

## Sexual reproduction in *Thorea* BORY (Rhodophyta, Thoreaceae)

Orlando NECCHI Júnior<sup>1</sup>

*Instituto de Botânica, Seção de Ficologia, Caixa Postal 4005, 01000 —São Paulo, SP, Brasil*

NECCHI O. Jr. 1987. Sexual reproduction in *Thorea* BORY (Rhodophyta, Thoreaceae). Jap. J. Phycol. 35: 106–112.

Spermatangium, carpogonium and carposporophyte are described from Brazilian material of *Thorea bachmannii*. In addition, “Chantransia” stage is also described. These plants are dioecious and male plants are clearly distinguished from the female ones by their slender thalli. Spermatangia are borne in pairs terminally and sub-terminally on short specialized branches. Carpogonia are conical. Carpogonial branches are borne laterally on short vegetative branches and consist of one or two short cylindrical or barrel-shaped, slightly pigmented cells. The trichogyne is elongate filiform and straight or curved. The gonimoblast filaments develop directly from the fertilized carpogonium. The carposporophyte is arranged in clusters without any kind of envoltorium. Gonimoblast filaments are short and sparsely branched. They are composed of cylindrical cells compactly arranged. Carposporangia are borne singly and in pairs, terminally and sub-terminally on gonimoblast filaments, with a dense and strongly coloured content. “Chantransia” stage arises in small tufts from a prostrate crustose basis which gives rise to abundantly and irregularly branched basal filaments and upper straight upright filaments of cylindrical elongate cells. Monosporangia are borne singly on short lateral branches and they are globose, ovoidal or obovoidal. Taxonomic implications of the findings are fully discussed. An amendment is proposed to the genus, since in the original diagnosis sexual reproductive organs, carposporophyte and “Chantransia” stage were not mentioned.

*Key Index Words:* carpogonium; carposporophyte; “Chantransia” stage; Rhodophyta; sexual reproduction; spermatangium; *Thorea*.

The genus *Thorea* was proposed by BORY (1808) with no reference to the reproductive organs. It comprises of about 10 species and is classified in the family Thoreaceae with the allied genus *Nemalionopsis* SKUJA, both containing only freshwater representatives. According to FRITSCH (1945) the thallus may be regarded as showing a specialized type of multiaxial structure.

Although the genus has been relatively well studied recently (SWALE 1962, 1963; BISCHOFF 1965; PUJALS 1967; SETO 1979;

NAKAMURA 1980; RATNASABAPATHY and SETO 1981; NECCHI 1985; YOSHIKAZI 1986), their reproductive organs have rarely been described. SCHMIDLE (1896) described trichogyne, antheridium and cystocarp in *Thorea ramosissima* BORY. However, FRITSCH (1945) regarded Schmidle’s cystocarp as probably being epiphytic blue-green algae, and the monosporangia as the only reproductive organs known. Sexual organs were described by NECCHI (1985) in *T. bachmannii* PUJALS ex PUJALS. YOSHIKAZI (1986) has reported sexual reproduction in *T. okadai* YAMADA. Thus sexual reproduction in *Thorea* is still a poorly known matter.

