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The Species of *Eucheuma* from Ryûkyû and Formosa

By

YUKIO YAMADA

With Plates XXI–XXIX.

During the course of a study of the marine algae from the southern parts of Japan several forms of the present genus were met with. As well known to all phycologists, the species of *Eucheuma* are very difficult to be distinguished specifically, because it is exceedingly perplexing to attempt to understand exactly the species hitherto described from the descriptions only, even when they are accompanied with figures. Recently, however, WEBER VAN BOSSE studied the species from the Malay archipelago and the Indian Ocean very precisely, and distinguished two sections, Axifera and Anaxifera according to the difference of the anatomical character. In studying our material, this monograph was of great help.

In the present paper seven species are enumerated which have been found in the Ryûkyû archipelago and Formosa. In describing them special attention has been paid to give as many figures and photographs as possible, which were taken from the material preserved in formalin solution.

As to the anatomical character there are some species, which proved to be somewhat intermediate forms between the Axifera and the Anaxifera. For example in *E. muricatum* f. *depauperata* WEB. v. BOS. and *E. muricatum* WEB. v. BOS. f. *incrassata* YAM. the central rhizoids are found, but are not so densely packed together as in *E. gelatinae* J. AG. and *E. serra* J. AG.

The expense for collecting a part of the material used for the present study was covered by a grant from the Foundation for the Promotion of Scientific and Industrial Research of Japan, for which the writer expresses here his best thanks.

Scientific Papers of the Institute of Algological Research, Faculty of Science, Hokkaido Imperial University, Vol. I, no. 2, 1936.

An analytical key to the species of *Eucheuma* from Ryûkyû and Formosa.

1. Frond with thin longitudinally elongated cells (rhizoids) in the centre 2
1. Frond without rhizoid in the centre 6
   2. Rhizoids very thick-walled, packed together very densely 3
   2. Rhizoids not as above 4
3. Branches covered with branchlets on one side only ..... *E. gelatinae*
3. Branches not as above, branchlets opposite or verticillate ..... *E. serra*
   4. Frond covered densely with spine-like branchlets 5
   4. Frond covered sparingly with spine-like branchlets .... *E. muricatum* f. *depauperata*
5. Branches often irregularly incrassate ..... *E. muricatum* f. *incrassata*
5. Branches not incrassate ..... *E. striatum*
   6. Branches cylindrical or compressed 7
   6. Branches complanate ..... *E. Okamurai*
7. Branches attenuated upwards 8
7. Branches not as above ..... *E. crassum*
   8. Branchlets clearly verticillate.. *E. cupressoideum* var. *verticillata*
   8. Branchlets not as above ..... *E. cupressoideum.*

1. **Eucheuma gelatinae** J. AGARDH

Spec. alg., vol. 2 (1852) p. 628, Epicr. (1876) p. 602, Anal. alg. (1892) p. 125; DE TONI, Syll. alg., vol. 4 (1897) p. 347; WEBER VAN BOSSE, Liste des alg. du Siboga, vol. 4 (1928) p. 412.

Fucus gelatinus ESPER, Icon. fuc. (1797) pl. 101.

Japanese name. *Katamen-kirinsai.*

Hab. Naha, Ryûkyû; Bôkotô, Formosa.

The present species is the commonest *Eucheuma* in the vicinity of Naha, being found on the coral reefs in the littoral zone. It is very characteristic that the under surface and both margins of the branches are densely covered with long, thin branchlets while the upper surface usually remains smooth.

The rhizoids in the centre of the frond are exceedingly thick-walled and packed against each other very densely.

2. **Eucheuma serra** J. AGARDH

Plates XXI–XXII, Text-figs. 1–2.

Spec. alg., vol. 2 (1852) p. 626; DE TONI, l. c. p. 371; WEBER VAN BOSSE,

l. c. p. 411, pl. 13, figs. 4–5; KYLIN, Florideengat. Gigart. (1932) p. 24, pl. 10, fig. 21.

Eucheuma nodulosum ARESCHOUG, "Phyc. nov. (1954) p. 22"; Kylin, l. c. p. 24, pl. 10, fig. 22.

Japanese name. *Toge-kirinsai.*

Hab. Iriomote-zima, Ryûkyû; Kelung, Dairi, Kasyôtô, Garanbi and Kaikô, Formosa.

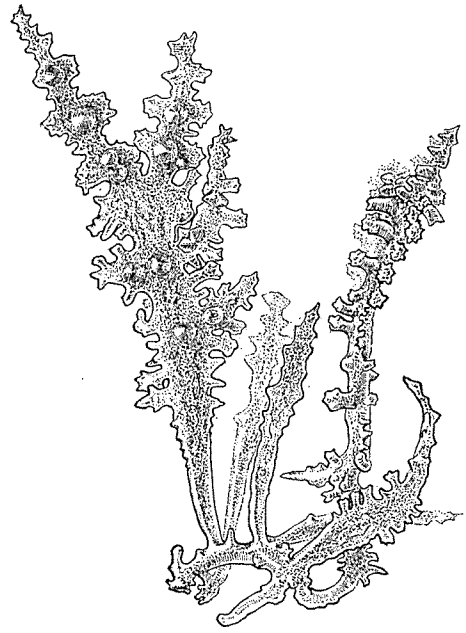


Fig. 1. *Eucheuma serra* J. AG.
A specimen from Kelung, Formosa. ×1.

This species of *Eucheuma* seems to be distributed most widely on our coast, from Sikine-zima, Idu Prov. to Garanbi, the south end of Formosa. In every characteristic the present specimens agree well with the descriptions and figures cited above, but there are still other characters which may be peculiar in our specimens or which have not been described. The frond of our specimens is usually decumbent, though some branches are ascending. On the under surface in almost all the present specimens there are small wart-like protuberances forming one longitudinal row. They are simple or often divided at apices into 2–3 sharp, spine-like parts.

The rhizoids in the frond of this species are allied to those of *E. gelatinae* J. AG.

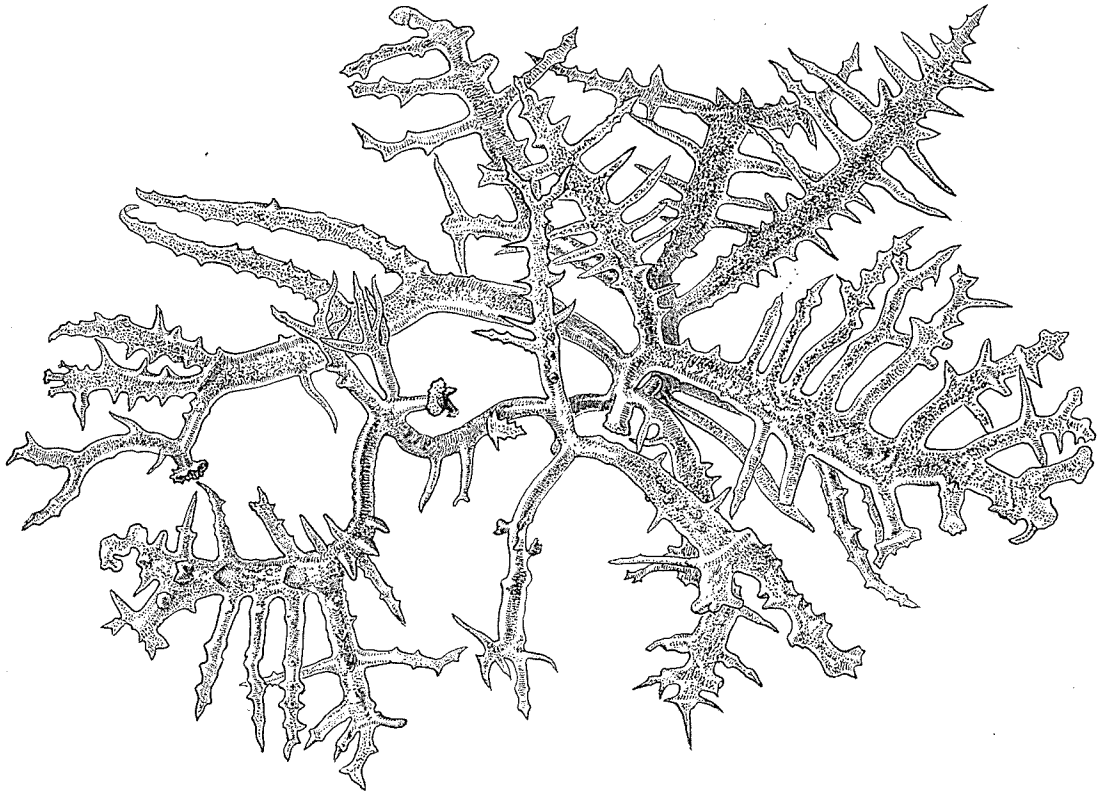


Fig. 2. *Eucheuma serra* J. AG. A specimen from Kaikô, Formosa. ×1.

