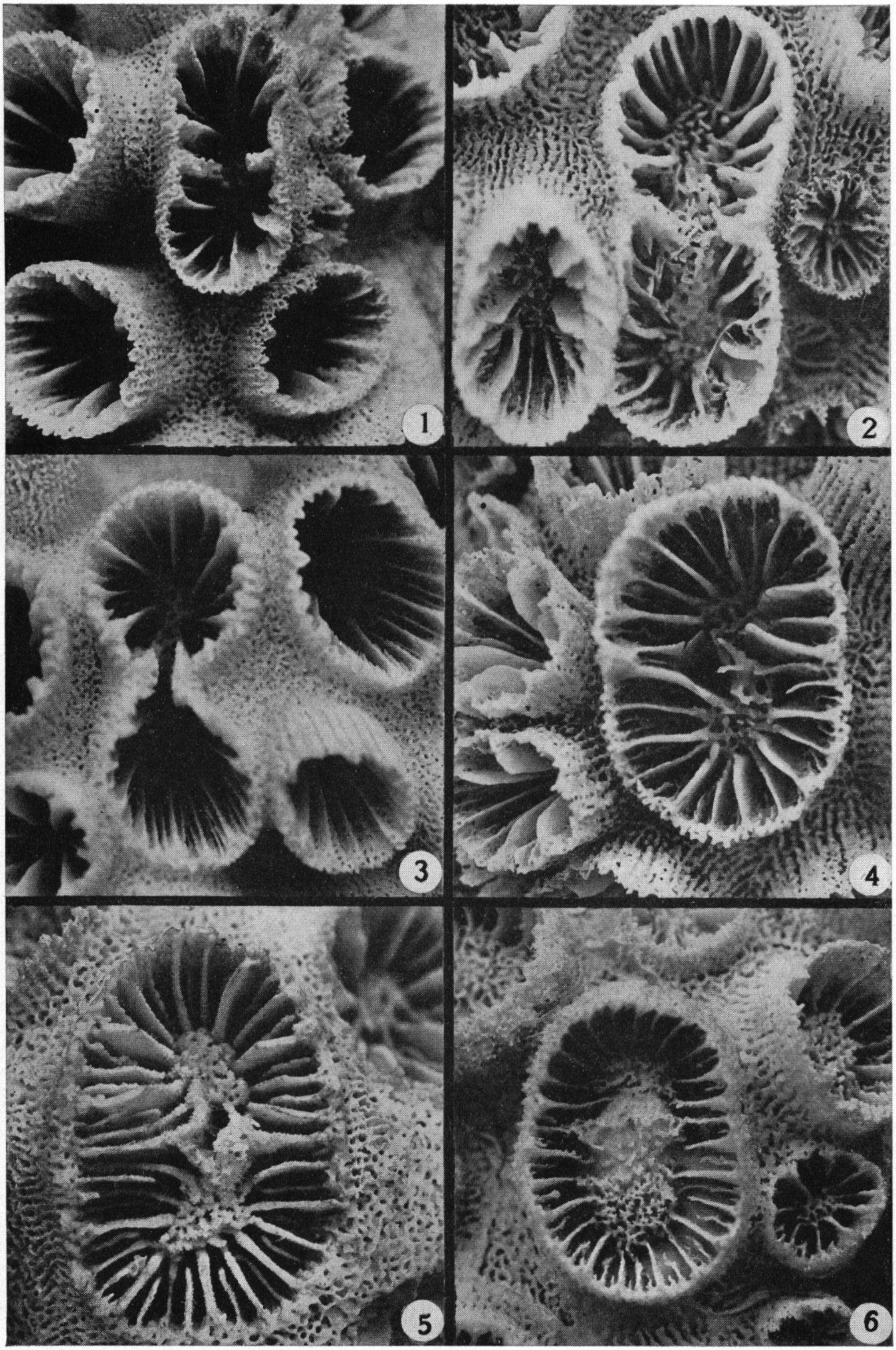



For explanation of Plate IX, see p. 119.