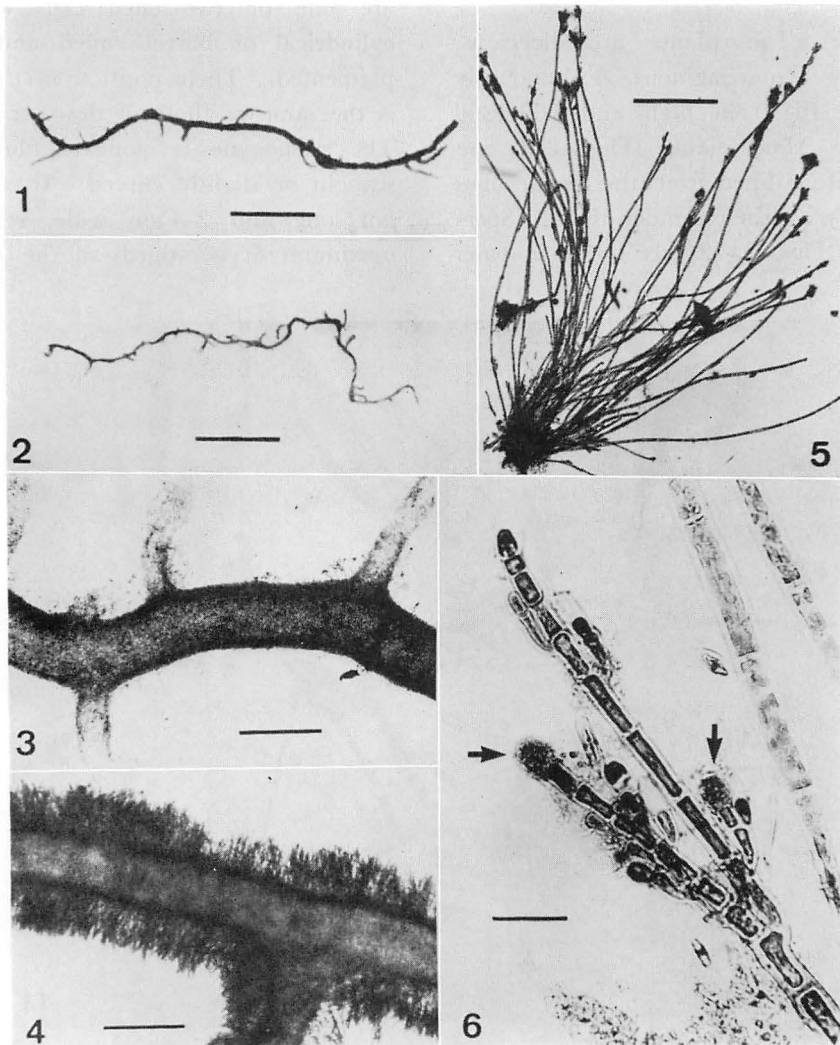
In the course of a taxonomic survey of

1. Present address: Instituto de Biociências, Letras e Ciências Exatas, UNESP, Departamento de Botânica, Caixa Postal 136–15.001–São José do Rio Preto, SP, Brasil.

the Brazilian freshwater Rhodophyta the author collected specimens of *Thorea bachmannii* presenting carpogonium, spermatangium, carposporophyte and "Chantransia" stage. The purpose of this study is to describe in detail the structures of sexual reproduction in *Thorea* as well as the carposporophyte and the "Chantransia" stage, and to discuss its taxonomic implications.

### Material and Methods

Fertile gametophytes of *Thorea bachmannii* were collected at River Conchas, Marechal Rondon Highway (SP-300), Município of Conchas, State of São Paulo, Brazil, 23°03'S, 47°57'W, on 23 August, 1983. Specimens of the "Chantransia" stage were collected on 31 October, 1984.



Figs. 1-6. *Thorea bachmannii*. 1. A portion of female plant. 2. A portion of male plant. 3. Structure of the thallus of male plant. 4. Structure of the thallus of female plant. 5. Habit of the "Chantransia" stage. 6. Apex of "Chantransia" stage filament showing monosporangia (arrows). (Scale bar: 10 mm for Figs. 1-2; 500  $\mu\text{m}$  for Figs. 3-5; 30  $\mu\text{m}$  for Fig. 6).