3. **Eucheuma muricatum** (GMELIN) WEBER VAN BOSSE

Plate XXIII, Text-figs. 3–5

l. c. p. 413, pl. 12.

Fucus muricatus GMELIN, Hist. fuc. (1768) p. 11, pl. 6.

Fucus spinosus TURNER, Hist. fuc., vol. 1 (1808) tab. 18.

Eucheuma spinosum J. AGARDH, Spec. alg., vol. 2 (1852) p. 626, Anal. alg. (1892) p. 122; DE TONI, l. c. p. 369; OKAMURA, Icon. of Japan. alg., vol. 2 (1912) p. 41, pl. 61.

Japanese name. *Kirinsai.*

Hab. Miyako-zima and Naha, Ryûkyû.

As has already been mentioned by former authors *E. muricatum* WEB. v. BOS. is exceedingly variable in habit and in the Ryûkyû archipelago it is represented by the following forms.

Fig. 3. *Eucheuma muricatum* f. *depauperata* WEB. v. BOS.
A specimen from Miyako, Ryûkyû. ×9/10.

f. **depauperata** WEBER VAN BOSSE
l. c. p. 415, pl. 12, fig. 5.
Japanese name.
Hab. Miyako-zima.

Fig. 4. *Eucheuma muricatum* WEB. v. BOS. f. *incrassata* YAMADA.
A Specimen from Naha, Ryûkyû. ×1.

f. **incrassata** f. nov.

Hab. Miyako-zima and Naha, Ryûkyû.

This forma is very peculiar being incrassated irregularly at any places of the branches. Some extreme forms remind one of *E. crustaeforme* WEB. v. BOS.

4. **Eucheuma striatum** SCHMITZ

Plates XXIV–XXV, Text-figs. 6–7.

Mar. Flor. von Ost-Asien (Engl. Bot. Jahrb. Bd. 21, 1895) p. 151; WEBER VAN BOSSE, l. c. p. 423, fig. 171, pl. 14, fig. 1, pl. 16, fig. 4.

Japanese name. *Ô-kirinsai.*

Hab. Isigaki-zima and Naha, Ryûkyû.

The writer refers a number of specimens from the localities mentioned above to the present species. In general they agree well with the description by SCHMITZ and photographs by WEBER VAN BOSSE. But in our speci-

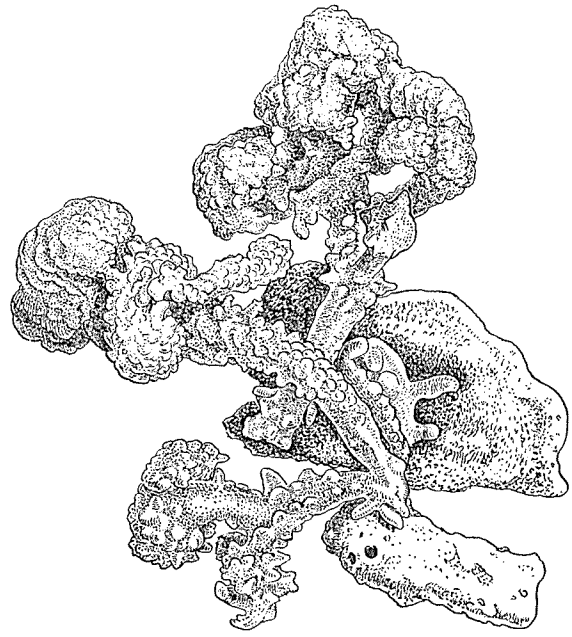


Fig. 5. *Eucheuma muricatum* WEB. v. BOS. f. *incrassata* YAMADA.
A specimen reminding one of *E. crustaeforme* WEB. v. BOS. ×1.

mens branches are sometimes compressed especially in the upper portion, or less often trigonous. From the old part of the frond young, rather smooth branches often issue.

In the centre of the frond there are some rhizoids. These rhizoids are neither so densely aggregated nor so thick-walled as in *E. gelatinae* J. AG. and *E. serra* J. AG.

The present species grows on the coral reefs in the sublittoral zone, about 1–2 fath. deep.

5. **Eucheuma Okamurai** sp. nov.

Plates XXVI–XXVII, Text-figs. 8–9.

Frons prostrata, intricata, anastomosans, basi fere cylindracea, sursum mox complanata, ca. 1–1.5 cm. lata, vel irregulariter dichotoma vel trichotoma vel ramos in latere superiore emittens. Superficies dorsalis ramorum saepe convexa, longitudinaliter striata, papillis tuberculosis in ramis juvenilibus saepe transversim dispositis, dense obtecta, ventralis humilibus, interdum hemisphaericis sparsissime obtecta. Cystocarpia ignota.

Fig. 6. *Eucheuma striatum* SCHMITZ.
A typical specimen from Isigaki, Ryûkyû. ×4/5.

Japanese name. *Okamura-kirinsai.*

Hab. Miyako-zima.

Frond prostrate, with branches overlapping and adhering to one another, forming a large cluster with a diameter of 20–30 cm. Frond

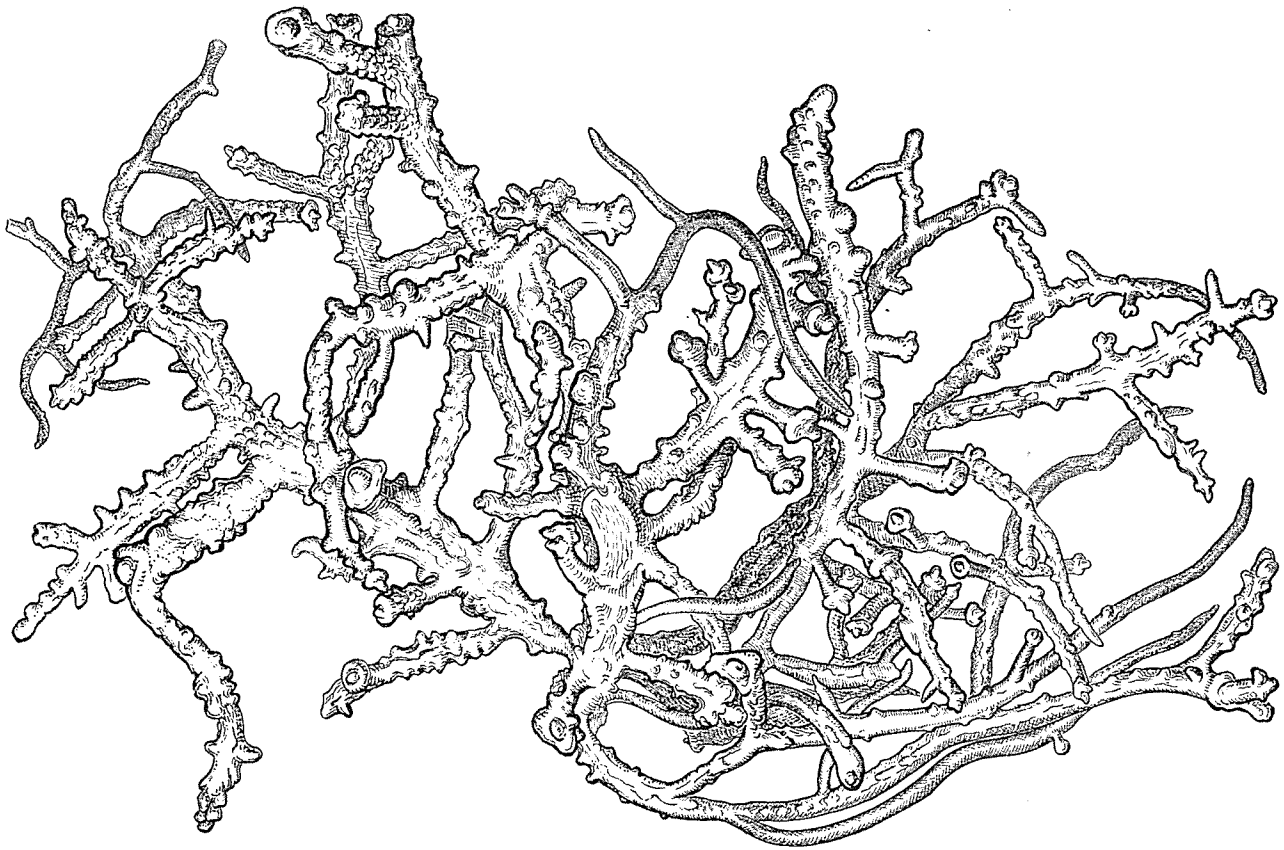


Fig. 7. *Eucheuma striatum* SCHMITZ.
An old specimen with young shoots. × ca. 17/20.