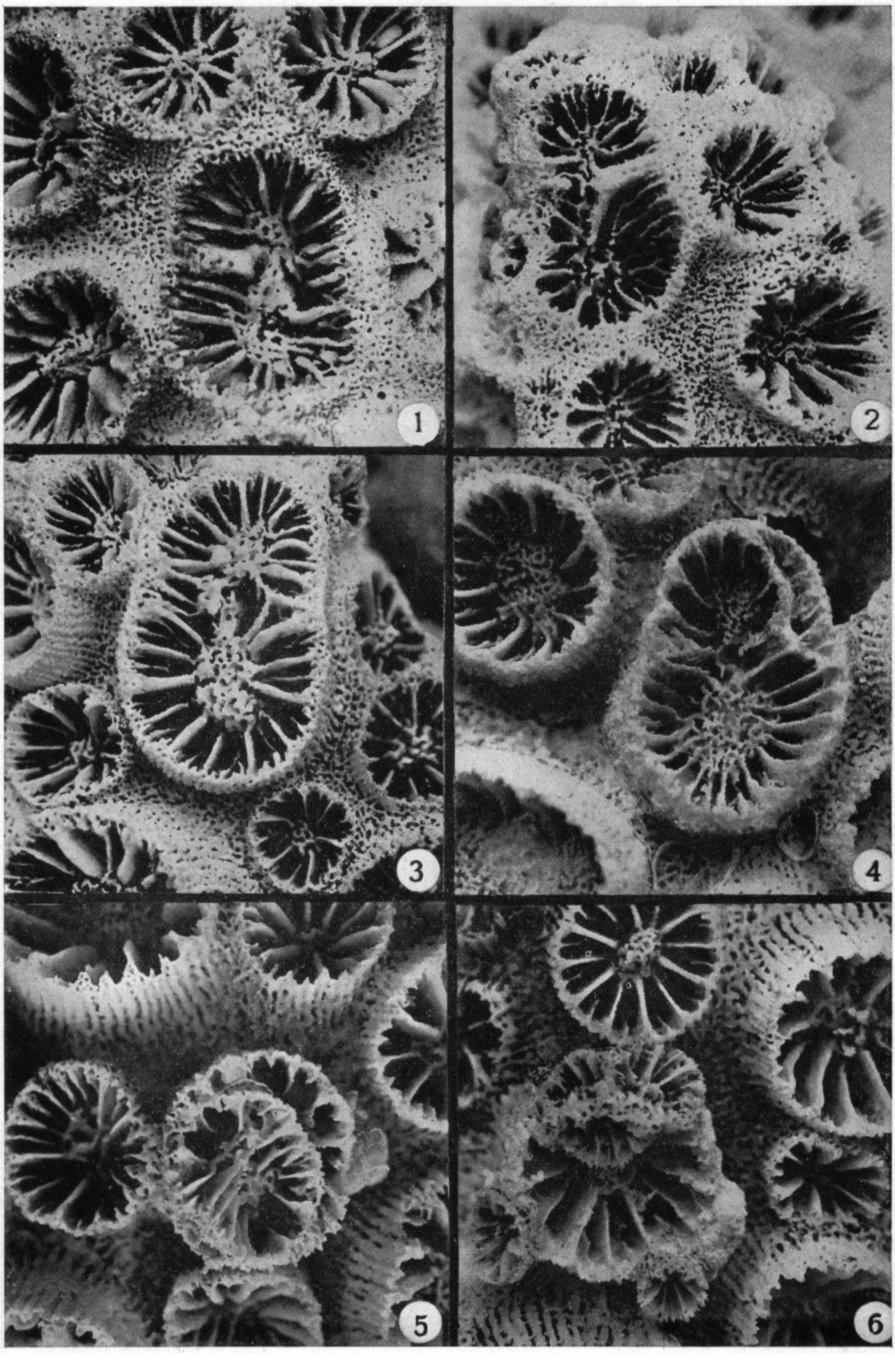
PLATE X




For explanation of Plate X, see p. 119.




For explanation of Plate XI, see p. 119.




For explanation of Plate XII, see p. 119.