SOME CHLOROPHYCEAE FROM THE MARINE SALINES OF BONAIRE (NETHERLANDS WEST INDIES)

by

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A collection of samples containing algae from the salines of Bonaire was brought home by Mr P. Wagenaar Hummelinck from his trips to the Netherlands West Indian Islands in 1930 and in 1936—1937. Though these trips were chiefly undertaken in order to gather zoological material (1, 2) [1]), the collector paid attention to botanical objects as well, results of which are to be found in eight earlier papers (3—10).

Several data concerning Bonaire can be learned from Mr Wagenaar Hummelinck's publications. The island, having an area of about 265 km², is chiefly composed of quaternary limestone (coralrocks), which forms a large plateau in the North East and the South. The Northwestern part of the island is much higher and more indented. Klein Bonaire, having an area of only 7 km² and situated ¾ km West of Bonaire, consists of a low limestone plateau only.

A saline (saliña, salinja) may be a real saltlake or a plain, on which in the rainy time more or less briny water is to be found. The salines are usually separated from the sea by a porous wall of coral debris.

The algae have been preserved either dry, or in formaline or alcohol and are to be found in the Rijksherbarium at Leiden.

Bathophora Oerstedi J. Ag. in Ofvers. Kungl. Vet. Akad. Förh. 11, 1854, 107; Børgesen in Bot. Tidsskr. Bd. 23, 1900, 56; Howe in Bull. Torrey Bot. Club Vol. 32, 1905, 578; Børgesen in Bot. Tidsskr. København Bd. 28, 1908, 273, fig. 3; Børgesen in Biol. Arbeyder tilegnede Eug. Warming, 1911, 50; Børgesen, Mar. alg. Dan. W. Ind. Vol. I, 1913—1914, 73, fig. 58—60; Howe in Britton, Fl. of Bermuda, 1918, 499; Howe in Britton and Millspaugh, Bahama Fl., 1920, 604; Printz in Engl.-Prantl, Nat. Pfl. Fam. 2. Aufl. Bd. 3, 1927, 291, fig. 228, 229; Taylor in Pap. Tortugas Lab. Carn. Inst. Wash. Vol. XXV, 1928, 68, Pl. 5, fig. 1, 2, 15, 16; Fritsch, Struct. and Reprod. of the Algae, 1935, 389, fig. 123 E, G; Taylor in Carn. Inst. Wash. Publ. 461, 1935, 118; Taylor in Pap. Mich. Acad. Sci., Arts and Lett. Vol. XXI, 1935, 205; — *Dasycladus occidentalis* Harv. Ner. Bor. Amer., Part III, 1857, 38, Pl. 41 B, fig. 1—6; Cramer

[1]) The numbers in brackets refer to the bibliography.

in Neue Denkschr. Allgem. Schweiz. Naturf. Gesellsch. Bd. 30, 1887, 37, T. V, fig. 2—8 (subgenus *Coccocladus*); — *Dasycladus Conquerantii* Crouan in Schramm et Mazé, Alg. de la Guadeloupe, 1866, 115; Mazé et Schramm, Alg. de la Guadeloupe, 2e ed., 1870—1877, 108; — *Botryophora occidentalis* J. Ag., Till Alg. Syst. V Afd., 1887, 141; Murray in Journ. of Bot. Vol. 27, 1889, 242; Børgesen in Bot. Tidsskr. Bd. 23, 1900, 56; Collins in Proceed. Amer. Acad. of Arts and Sci. Vol. 37, 1901, 247; Sluiter in Rec. Trav. Bot. Neerl. IV, 1907, 6; — *Coccocladus occidentalis laxus* Howe in Bull. Torrey Bot. Club Vol. 31, 1904, 95, Pl. 6, fig. 1, 2 — *Coccocladus occidentalis Conquerantii* (Crouan) Howe in Bull. Torrey Bot. Club Vol. 31, 1904, 96.[1])

Loc.: Salinja Plenchi, on shells of *Cerithium*, along the flat and low shore of a very shallow lake, which contains sea water; temp. ca 32—35° C; Cl ca 30—40 gr/l; 3 XII 1930. Two groups of club-shaped plants, among which one specimen with spherical sporangia (according to Fritsch gametangia, called aplanosporangia by Printz); plants 2½—6 cm long, 6—9 mm thick, of one group of plants the principal axis is covered with branches to the base, of the other it becomes branchless to the base. Of the specimens in the Leiden Herbarium this branchless basal part is quite variable in length varying from 0—8½ cm. There seems to be a relation between the age of the plant and the length of this branchless basal part, the branches dropping from the base to the apical part. Whorls of scars are to be seen on the branchless basal part.