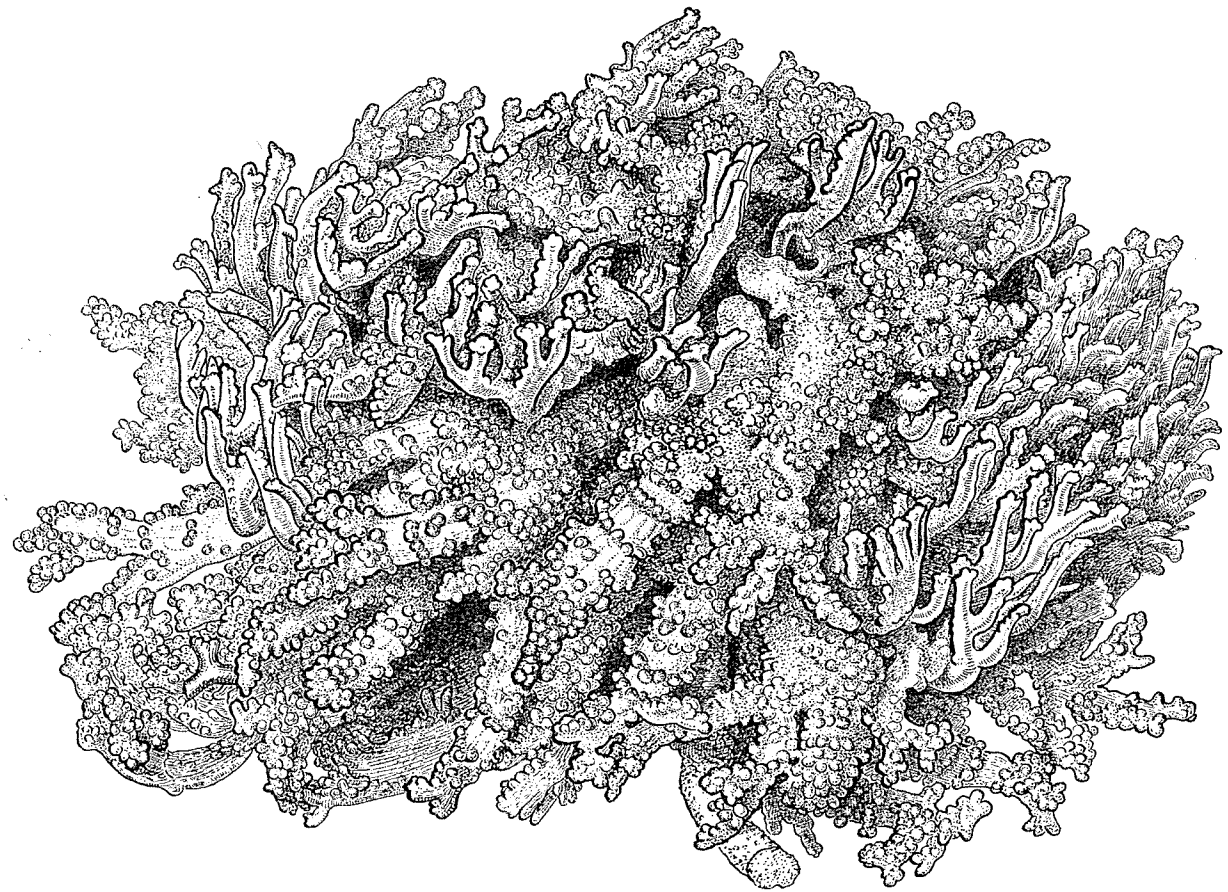


Fig. 8. *Eucheuma Okamurai* YAMADA.
A large specimen with young shoots from Miyako, Ryûkyû. ×ca. 2/3.

nearly cylindircal at the base, soon becoming compressed and complaneted upwards, about 1–1.5 cm. wide, divided sometimes irregularly dichotomously or trichotomously, sometimes sending branches from the upper surface. Upper surface of branches often convex, longitudinally striate, covered rather densely with papillae, while the other surface mostly not wrinkled. Papillae on the upper surface of branches nearly spherical or somewhat conical, densely produced, or especially in the younger branches forming transverse lines, those on the other side sparingly found, very low, usually forming only low elevations, or sometimes hemispherical. Colour carneous.

According to the age the habit of the present species is exceedingly variable, in age all the papillae becoming very low (fig. 9). Among our specimens there is one in which many young shoots issue from the upper surface as well as from both margins of branches. Those young branches are erect and do not show many papillae, being nearly smooth (fig. 8).

In cross section of the frond of this species there are no rhizoids, and

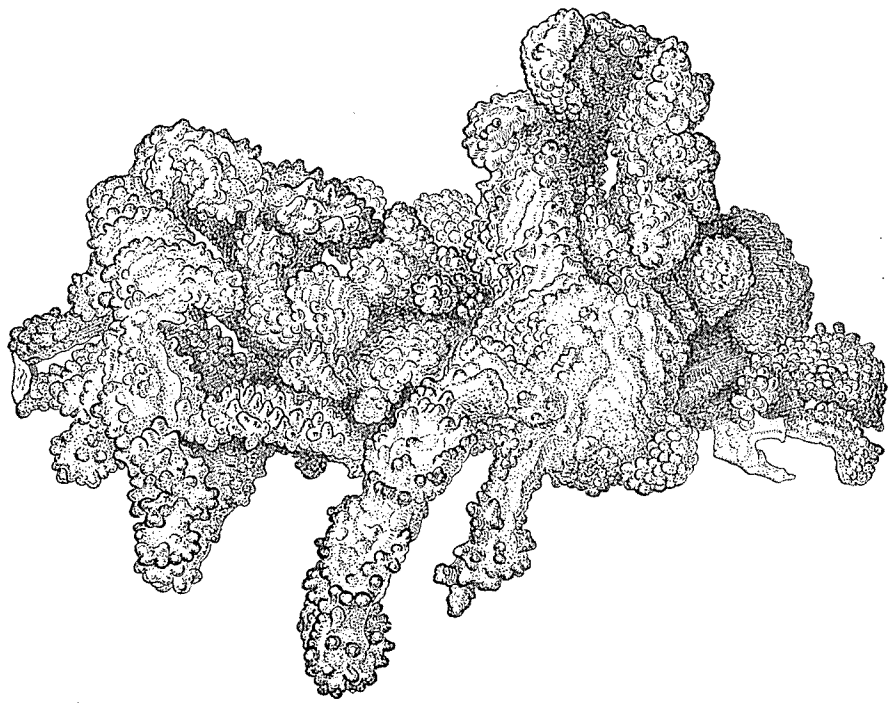


Fig. 9. *Eucheuma Okamurai* YAMADA.
An old specimen from Miyako, Ryûkyû. Slightly reduced.

so this species clearly belongs to the section Anaxifera. Among the species belonging to this section *E. Cottonii* WEB. v. BOS. seems to be related most closely to the present species, but they can be distinguished by the difference of the ramification and that of the papillae.

The late Dr. K. OKAMURA reported *E. crustaeforme* WEB. v. BOS. from Kôtôsho,[1] Formosa (formerly he had identified it with *E. Cottonii* WEB. v. BOS.). His specimen is only a fragment as mentioned by himself, but it appears to the present writer to be the same as *E. Okamurai*.

The present species grows on the coral reefs in the sublittoral zone, about 1–2 fathoms deep.

6. **Eucheuma crassum** ZANARDINI

Plate XXVIII, 2, Text-fig. 10.

Phyc. Papuanae (1878) n. 7; DE TONI, l. c., p. 375; WEBER VAN BOSSE, l. c., p. 419, pl. 13, fig. 6.

Fig. 10. *Eucheuma crassum* ZANARD.
A specimen from Garanbi, Formosa. ×1.

1) K. OKAMURA: On the marine algae from Kôtôsho (Bull. Biogeogr. Soc. Jap., vol. 2, 1913) (under *E. Cottonii* WEB. v. BOS.); Id., Icon. of Japan. alg., vol. 6 (1932) p. 65, pl. 281, figs. 13–16.

Japanese name. *Bô-kirinsai.*

Hab. Garanbi, Formosa.

At Garanbi, the south end of Formosa some specimens of *Eucheuma* have been collected by the writer which correspond well to the description of the present species. Because the descriptions cited above are all very short, the full description of our specimens is given here.

Frond cylindrical, 0.5–1.0 cm thick, unilaterally or, more usually very irregularly branched, forming an irregularly decumbent mass; branches intricate, attached to each other, covered densely with short conical spine-like branchlets. Cystocarps spherical, rather large, often apiculate, scattered sparingly. In the centre of the frond there is no rhizoid but some small cells which do not elongate longitudinally, are found among large ones.

All specimens grow on the coral reefs which are exposed when the tide is low.