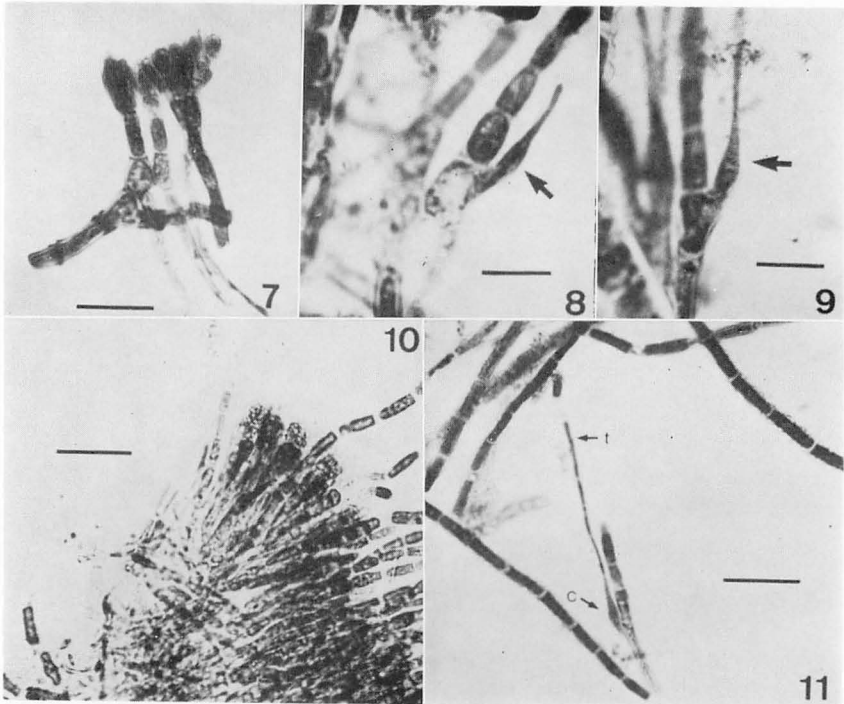
Specimens studied were preserved in 4% formaldehyde. For microscopic examination fragments were dissected with needles and mounted on slides in 1% aniline blue solution acidified with 3% 1N HCl and 50% Karo syrup. Specimens and slides of the plants studied are deposited in the Herbarium of the Instituto de Botânica, São Paulo, Brazil (SP).

## Results

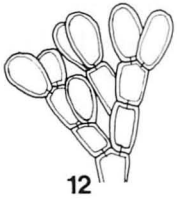
*Gametophyte*: The plants are dioecious, moderately mucilaginous, abundantly branched, 10–50 cm high and 800–1300  $\mu\text{m}$  wide. Male plants (Figs. 2–3) are clearly distinguished from the female ones (Figs. 1–4) by their slender thalli. Spermatangia (Figs. 7, 12) are borne in pairs

terminally and sub-terminally on short specialized branches near the basis of assimilatory filaments. They are elliptic or obovoidal, being  $8\text{--}10 \times 4\text{--}7 \mu\text{m}$ . The content is sparse and almost colourless. Spermatia are spherical or ovoidal after release and  $5\text{--}6 \mu\text{m}$  in diameter.

Carpogonia (Figs. 8–9, 11, 13–16) are conical and  $5\text{--}7 \mu\text{m}$  wide. Carpogonial branches (Figs. 8–9, 11, 13–16) are borne laterally on short vegetative branches and are one or two-celled; cells are short cylindrical or barrel-shaped and slightly pigmented. Their position in the thallus is the same as those of the spermatangia. The trichogyne is elongate filiform and straight or slightly curved. It is  $100\text{--}300 \mu\text{m}$  long and  $2\text{--}4 \mu\text{m}$  wide, reaching a maximum of two-thirds of the length of



Figs. 7–11. *Thorea bachmannii*. 7. Spermatangia on short specialized branches. 8. Early stage in the development of the carpogonium (arrow) with a young trichogyne. 9. Mature carpogonium (arrow) showing the basal portion of the trichogyne. 10. Mature carposporophyte. 11. Entire female gametangium showing the carpogonium (c) and the trichogyne (t). (Scale bar:  $20 \mu\text{m}$  for Fig. 7;  $10 \mu\text{m}$  for Figs. 8–9;  $30 \mu\text{m}$  for Figs. 10–11).