Loc.: Salinja Plenchi, on crusts of lime and shells, in a very shallow pool; temp. ca 32—35° C; Cl. 42, 25 gr/l; 26 III 1937. Much aggregated, 2—2½ cm long, 3—7 mm thick, covered with branches almost to the base; sporangia spherical, crowded.

Loc.: Lac, to the West of the island Rancho, in a shallow muddy lagoon, about ¾ m deep, blocked from the open water by mangroves; temp. ca 32° C; Cl 20—25 gr/l; 8 X 1930. Lac is a bay on the East-coast, which is protected against the violence of the surf by a reef. A large beach forest of *Rhizophora* borders Lac (1, p. 304). Lax habit; most of the plants elongated, 2—11 cm long, 3—7 mm thick, basal part, ½—6½ cm long, without branches, whorls distanced; sporangia ovoid.

Loc.: Salinja Klein Bonaire, on crusts of lime, along the wall of debris bordering a shallow saltlake; much floating material in the water; temp. 32° C; Cl ca 39 gr/l; 9 VI 1930. Small poor plants, about 1 cm high.

The area of *Batophora Oerstedi* (fig. 1) is limited, but the species is locally frequent (acc. to the labels of the herbarium specimens and to literature). The area includes: the Bermuda Islands, Florida (Pinellas County, Tarpon springs, Miami, Cutler, Key West, Dry Tortugas), Bahama Islands (Great Bahama Island, Berry Islands, Rose Island, New Providence Island, Nassau Island, Andros Island, Cat Island, Great Exuma (Georgetown), Great Ragged Island, Watling's Island, Acklin Island, Mariguana Island, Caicos Island); Cuba, British Honduras (Belize),

[1]) As a consequence of the present war a great deal of the new literature of the last four years has been inaccessible to the author.

Jamaica (Kingston, Port Antonio), St Croix, Tortola, Guadeloupe (Pointe à Pitre), Bonaire (and Klein Bonaire), Curaçao.

Bathophora Oerstedi occurs in brackish or salt, quiet (sometimes dirty), shallow to 3 m deep water, between the tide marks or near the low water mark. The habitats mentioned include: pools, lagoons and creeks, mud (sometimes almost dry), sand, rocks, cays, coral fragments, crusts of limestone, shells, pebbles, sticks, old shoes, algae (*Halimeda*, *Sargassum*), rhizomes of *Thalassia*, and roots of *Rhizophora* and *Avicennia*.