7. **Eucheuma cupressoideum** Weber van Bosse

Plate XXVIII, 1, Plate XXIX, Text-figs. 11–13

l. c. p. 421, pl. 14, fig. 3.

Japanese name. *Byakusin-Kirinsai.*

Hab. Miyako-zima.

The frond of this species forms a rather large entangled mass which covers the substratum. It seems to creep at first on the substratum, but the branches are erect and they attach to each other or to other things, thus forming so entangled a mass that it is difficult to separate them without damage. Branches issue usually unilateral, cylindrical and covered with short conical branchlets which are rather densely set or often verticillately arranged. In the basal portion, however, the frond is irregularly dichotomous and often becomes somewhat compressed; it is covered with small wart-like papillae not very densely.

This typical form agrees fairly well with the description and the photograph cited above, while there is still another form which must be fererred to the present species but is well distinguished by the different habit. Therefore it seems best to describe it as a variety of *E. cupressoideum* Web. v. Bos.

var. **verticillata** var. nov.

Japanese name. *Husi-Kirinsai.*

Hab. Miyako-zima.

Fig. 11. *Eucheuma cupressoideum* WEB. v. BOS.
A typical specimen from Miyako, Ryûkyû. Slightly reduced.

Frond thicker than the species, and arrangement of the ramuli evidently verticillate.

The frond of the new variety is very much thicker than that of the typical form, being about 7 mm. in diameter, and the whole entangled mass of an individual reaches about 16 cm across or much more.

The ultimate ramuli are conical in shape, short and thick, rather sharp at the apices, and produced clearly verticillately at first, but afterward

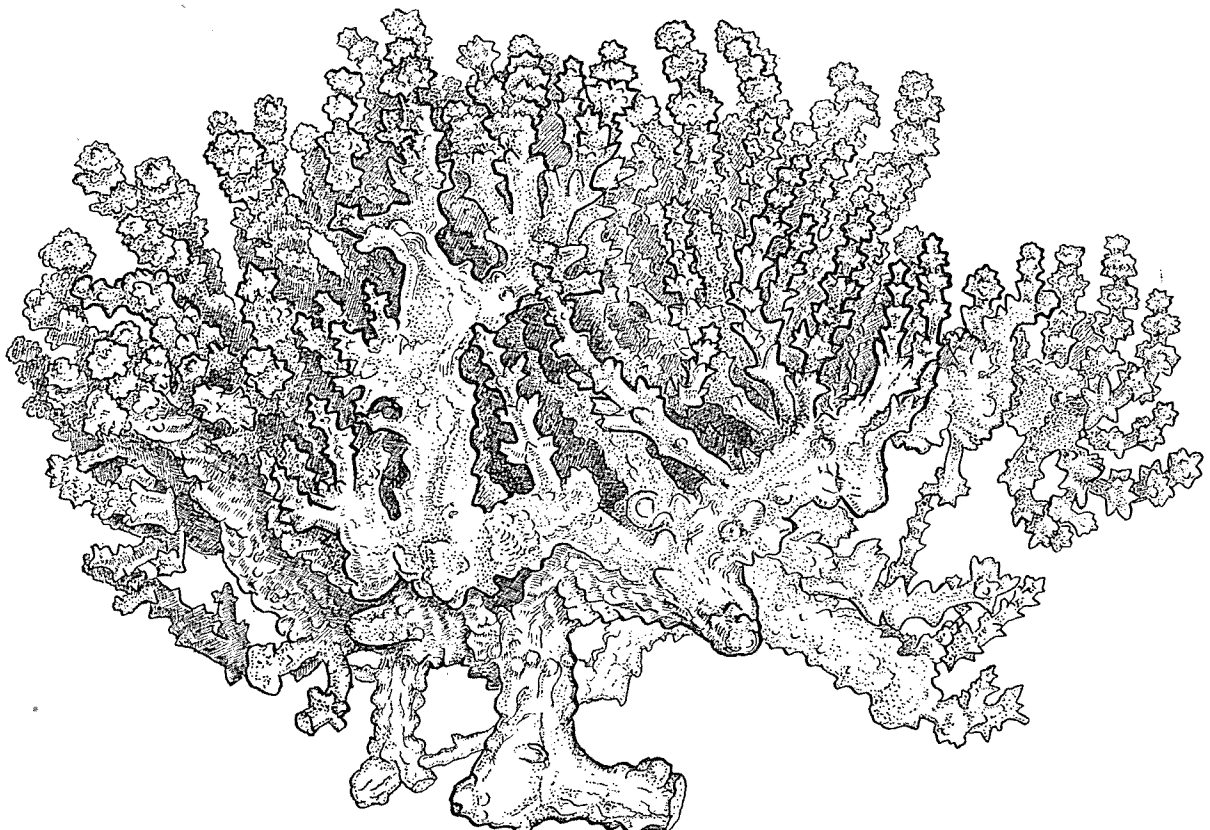


Fig. 12. *Eucheuma cupressoideum* WEB v. BOS. var. *verticillata* YAMADA.
A specimen from Miyako, Ryûkyû. ×1.

Fig. 13. *Eucheuma cupressoideum* WEB. v. BOS. var. *verticillata* YAMADA. A part of the fig. 12. Slightly reduced.

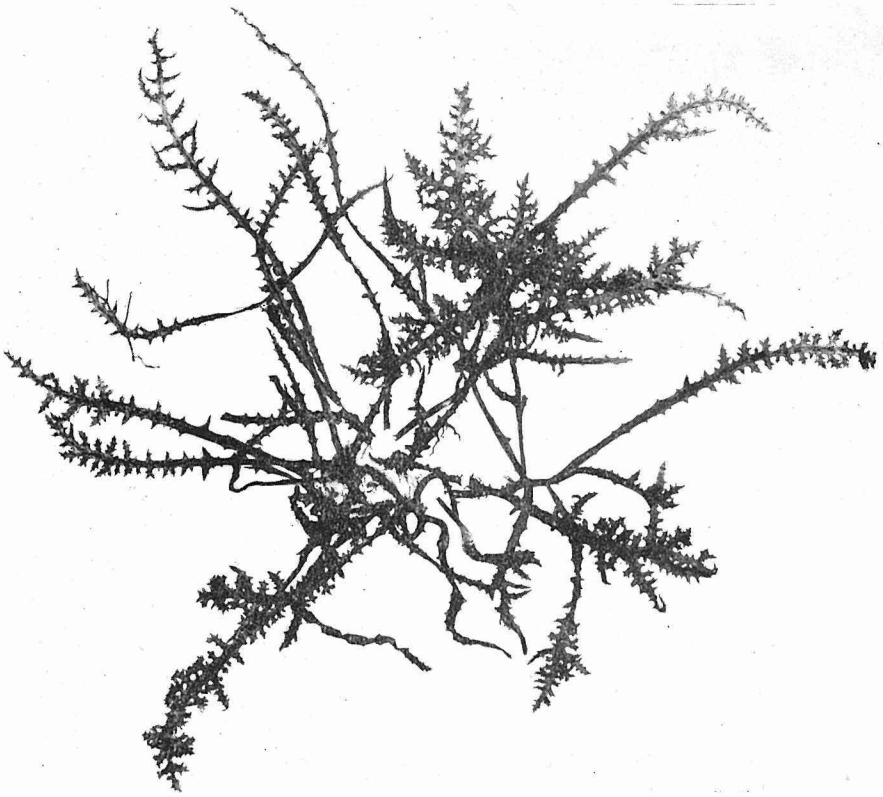
some others are added near every verticillation, thus forming thick nodes, but almost always there remain smooth places between every two successive verticillations.

This variety was found on the coral reef in the sublittoral zone, about 1–2 fathoms deep. People of Miyako call it *Sû-ur* and eat it.

