THE NETHERLANDS' MARINE CLADOPHORA SPECIES

by

A. F. G. SLOOTWEG

(Leiden).

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When studying the marine species of the genus *Cladophora* in the Netherlands, I had the disposal of the material of the National Herbarium at Leiden, the herbaria of the Universities of Amsterdam, Groningen and Utrecht and those of the "Zoölogisch Station" at Den Helder and the "Koninklijke Nederlandse Botanische Vereniging" at Leiden. It is a pleasure to me to express my best thanks to the directors of the Institutes mentioned above, for putting the material at my disposal, and to Miss Dr J. Th. Koster, who gave me much valuable help.

Especially the material of the National Herbarium at Leiden was very interesting to me, since it contains the herbaria of Kützing, Hauck, and very many reliable exsiccata, so it was possible to compare some Dutch species with the original specimens.

The herbarium of the "Zoölogisch Station" at Den Helder contains the collection of Van Goor, on which he based his observations on the marine Cladophora species in: Van Goor, "Die Holländischen Meeresalgen"; so I could check the determinations of Van Goor and compare his specimens with those in the herbarium of Kützing.

The genus *Cladophora* is known as a very difficult one, because the species are poor in adequate morphological characters. Moreover, the sterile parts are very dependent on environmental factors, such as salinity, current, temperature, insolation etc. A change in one or more of these factors may influence the growth of the algae and cause them to vary from the normal type. I therefore think it possible that under extreme conditions, such as exist in several localities in Zeeland, widely different species tend to develop the same phenotype, and may show different degrees of divergence from the type. This divergence may concern several features in which case identification must be based on a large number of specimens. Especially the dimensions, and, to a lesser degree the branching of the filaments and the number of the branches vary under the influence of the environment.

Bliding pointed out that the zoospores belonging to closely related species of *Cladophora* are different, so that it seems possible that they possess the more constant features on which identification may be based.

All the investigations, as well as the figures are based on herbarium material.

Van Goor collected specimens which he identified as *Cladophora albida* (Huds.) Kütz. (v. Goor, p. 126) at Zeeburg and Stavoren, and mentioned this species as new for the Netherlands. He based his determination on the description and the herbarium material of Kützing. I had the opportunity to compare both Van Goor's and Kützing's material with a specimen identified by Hudson (Kew Herbarium), and found that none of it belonged to *Cl. albida* (Huds.) Kütz. Van Goor's specimens appeared to be *Cl. refracta* (Roth.) Kütz., just as two specimens collected by Van den Bosch at "Zandkreek" and "Haven van Goes". *Cl. refracta* is very variable (diameter ultimate ramuli 40—120 μ), the specimens mentioned above are extraordinarily thin. As far as I know, *Cl. albida* has not been found in the Netherlands up to this time.

Hauck as well as De Toni and Van Goor mentioned *Cl. chlorothrix* Kütz. and *Cl. tenuis* Kütz. as synonyms of *Cl. albida* (Huds.) Kütz. Comparison of the types of *Cl. chlorothrix* and *Cl. tenuis* (National Herbarium, Leiden) with the specimen of *Cl. albida*, identified by Hudson (Herbarium Kew) shows, that both *Cl. chlorothrix* and *Cl. tenuis* differ from *Cl. albida* by their very long branches, which bear only very few ultimate ramuli with a smaller diameter than these branches and a smaller relative celllength (length times breadth). *Cl. chlorothrix* and *Cl. tenuis*, however, are synonyms; this species must be maintained, under the name *Cl. chlorothrix* Kütz.

Comparison of specimens of *Cl. laetevirens* (Dillw.) Kütz. identified by Dillwyn (Kew herbarium) with the specimens of that species in the herbaria Kützing and Van Goor showed that the specimens of Van Goor and Kützing belong to *Cl. flexuosa*. *Cl. laetevirens* has not been found in the Netherlands.

Van Goor (p. 120) mentions that the only specimen of *Cl. macallana* Harv., known from the Netherlands was lost, but I found it back in the material of the National Herbarium; the identification was correct.

The specimen of *Cl. glaucescens* (Griff.) Harv. found by Van Goor among *Zostera*, has some resemblance with the specimens of *Cl. flexuosa* Harv. of the herbarium Kützing and with exsiccates (Wyatt a. o.). Therefore, I do not believe that *Cl. glaucescens* was ever found in the Netherlands.

The specimen of *Cl. bertholini* Kütz. found by Suringar between Hoorn and Edam is to be found in the National Herbarium. On examination, it turned out to be *Cl. fracta*. No other specimen of *Cl. bertholini* was found, so we have to strike this species from the Flora of the Netherlands.