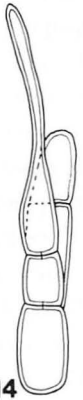


12

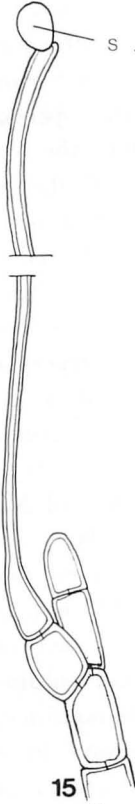


13

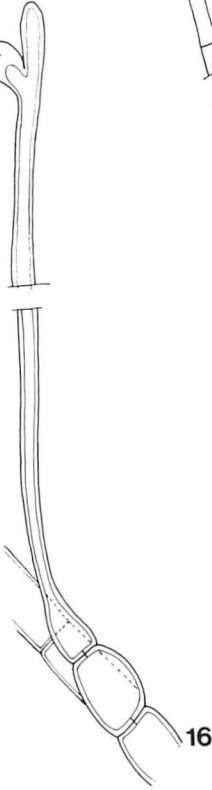
12-16  
10 μm



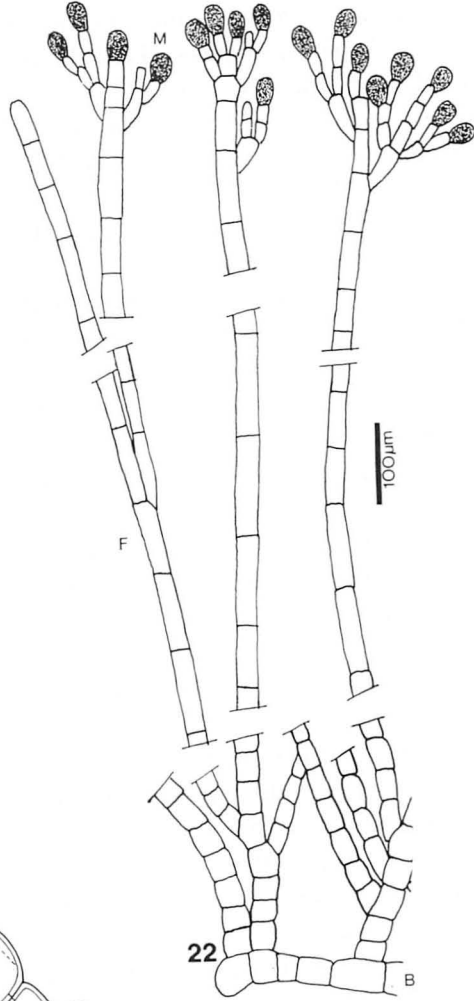
14



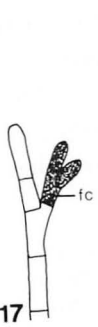
15



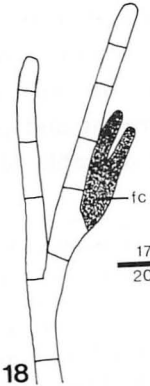
16



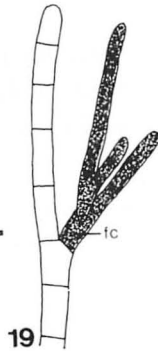
22



17

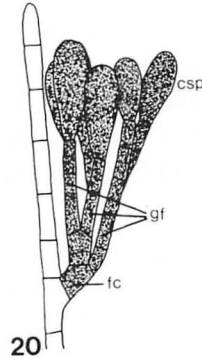


18



19

17-20  
20 μm



20

1 μm



21

the assimilatory filaments.

**Fertilization:** Spermata adhere to the distal end of the trichogynes (Figs. 15–16). Several spermata are generally seen adhering on the same mature trichogyne. The adhering spermatium fuses with the trichogyne (Fig. 16) and presumably migrates to the base of the carpogonium. The trichogynes fall off after fertilization.

**Carposporophyte.** Early carposporophyte development shows that the gonimoblast filaments develop directly from the fertilized carpogonium (Figs. 17–19). The mature carposporophyte (Figs. 10, 20) has a simple arrangement in clusters without any kind of envoltorium. Gonimoblast filaments (Figs. 20–21) are short and sparsely branched. They are composed of cylindrical cells compactly arranged. Carposporangia (Figs. 20–21) are borne singly or in pairs, terminally and sub-terminally on gonimoblast filaments. They are club-shaped or obovoidal and 17–25  $\mu\text{m}$  long and 8.5–13  $\mu\text{m}$  wide. Their content is dense and strongly coloured.