PLATE XXI

PLATE 21

1. *Eucheuma serra* J. Ag.
   A dried specimen from Kasyôtô, Formosa. ×1
2. *Eucheuma serra* J. Ag.
   A dried specimen from Kaikô, Formosa. ×1



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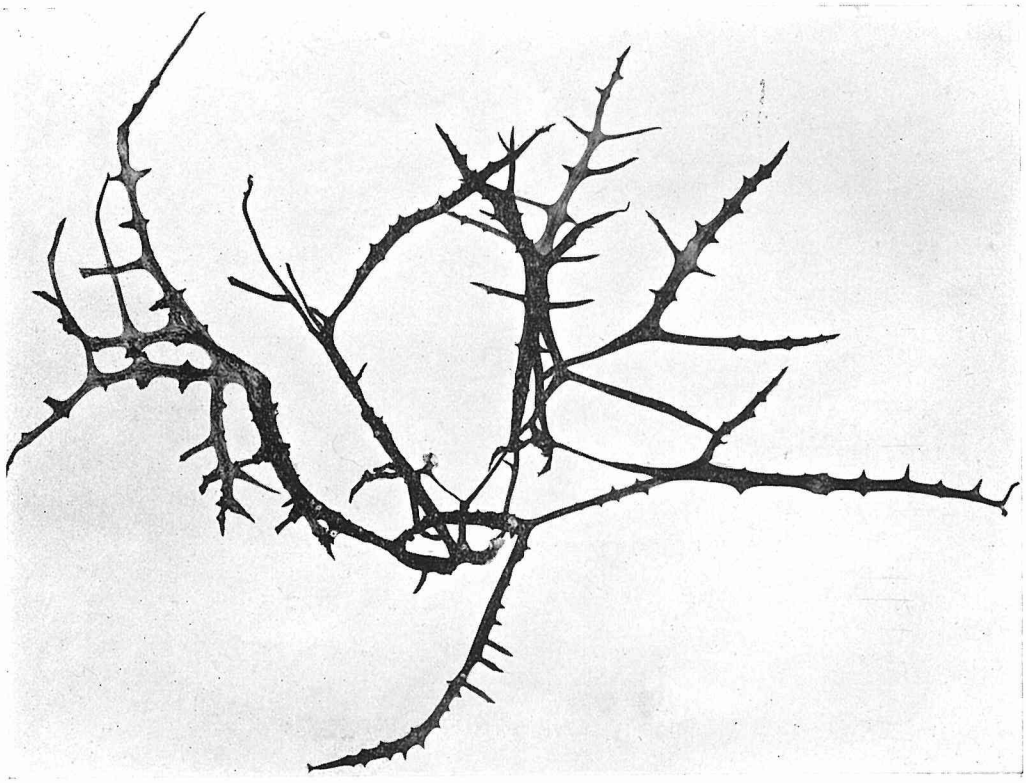

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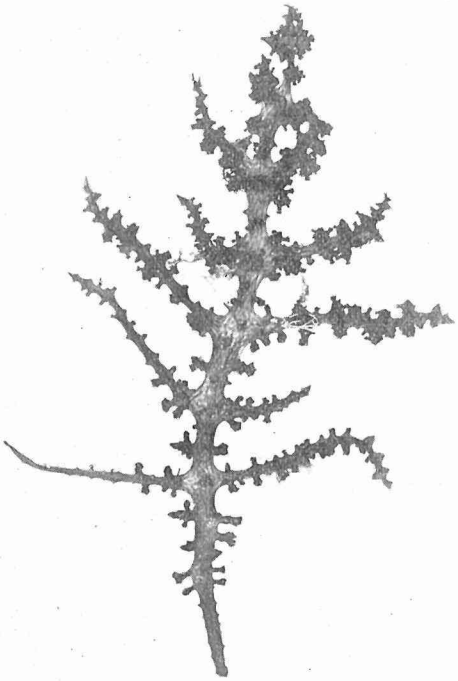
PLATE XXII

PLATE 22

1. *Eucheuma serra* J. Ag.
   A dried specimen from Kaikô, Formosa. ×1

2. *Eucheuma serra* J. Ag.
   A dried specimen from Garanbi, Formosa. ×1



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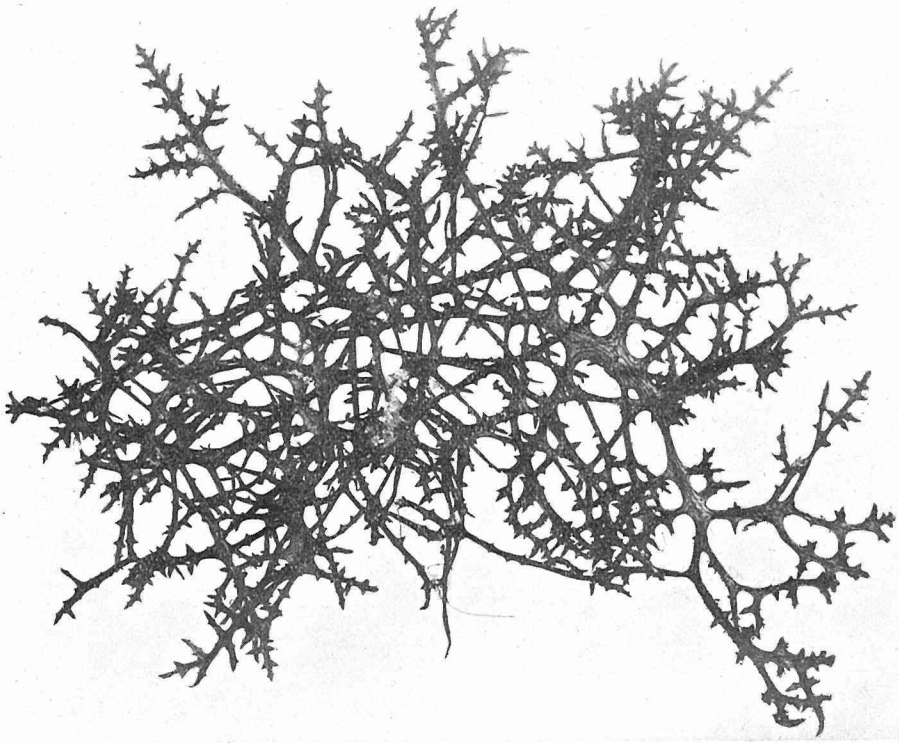

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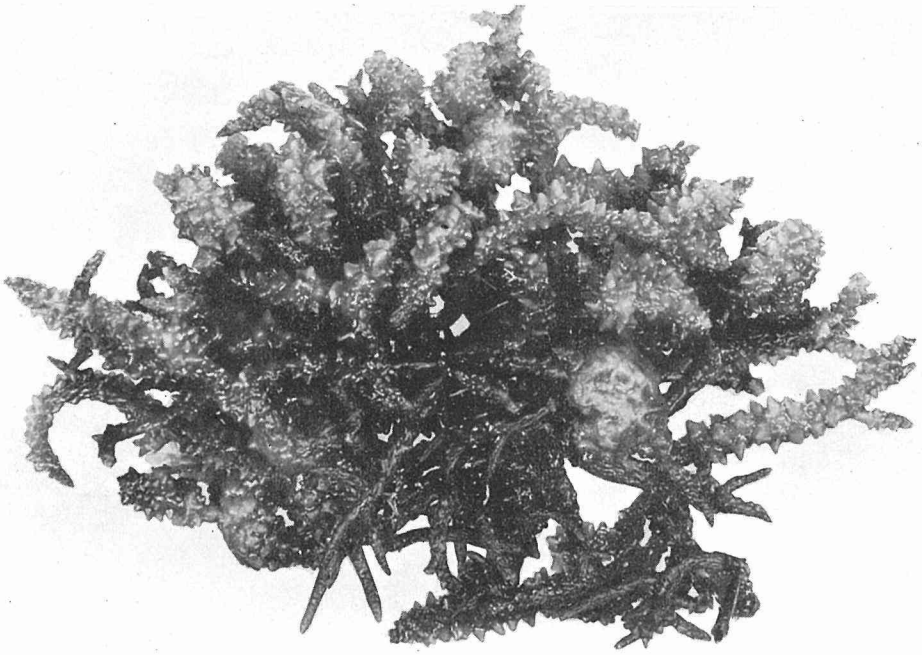
PLATE XXIII

PLATE 23

1. *Eucheuma muricatum* WEBER VAN BOSSE.
   f. *incrassata* f. nov.
   The co-type specimen. ×1

2. *Eucheuma muricatum* WEBER VAN BOSSE.
   f. *depauperata* WEBER VAN BOSSE.
   A specimen from Naha, Ryûkyû. ×1