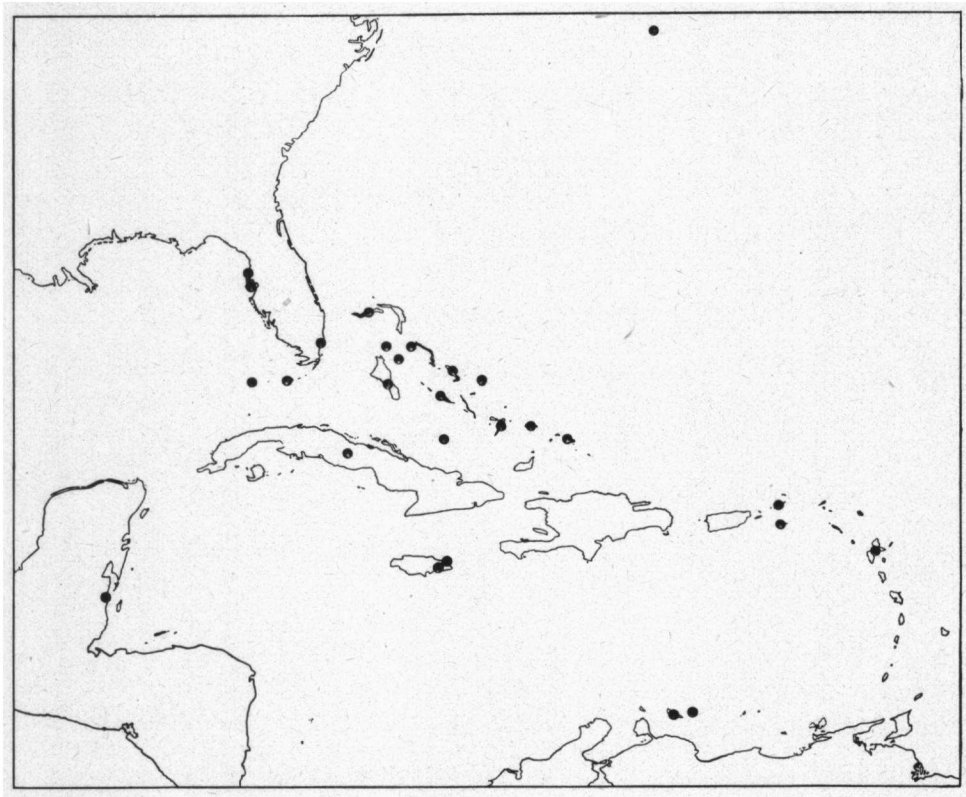


Fig. 1 — Area of *Batophora Oerstedi* J. Ag.
Where no exact locality is known to the author, the dot is placed in the centre of the island concerned.

Howe concludes that the salinity and the quietness of the water influence the size and habit of the plant and the shape of the sporangia. In quiet and often brackish water the habit is lax and large, the sporangia are obovoid or oblong (var. *laxus* Howe, considered by himself unworthy to be kept up as a variety); along the border of the open ocean the habit is condensed (var. *occidentalis* [Harv.] Howe, kept up by Taylor). Howe studied living plants and found intermediate habits in places of

intermediate character. Børgesen, after having inspected the species in St Croix, quite agreed with him.

The specimens in the Leiden Herbarium are 1—14 cm long and 2—12 mm thick on the greatest width. Geographically distinguished they have the following dimensions.

Usually robust are the plants from the Bahamas:

cm long	mm thick	sporangia	habitat
1½—2½	3—4		
5—7	5—6	spherical	low littoral to 2 m
5—10	5—6	ovoid	salt water
10—14	6—12	spherical or ovoid	slightly brackish pond

The plants from the Bermudas are small:

cm long	mm thick
2—2½	3
2½—3½	2—3

and very small those from Key West:
1—1½ cm long, 2 mm thick.

and from Jamaica:
1 cm long, 2 mm thick.

The specimens from the peninsular part of Florida are moderate in size

cm long	mm thick	sporangia
± 4	3	spherical
3½—6½	4—5	

but from the Antilles we find all sizes:

St Croix:	cm long	mm thick	sporangia
	2—5½	5—9	ovoid
	2½—6	5—6	spherical or ovoid

Tortola: 1½—2½ cm long, 2—3 mm thick.

Bonaire: cm long	mm thick	sporangia	habitat, Cl gr/l
± 1	5	-	39
2—2½	3—7	spherical	42, 25
2½—6	6—9	spherical	30—40
2—11	3—7	ovoid	20—25

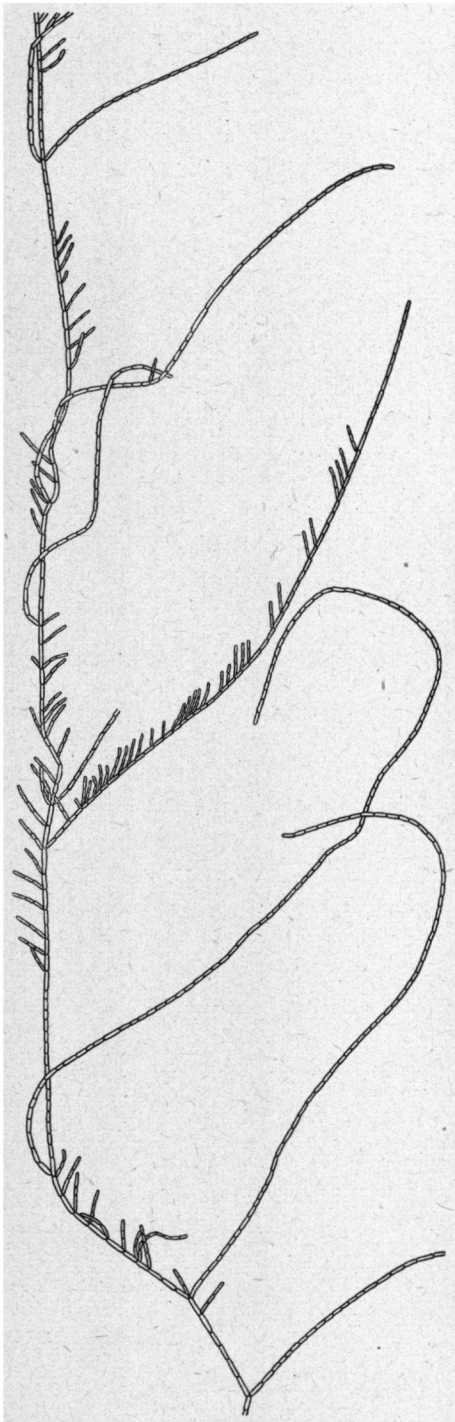
The data of the plants from Bonaire give some indications to Howe's conclusion: the higher the salinity of the habitat, the smaller the plant and the more spherical the sporangia.