**“Chantransia” stage:** Plants of the “Chantransia” stage (Figs. 5, 22) arise in small bluish or blue-green tufts up to 3 mm high and arise from a prostrate crustose basis (Fig. 22). They are abundantly and irregularly branched in their basal parts and form straight upright filaments (Fig. 22) of cylindrical elongate cells, 20–60  $\times$  10–17  $\mu\text{m}$ . Monosporangia (Figs. 6, 22) are borne singly on short lateral branches. They are globose, ovoidal or obovoidal,

17–24  $\times$  13–16  $\mu\text{m}$ , monospores become round after release, and are 12–15  $\mu\text{m}$  in diameter.

## Discussion

Some progress has been made in knowing more about the sexual reproduction in *Thorea* since it was recorded by SCHMIDLE (1896). His observations were unsatisfactory and some points remained unclear, including the spermatangia, the carpogonium, and the carposporophyte. His description of the trichogyne and the illustration of fusion of the spermata with the trichogyne are fundamentally identical to ours. NECCHI (1985) described the spermatangia and the carpogonia, but not the carposporophyte. YOSHIZAKI (1986) supplied a better description of the reproductive organs, as well as of the carposporophyte. Schmidle's observations as well as those of NECCHI (1985) and of YOSHIZAKI (1986) complement and corroborate the present findings.

SWALE (1962) gave a description of the “Chantransia” stage of *Thorea ramosissima* from wild and cultured material. However, he could not interpret the significance of “Chantransia” in relation to the life history of *Thorea* because of the lack of knowledge of sexual organs. The “Chantransia” stage has also been reported in *T. riekei* BISCHOFF (BISCHOFF 1965). On the basis of the present and preceding observations it is reasonable to infer that the

---

Figs. 12–22. *Thorea bachmannii*. 12. Spermatangia terminal and sub-terminal on short specialized branches. 13–14. Early stages in the development of carpogonium with young trichogynes. 15. Mature carpogonium with spermatium (S) on the distal ending of the trichogyne. 16. Mature carpogonium showing fusion of the spermatium (S) with the trichogyne. 17–19. Early stages in the development of carposporophyte showing gonimoblast filaments developing directly from the fertilized carpogonium (fc). 20. Mature carposporophyte showing fertilized carpogonium (fc), gonimoblast filaments (gf) and carposporangia (csp). 21. Carposporangia terminal and sub-terminal on gonimoblast filaments. 22. Portion of “Chantransia” stage showing prostate crustose basis (B), upright filaments (F) and monosporangia (M).

life history of *Thorea* is probably the same as that of the representatives of the Batrachospermaceae. This assumption was previously made by PUESCHEL and COLE (1982) in classifying the Thoreaceae together with the Batrachospermaceae within their new order Batrachospermales. Their assumption is chiefly based on the ultrastructural characteristics of the pit plugs and also on the development of the gametophyte on the filaments of the "Chantransia" stage. This last fact was observed by SWALE (1962) in *Thorea ramosissima*.

HEDGCOCK and HUNTER (1899) found in the outer portion of the axis in *T. ramosissima* certain longitudinal fibers, which show no chlorophyll, and whose protoplasmic contents seemed to be homogeneous. They considered these fibers as being a portion of the assimilative axial region of the plant. To judge from their description such fibers are possibly trichogynes.

PUJALS (1967) in the description of *T. bachmannii* mentioned the occurrence of elliptical or pear-shaped monosporangia,  $6.5-9 \times 5-6.5 \mu\text{m}$ . They are very similar to the spermatangia described here in shape and size. So, it is probable that the "monosporangia" described by PUJALS are spermatangia. Similarly, it is possible that the structures described as "monosporangia" by other authors for different species are spermatangia or carposporangia. The real occurrence of monosporangia in the genus has to be carefully studied in the light of a new information concerning sexual reproduction.

The present finding of sexual reproduction permits proposal of an amendment of the genus since it was described by BORY (1808) without reference to the sexual structures, the carposporophyte, and the "Chantransia" stage.

### *Thored* BORY emend. NECCHI

Spermatangia e strato corticali evoluta, singula vel duo, in apicibus ramulorum specialium breviorum.

Ramuli carpogoniferi e basi ramulorum corticalium laterale evoluta, brevi, ex 1-2 cellulis constantes. Trichogyne filiformis, longa.