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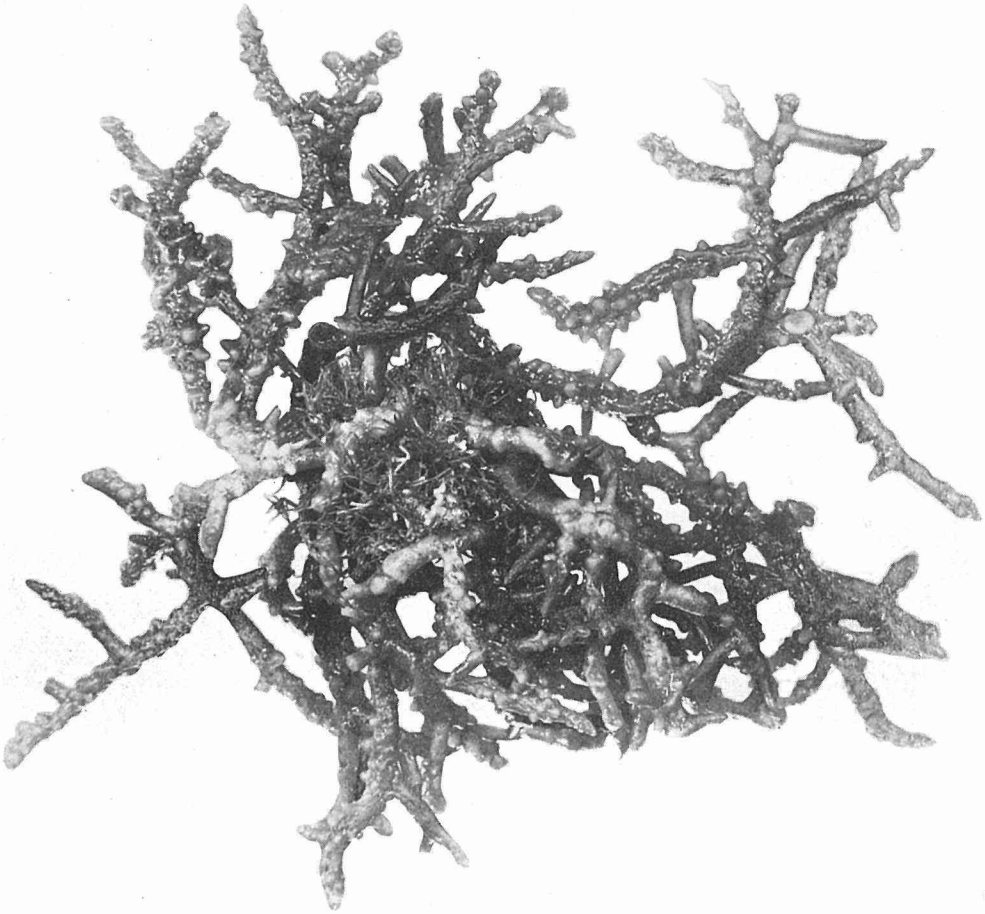

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PLATE XXIV

PLATE 24

Eucheuma striatum SCHMITZ.
A specimen from Miyako-dima, Ryûkyû. ×1

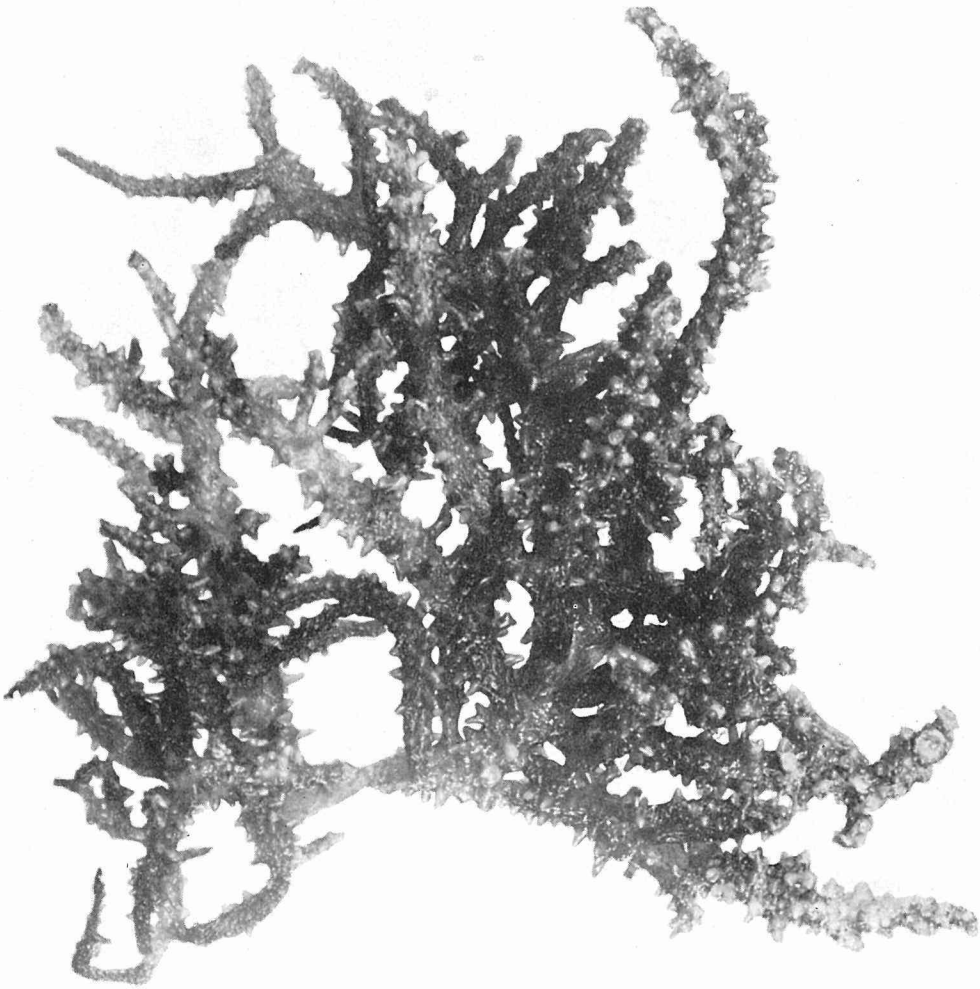


PLATE XXV

PLATE 25

Eucheuma striatum SCHMITZ.

A specimen with numerous young slender branches. Slightly reduced.

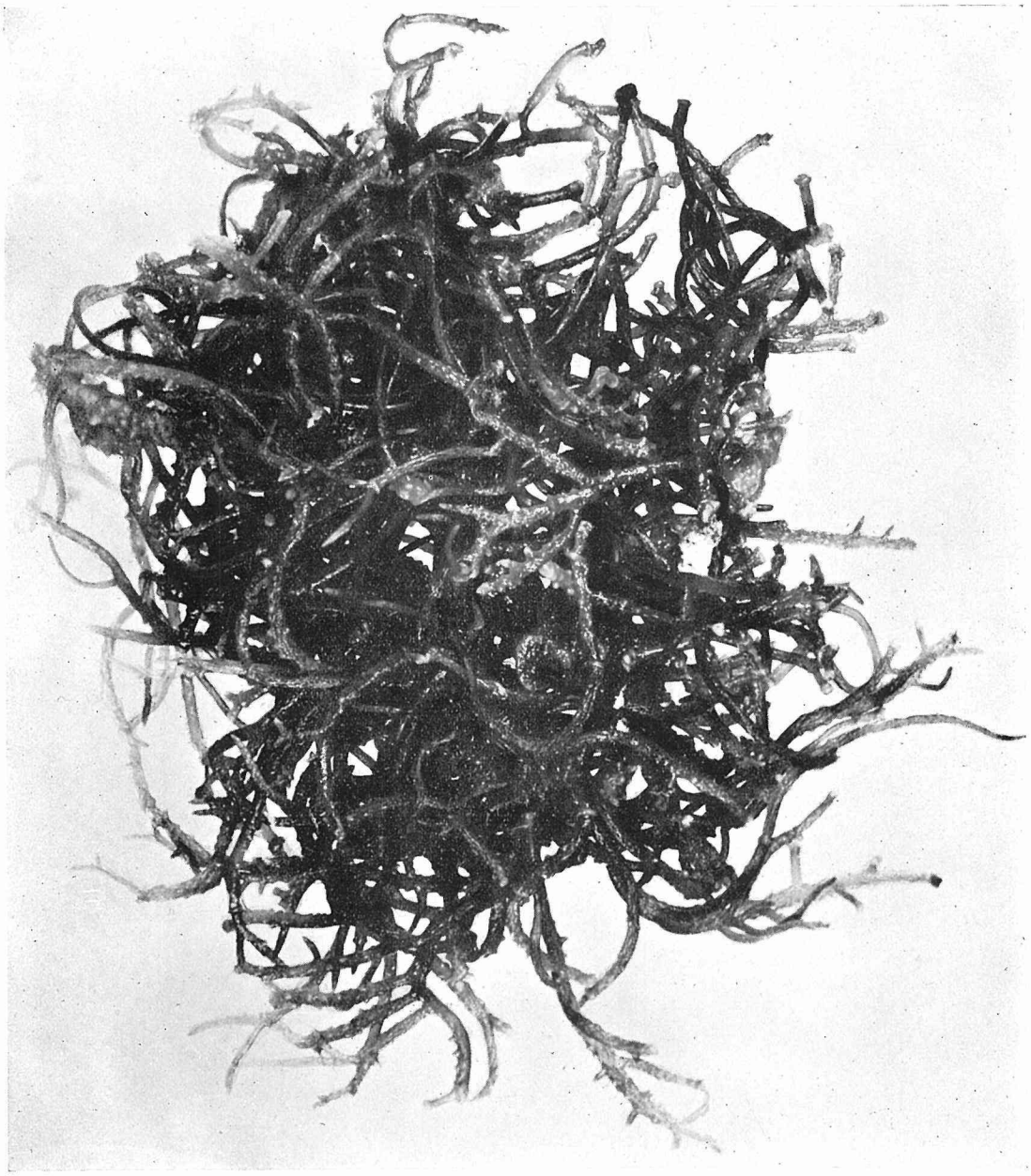


PLATE XXVI

PLATE 26

Eucheuma Okamurai sp. nov.
The type specimen. Slightly reduced.