Enteromorpha flexuosa (Wulf.) J. Ag., Till Alg. Syst. III Afd., 1883, 126; Collins in Proceed. Amer. Acad. Arts and Sci. Vol. 37, 1901, 242; Collins in Rhodora V, 1903, 21, Pl. 42, fig. 3; Vickers, Phycol. Barbad., 1908, 15, Pl. III, fig. 1—9; Børgesen, Mar. Alg. Dan. W. Ind. I, 1913—1914, 5; Weber—van Bosse, Liste des Alg. du Siboga, 1913—1928, 52; Howe in Britton, Fl. of Bermuda, 1918, 494; Setchell and Gardner in Univ. Calif. Publ. Bot., Vol. VIII, 1919—1920, 255; Howe in Britton and Millspaugh, Bahama Fl., 1920, 598; Taylor in Pap. Tortugas Lab. Carn. Inst. Wash., Vol. XXV, 1928, 55, Pl. 7, fig. 2; Taylor and Arndt in Amer. Journ. of Bot. XVI, 1929, 655; Lakowitz, Algenfl. Ostsee, 1929, 121, fig. 167; Feldmann in Bull. Soc. Hist. Nat. Afr. du Nord, T. 22, 1931, 202; Børgesen in Kgl. Danske Vidensk. Selsk., Biol. Medd. XII, 2, 1935, 8; Feldmann in Rev. Alg. T. IX, 1937, 52; Børgesen in Kgl. Danske Vidensk. Selsk. Biol. Medd. XV, 4, 1940, 9 — *Enteromorpha compressa* (L.) Grev. var. *flexuosa* (Wulf.) Hamel in Rev. Algol., T. VI, 1931, 63, fig. 48, 1—2.

Loc.: Lagoen di Goto, near Riscado, on debris, in a porous place of the shore of a large saltlake; temp. ca 30° C; Cl ca 20—30 gr/l?; 26 VIII 1930. Tubular, tubes attached, many together, aggregated, gradually attenuate to the base to filiform, sometimes undulate and somewhat shrivelled, unbranched, (except for some few very short branches at the base), to 6 cm long, ¼—5 mm wide; cells in regular longitudinal rows, mostly square or rectangular, sometimes triangular, often with rounded angles, 12—20 μ long and broad.

Loc.: Lagoen di Goto, Eastshore, on coral debris, in porous places of the steep shore of a large saltlake and near the wall of debris; salinity locally variable; temp. ca 30° C; Cl ca 25—35 gr/l; 26 VIII 1930. Tubes about ½ mm wide, consisting of about 2—30 longitudinal rows of cells; cells rectangular or polygonal, 20—32 μ long, 16—20 μ broad.

Loc.: Salinja Foenshi, on debris, along the porous wall of debris of a saltlake; temp. ca 30° C; Cl ca 25—30 gr/l; 9 IX 1930. Tubes flexuous, often more or less crispate, unbranched, to 12 cm long, ½—2 mm wide; cells in fairly regular longitudinal rows, subrectangular, 12—16 μ long and broad.