Carposporophytum e strato corticali evolutum, in fasciculo dense aglomeratum. Fila gonimoblastorum brevia, sparse ramicantia, ex cellulis cylindratis brevibus constantes. Carposporangia singula vel duo in filibus gonimoblastorum terminalibus vel subterminalibus.

Status "Chantransia" caespitosus, e filis repentibus et filis erectis irregulariter ramosis constructus, ex cellulis cylindratis longis constantes. Monosporangia singula vel duo in filis lateralia stipitata.

### Acknowledgements

The author wishes to express his sincere thanks to Mr. Alasdair G. BURMAN for reviewing the English text and the Latin diagnosis. This study was supported by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) Grant nr 82/1071-9.

### References

- BISCHOFF, H.W. 1965. *Thorea riekei* sp. nov. and related species. *J. Phycol.* **1**: 111-117.
- BORY DE SAINT-VICENT, J.B. 1808. Mémoire sur un genre nouveau de la Cryptogamie aquatique, nommé *Thorea*. *Ann. Mus. Jist. nat.* **12**: 126-135.
- FRITSCH, F.E. 1945. The structure and reproduction of the algae. Vol. 2. University Press. Cambridge.
- HEDGCOCK, G.G. and HUNTER, A.A. 1899. Notes on *Thorea*. *Bot. Gaz.* **28**: 425-429.
- NAKAMURA, T. 1980. Some remarks on *Thorea* found in the Kanto district, Japan. *Jap. J. Phycol.* **28**: 249-254.

- NECCHI, O. Jr. 1985. Rhodophyta de água doce do Estado de São Paulo: levantamento taxonômico. Master Thesis, Universidade Estadual Paulista "Júlio de Mesquita Filho", Rio Claro.
- PUESCHEL, C.M. and COLE, K.M. 1982. Rhodophycean pit plugs: an ultrastructural survey with taxonomic implications. *Am. J. Bot.* **69**: 703-720.
- PUJALS, C. 1967. Presencia em la Argentina del genero *Thorea*. *Com. Mus. argent. Ci. nat. Bern. Rivad.* **1**: 55-64.
- RATNASABAPATHY, M. and SETO, R. 1981. *Thorea prowsei* sp. nov. and *Thorea clavata* sp. nov. (Rhodophyta, Nemaliales) from West Malaysia. *Jap. J. Phycol.* **29**: 243-250.
- SCHMIDLE, W. 1896. Untersuchungen über *Thorea ramosissima* BORY. *Hedwigia* **35**: 1-33.
- SETO, R. 1979. Comparative study of *Thorea gaudichaudii* (Rhodophyta) from Guam and Okinawa. *Micronesica* **15**: 35-39.
- SWALE, E.M.F. 1962. The development and growth of *Thorea ramosissima* BORY. *Ann. Bot., new ser.*, **26**: 105-117.
- SWALE, E.M.F. 1963. Notes on the morphology and anatomy of *Thorea ramosissima* BORY. *J. Linn. Soc. (Bot.)* **58**: 429-435.
- YOSHIZAKI, M. 1986. The morphology and reproduction of *Thorea okadai* (Rhodophyta). *Phycologia* **25**: 476-486.

**Orland Necchi Júnior : チスジノリ属 (紅藻, チスジノリ科) の有性生殖**

ブラジル産の *Thorea bachmannii* の造精器, 造果器, 果胞子体に加えてシャントランシア期を記載した。本種は雌雄異株, 雄株は雌株より細い。造精器は短い特別の枝の先端, または先端近くに2個ずつ形成される。造果器は徳利形。造果器をつける枝は1-2個の円柱形または樽形の細胞からなり, 短い栄養枝上に側生する。長い糸状の受精毛は真っ直ぐ, または弯曲する。受精した造果器から直接発出する造胞糸は, 短く, 疎らに分枝する。果胞子嚢は, 造胞糸の先端, または先端近く, 単独に, または2個ずつ形成される。(Instituto de Biociências, Letras e Ciências Exatas, UNESP, Departamento do Botânica)