Cladophora fracta (Dillw.) Kütz. f. *marina* Hauck (p. 461) was considered by Børgesen (p. 18) as a separate species: *Cl. hauckii* Børg. Though Brand (p. 178) ascertains that *Cl. fracta* is not found in salt water, many specimens have been found in the Netherlands in brackish and even in salt water. There is a fair number of intermediate forms between *Cl. fracta* f. *marina* and *Cl. fracta* in existence. I am, therefore, of the opinion that the two forms are very closely related and that the differences between them are not important enough to distinguish two separate species, as was done by Brand (p. 177) and Børgesen. Therefore, I propose to maintain *Cl. hauckii* Børg. as a form of *Cl. fracta* under the name **Cl. fracta** (Dillw.)

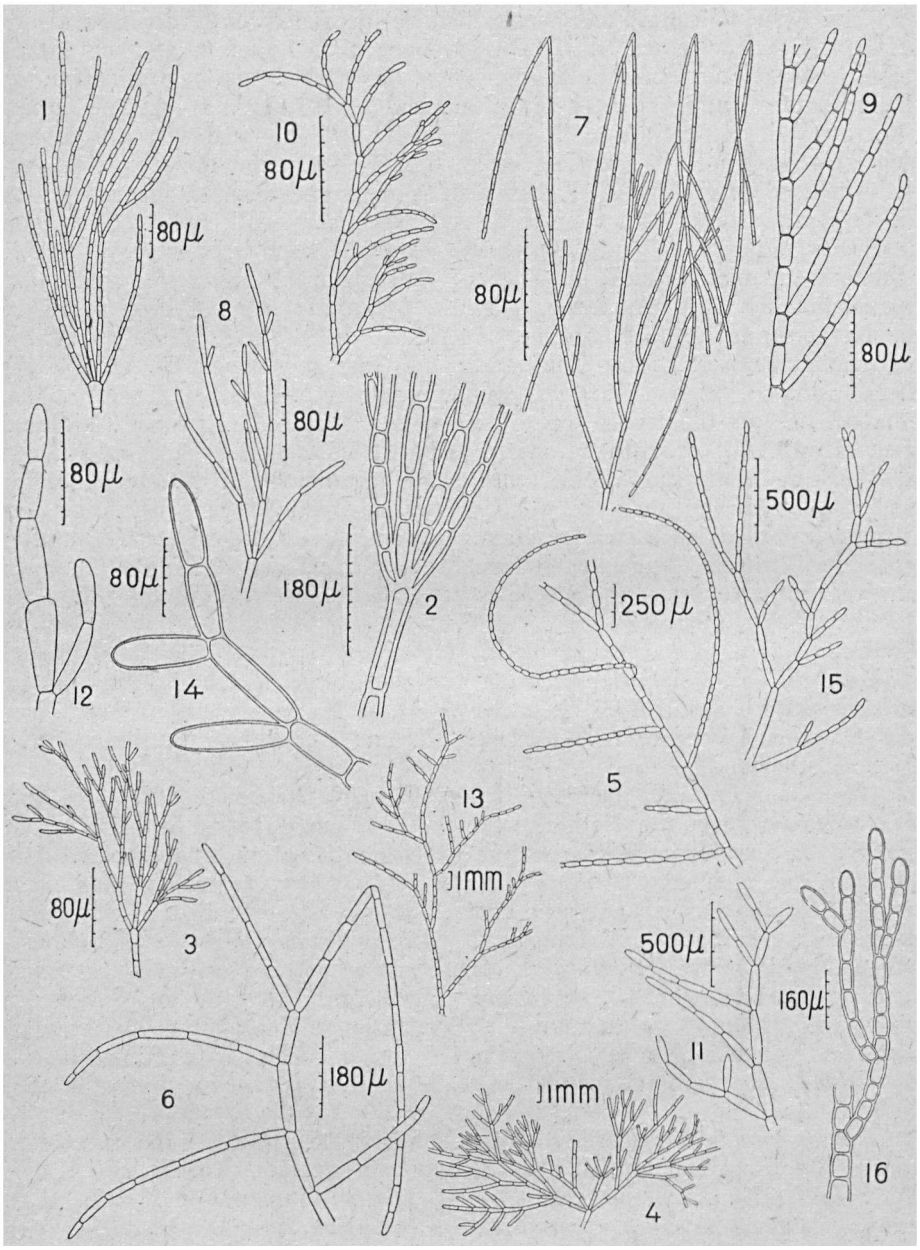

Fig. 1, 2. *Cl. rupestris* (L.) Kütz.; 3. *Cl. penicillata* (Kütz.) var. *lutescens* (Kütz.) Ardiss. f. *longiarticulata* Kütz.; 4. *Cl. fascicularis* (Mert.) Kütz.; 5. *Cl. gracilis* (Griff.) Kütz.; 6. *Cl. fracta* (Dillw.) Kütz. f. *hauckii* (Børg.) Slootweg; 7. *Cl. nitida* Kütz.; 8. *Cl. crystallina* (Roth) Kütz.; 9. *Cl. flexuosa* Harv.; 10. *Cl. refracta* (Roth) Kütz.; 11, 12. *Cl. utriculosa* Kütz.; 13, 14. *Cl. macallana* Harv.; 15. *Cl. hirta* Kütz.; 16. *Cl. arcta* (Dillw.) Kütz.

Kütz. f. **hauckii** (Børg.) Slootweg, nov. comb.; *Cl. fracta* (Dillw.) Kütz. f. *marina* Hauck cannot be maintained as has been pointed out by Brand (p. 177) already.

I might suggest that the differences between *Cl. fracta* and *Cl. fracta* f. *hauckii* are the result of environmental differences, acting, however, not during one generation, but during a number of successive generations.

Forma *hauckii* can be distinguished from f. *typica* by the following features:

1. The relative cell-length is much greater.
2. The ultimate ramuli are longer and scarcer.
3. The evection is sooner completed; in f. *hauckii* we seldom find that the basal cells of the branches are partly grown together.
4. The diameter of the cells of the branches and filaments is somewhat larger.

Part of the material from the Zuiderzee, which was determined by Van Goor as *Cl. fracta* is *Cl. fracta* f. *typica*, the rest is *Cl. fracta* f. *hauckii* and all kinds of intermediate forms.

Key to the species.

1. a. Branches often 4 or more together 2