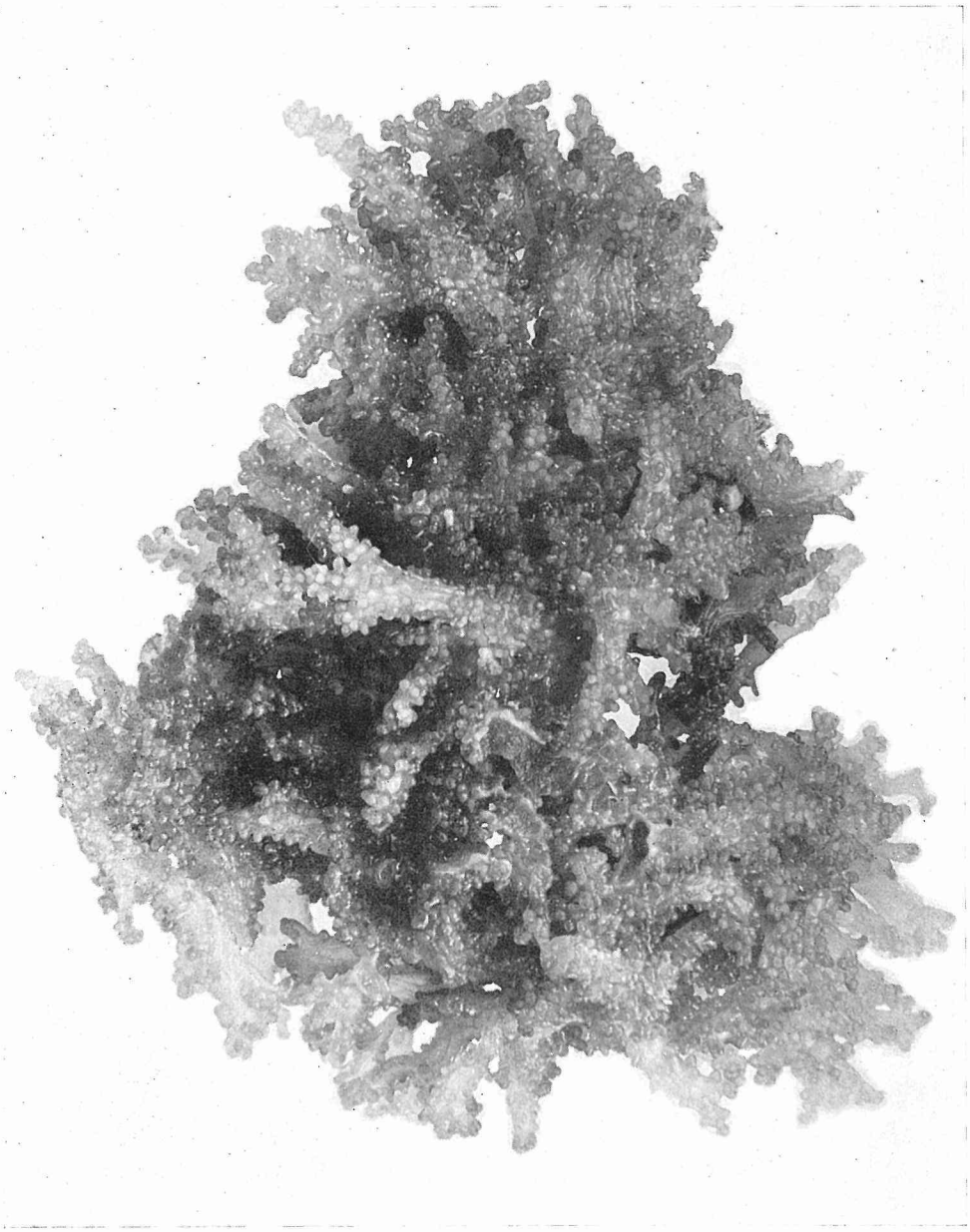


PLATE XXVII

PLATE 27

Eucheuma Okamurai sp. nov.

A specimen with young shoots. Slightly reduced.

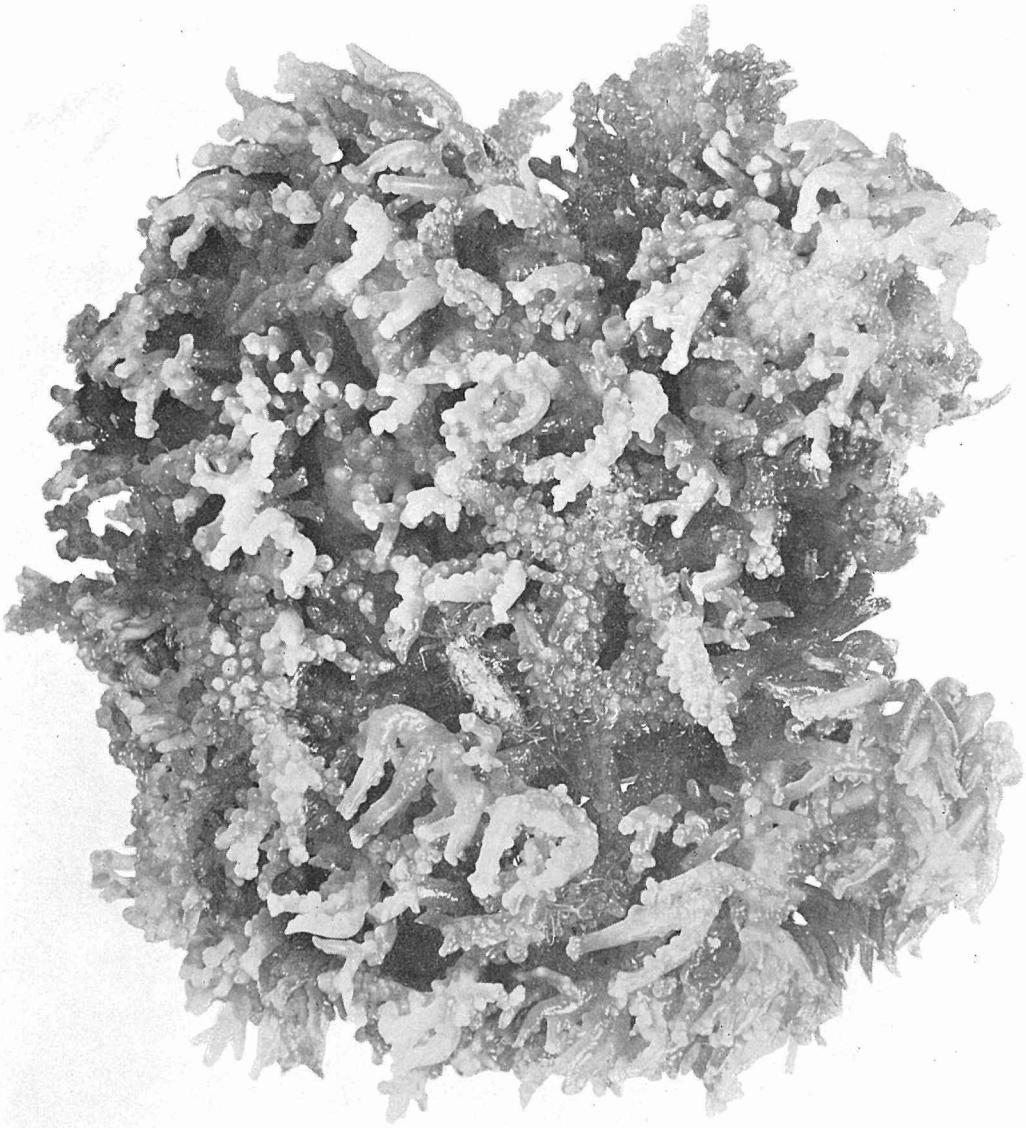
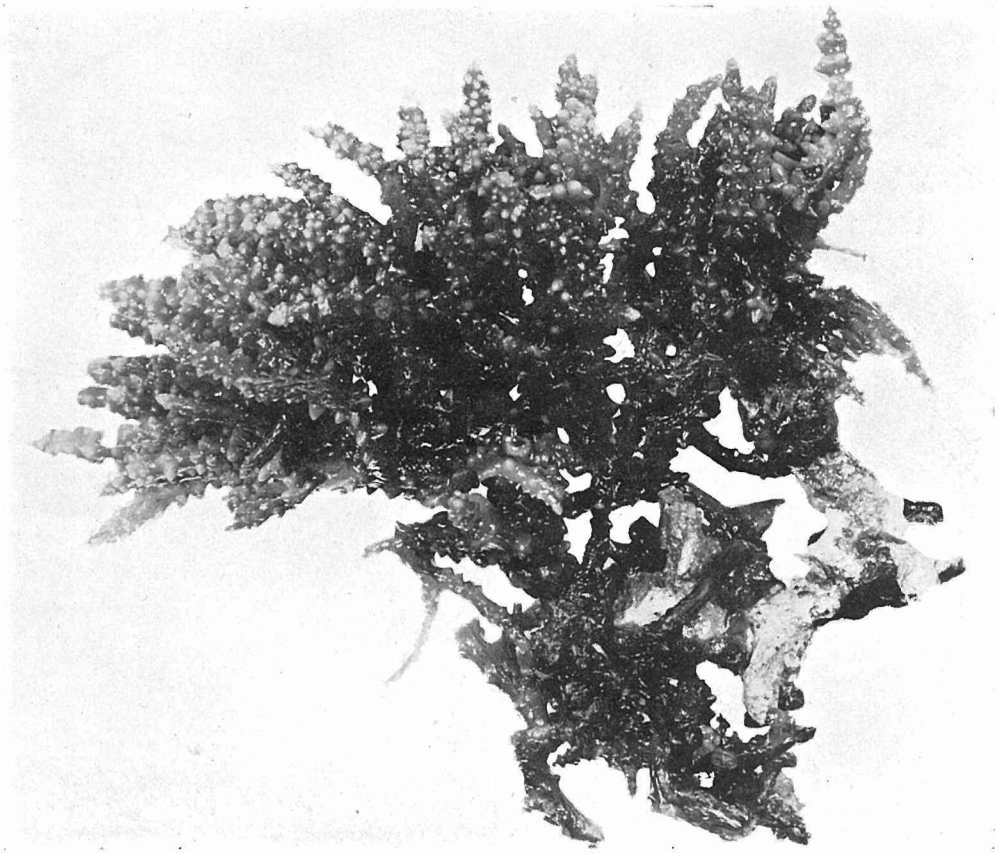