Loc.: Salinja Foenshi, on rocks, a few decimetres above the water-level, dry, indicating a higher water-level in the rainy season; temp. 30° C; Cl ca 30—40 gr/l; 9 IX 1930. Tubes narrow, to ½ mm broad; cells subrectangular, 8—16 μ long and broad.

This marine species occurs in the West Indies in: the Bahamas, Jamaica, Haiti, St Croix, St Jan, Barbados; further it is recorded from Florida, the Bermudas, from the Mediterranean, the Baltic, the Atlantic coast of France, Algeria and from Mauritius, Bombay and the Malay Archipelago. Feldmann supposes the species to be cosmopolitan, especially in the warmer seas. It grows on stones, rocks, shells, algae, in pools, in the littoral zone, in sheltered places, in stagnant water, as well as in places exposed to the surf, often in brackish water.

Cladophora delicatula Mont. in Ann. Sci. Nat. Sér. 3 Bot., T. XIV, 1850, 302; Kütz, Tab. Phyc. VI, 1856, 1, T. 1, fig. II; Mazé et Schramm, Alg. de la Guadeloupe, 2e ed., 1870—1877, 65; Murray in Journ. of Bot., Vol. 27, 1889, 259; Collins, Green Alg. N. Am., 1909, 337; Setch. et Gardner in Univ. Calif. Publ. Bot., Vol. VIII, 1919—1920, 220; Taylor in Pap. Tortugas Lab. Carn. Inst. Wash., Vol. XXV, 1928, 61; (fig. 2).

Loc.: Lagoen di Goto, near Riscado, on debris, in a porous place of the shore of a large saltlake; temp. ca 30° C; Cl ca 20—30 gr/l ?; 26 VIII 1930. Filaments very thin, about 40 μ thick; ramifications of the first order elongated, subdichotomous, especially to be found at the superior part of the plant; of the

Fig. 2 — *Cladophora delicatula* Mont., × 25.

second order short, comblike, fairly close together, often more or less unilateral, but not quite in the same plane above each other, lacking on many ramifications of the first order, obtuse at the tip, usually existing of 3—4 cells; cells 2—6 times as long as broad, gradually shorter to the tip.

Agrees well with the specimen in Kützing's Herbarium, to which a label is added, on which Montagne has written "Cladophora delicatula Montg. — Guyana — hb Montagne". This specimen must be part of the type and has been used by Kützing for the figure in Tab. Phyc.; it is still less branched than the specimens of Bonaire. More branched on the contrary are two specimens from California (Phyc. Bor. Am. 1582) and Bermuda (Phyc. Bor. Am. 2070) and of these the filaments are thicker, about 80 μ thick. They may belong to a variety or to a different species. The area of this *Cladophora* species includes with certainty only Cayenne (on rocks along the sea, exposed to the surf) and Bonaire, but Collins records also California, Florida, Jamaica and Puerto-Rico (however, his description does not quite agree with the specimen mentioned above).

Loc.: Lagoen di Goto, Eastshore, on coral debris, in porous places of the steep shore of a large saltlake and near the wall of debris; salinity locally variable; temp. ca 30° C; Cl ca 25—35 gr/l; 26 VIII 1930. Not numerous.

Some few more species of *Chlorophyceae* (*Chaetomorpha, Cladophora*) were only extant in too fragmentary specimens to secure a correct identification.

Frémy, whose paper (10) has reached the author only after her manuscript was completed, records the following species of *Chlorophyceae* from the salines of Bonaire: *Bathophora Oerstedi* (Salinja Klein Bonaire, 9 VI 1930), *Enteromorpha flexuosa* Ag. (Goto, Lagoen, 26 VIII 1930; Salinja Foenshi, 9 IX 1930), *Enteromorpha intestinalis* (Salinja Paloe Lechi, 28 VIII 1930), *Enteromorpha prolifera* (Goto, Lagoen, 26 VIII 1930), *Chaetomorpha Linum* (Salinja Paloe Lechi, 28 VIII 1930), *Rhizoclonium Kochianum* (Salinja Paloe Lechi, 29 VIII 1932 [not 1930, J. Th. K.]; Goto, Lagoen, 26 VIII 1930), *Cladophora expansa* (Salinja Paloe Lechi, 28 VIII 1930), *Cladophora fracta* (Salinja Slagbaai, 8 IX 1930).

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