   b. Mostly 2 branches together, sometimes 3 4
2. a. Not much branched, branches long, cells at the foot of the branches mostly somewhat broadened to the top, cells in the ultimate ramuli somewhat shorter than in the branches, more or less thickened; main branches up to 150 μ in diameter, cells 4—10 times as long as broad, ultimate ramuli 50—90 μ in diam., cells 2—6 times as long as broad, dark green. *(fig. 1, 2)*
   1. Cl. rupestris (L.) Kütz.
   b. Much branched, branches rather short 3
3. a. Lower branches single or in two's, upper branches three or four together, ultimate ramuli single, cell at the foot of a number of branches often much shorter than the lower cells and much broadened towards the top, terminal cells mostly elongated, main branches 100—150 μ in diam., cells 3—8 times as long as broad; ultimate ramuli 45—60 μ in diam., cells 4—10 times as long as broad, terminal cells 10—20 times as long as broad *(fig. 3)*.
   2. Cl. penicillata Kütz. var. **lutescens** (Kütz.) Ardiss. **f. longiarticulata** Kütz.
   b. Mostly 4 or more branches in a whorl; often with branches between the whorls; main branches 225 μ in diameter, cells 3—4 times as long as broad, ultimate ramuli 50—90 μ in diam., cells 2—3 times as long as broad. *(fig. 4)*.
   3. Cl. fascicularis (Mert.) Kütz.
4. a. Thin, slack, slender, cells mostly long (5—20 times as long as broad), ultimate ramuli up to 60 μ in diam. 5
   b. Not so slender 7
5. a. Very graceful, cells sometimes fairly short, ultimate ramuli long and thin (30—60 μ in diameter), cells 3—6 (sometimes 8—10) times as long as broad; main branches 100—140 μ in diam., cells 2—6 times as long as broad. Often specimens were found, of which the ultimate ramuli were 24 μ in diameter *(fig. 5)* . . . . . **4. Cl. gracilis** (Griff.) Kütz.
   b. Not so slender, attached when young, soon becoming detached; much branched when young, afterwards forming balls consisting of interwoven sparingly branched branches. Main branches stiff, with spreading angularly bent branches, ultimate ramuli few and partly obtuse. Very polymorphous, of variable dimen-

sions; main branches 120—180 μ in diameter, ultimate ramuli 30—60 μ in diam., cells 4—15 (1—3) times as long as broad *(fig. 6)*
5. Cl. fracta (Dill.) Kütz. f. **hauckii** (Børg.) Slootweg [1]).