PLATE XXVIII

PLATE 28

1. *Eucheuma cupressoideum* WEBER VAN BOSSE. ×1
2. *Eucheuma crassum* ZANARD. ×1



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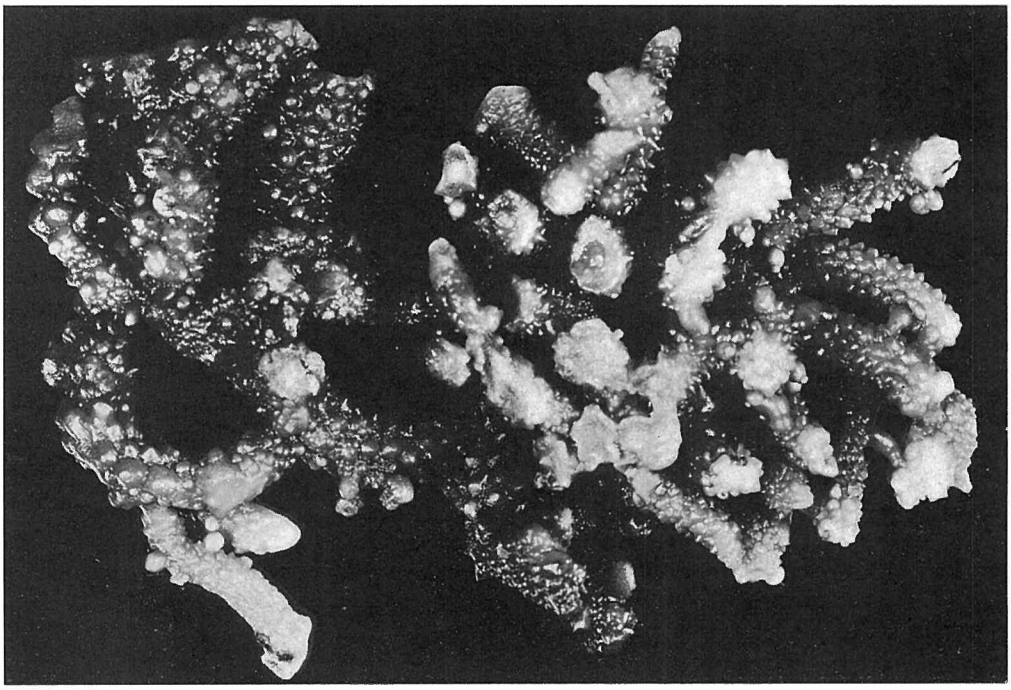

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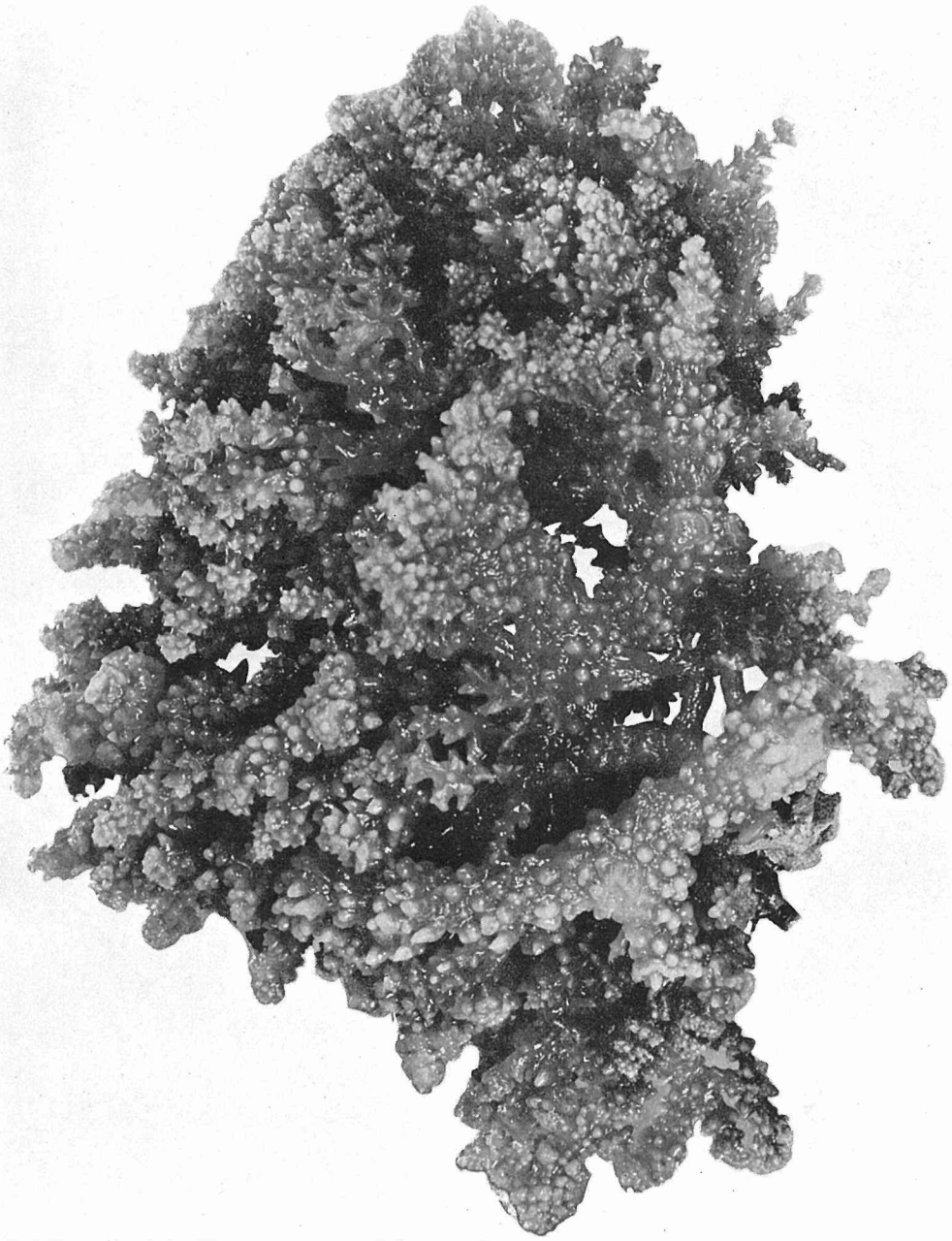
PLATE XXIX

PLATE 29

Eucheuma cupressoideum WEBER VAN BOSSE.
var. *verticillata* var. nov.
The type specimen. Slightly reduced.