c. Often fairly branched, very thin, somewhat silky 6

6. a. Ultimate ramuli extremely long (several mm), frequently dichotomous with short ultimate ramuli closely under the apex, branches 20—50 μ in diam., cells 3—10 (terminal cells 14) times as long as broad. Main branches 75—100 μ in diam., cells 3—9 times as long as broad *(fig. 7)* . . . . **6. Cl. nitida** Kütz.

b. Branches long, but not so long as those of *Cl. nitida*, ultimate ramuli short, at more or less regular distances on the branches, branches mostly dichotomous, sometimes trichotomous, very much branched, somewhat silky; main branches 70—130 μ in diam., cells 3—10 times as long as broad, ultimate ramuli 20—40 μ in diam., cells 5—15 times as long as broad *(fig. 8)* **7. Cl. crystallina** (Roth) Kütz.

7. a. There is a more or less distinct difference in relative length between the cells of the branches and those of the ultimate ramuli, plants stiff, very polymorphous, little branched main branches 80—160 μ in diam., cells 3—5 times as long as broad, ultimate ramuli 30—70 μ in diam., cells 1—3 times as long as broad *(fig. 9)*
8. Cl. flexuosa Harv.

b. No difference in relative cell-length between the cells of the branches and those of the ultimate ramuli 9

8. a. Ultimate ramuli mostly somewhat thinner (25—50 μ) than the branches, the relative cell-length, however, being the same (2—3 times as long as broad), branches sometimes reflexed, apices of ultimate ramuli mostly somewhat obtuse; main branches 60—120 μ (as a rule 80 μ in diam.), stiff. Very variable *(fig. 10)*
9. Cl. refracta (Roth) Kütz.

b. No distinct difference in length and diam. between the cells of the branches and ultimate ramuli 9

9. a. Fairly branched, top cells much longer than the other cells, branches 70—100 μ in diam., relative cell-length variable (2—8 times as long as broad), cells sometimes broadened towards the top, or club-shaped; top-cells sometimes also club-shaped *(fig. 11, 12)* . . . . . **10. Cl. utriculosa** Kütz.

b. Not so much branched, terminal cells not longer than the other cells . . 10

10. a. Branches up to 170 μ in diam., cells 4—5 times as long as broad, filaments and ultimate ramuli 90—110 μ in diam., 2—4 times as long as broad. Cells sometimes club-shaped, or conical, apices always obtuse, branches often partly coalescent *(fig. 13, 14)* . . . . . **11. Cl. macallana** Harv.

b. Branches (100—175 μ in diam.) long, ultimate ramuli (40—95 μ in diam.) short. Cells of the filaments 2—4 times as long as broad, of the ultimate ramuli 1—4 times as long as broad, often a little thickened, apices subacute *(fig. 15)*
12. Cl. hirta Kütz.

c. Algae with rhizoidal branches with club-shaped cells, at the base 75—90 μ, at the top 150—250 μ in diam. Relative cell-length dependent on the age, older cells 1—2 times as long as broad, younger ones (3—4)8—12 times as long as broad *(fig. 16)* . . . . . **13. Cl. arcta** (Dillw.) Kütz.

1. **Cladophora rupestris** (L.) Kütz. — Kützing, Phyc. gen. p. 270; Sp. p. 396; Tab. IV, t. 3; Harvey, t. 180; Hauck p. 452; De Toni p. 328; Hylmö p. 32, t. 3, f. 1; v. Goor p. 128; Hamel p. 19; Lakowitz p. 155; Newton p. 83.

Localities: Dronrijp, IX-1854 n. 114c; Southcoast of Friesland, VII-1854 n. 1146, *Suringar*; Vlieland, V-1851; *Weber—v. Bosse*; Hoorn, IX-1854, *Suringar* n. 114a; Monnikendam, VII-1905, *v. Goor*; Den Helder, VI-1882, *Went*; ibid., VII-1893, *Weevers*; ibid., VIII-1897; ibid. (Wierhoofd), VIII-1899, *Bonnema*; ibid., IV-1916, *Havinga*; ibid., VII-1931 n. 491; ibid., II-1936; ibid., IV-1938, all by *Koster*; Nieuwediep, 1837, *Broers*; Hook of Holland, VII-1947, *Koster* n. 1046; Zandkreek, XI-1843, *Suringar*; Oosterschelde, IX-1841, *Suringar* n. 194; Zierikzee, IV-1939 n. 38, n. 99 en

[1]) For the differences between *Cl. fracta* f. *typica* and *Cl. fracta* f. *hauckii* see above.

n. 114; Schouwen, IV-1939 n. 34 en n. 44, both by *Vervoort*; Vere, X-1940 n. 25 en n. 26; Kanaal door Zuid-Beveland, XII-1941 n. 305; Walcheren (Arnemuidens Kanaal) VI-1941 n. 283; ibid., XII-1943 n. 467; Kortgene, II-1941 n. 14; all by *Brakman*; Woensdrecht, XI-1943, *Maas Geesteranus* n. 2890; Yerseke, IX-1947, *Korringa*.

2. **Cladophora penicillata** Kütz. var. **lutescens** (Kütz.) Ardiss. f. **longiarticulata** Kütz. — Kützing, Sp. p. 403; De Toni p. 316; v. Goor p. 120.

Localities: Coast of Friesland, 1932, *Koopmans*; Den Helder (Zuidwal), VII-1919; ibid. (Vangdam), VIII-1919; both by *v. Goor*.

3. **Cladophora fascicularis** (Mert.) Kütz. — Kützing, Phyc. gen. p. 268; Sp. p. 393; De Toni p. 316.

Locality: Oosterschelde, VII-1846, *v. d. Bosch* n. 231.

4. **Cladophora gracilis** (Griff.) Kütz. — Kützing, Phyc. germ. p. 215; Sp. p. 403; Tab. IV, t. 23; Harvey, t. 18; Hauck p. 457 fig. 195; De Toni p. 322; Hylmö (1916) p. 33, t. 3, fig. 5; v. Goor p. 124; Hamel p. 21 fig. 16; Lakowitz p. 159 fig. 223; Newton p. 85.

Localities: Southcoast of Friesland, VII-1854, *Suringar* n. 118; Terschelling, *de Jong v. Rodenburg* n. R 7 en n. R 18; Nieuwediep, VI-1886 n. 182; ibid., VIII-1887, n. 498, both by *Weber—v. Bosse*; ibid., VIII-1891, *Moll*; ibid., VII-1937, *Koster* n. 355; ibid. (Zuidwal), VI-1916, *v. Goor*; Den Helder, 1893, *Weber*; Goes (Harbour), IX-1843 (2 ×); ibid., IV-1845 n. 176, both by *v. d. Bosch*; Oosterschelde, *Suringar*.

5. **Cladophora fracta** (Dillw.) Kütz. f. **typica** — Kützing, Phyc. gen. p. 263; Sp. p. 288; Tab. IV, t. 50; Harvey t. 294; De Toni p. 288; Hamel p. 14.

Localities: Nieuwediep, VII-1887, *Weber—v. Bosse* n. 475; Hoorn IX-1854, *Suringar* n. 115; Kampen, Zuiderzee n. A 17; Goes, VI-1846 n. 139 en n. 309; all by *v. d. Bosch*; Zeeburg, IV-1885, *Weber—v. Bosse* n. 278.

Cladophora fracta (Dillw.) Kütz. f. **hauckii** (Børg.) Slootweg — *Cl. fracta* f. *marina* Hauck p. 461; v. Goor p. 113; Lakowitz p. 162; Newton p. 86. — *Cl. heteronema* Brand p. 177 (non (Ag.) Kütz.). — *Cl. hauckii* Børgesen p. 18.

Localities: Coast of Friesland, XI-1918, *v. Goor*; Zuiderzee, *Rijns* (Herb. Nijland); and a further number of samples collected in the course of the Zuiderzee expedition (1905) and determined by *v. Goor* as *Cl. fracta*; Nieuwediep, VII-1887, *Weber—v. Bosse*, n. 496; W. Terschelling, VII-1937, *Koster* n. 166; Den Helder (Balgzand), *Weber*; Wieringen, VIII-1916, *v. Goor*; Goes (Harbour) VI-1846 n. 31, n. 326, n. 333; ibid., V-1841; both by *v. d. Bosch*, ibid., IX-1942, *Brakman* n. 383; Zandkreek, VI-1846 n. 312 en n. 313; Oosterschelde, VI-1846 n. 342; both by *v. d. Bosch*; Arnekanaal, VI-1941; ibid., X-1942; Sloedam, IX-1942 n. 361; Noordelijk Sloe VIII-1940 n. 20 en n. 22; Kanaal door Walcheren (Vere), VIII-1942 n. 359; Arnebrug IX-1940 n. 23 en n. 374; Middelburg, VIII-1940 n. 21; Kleverskerke, VII-1943 n. 405; all by *Brakman*; Schouwen, IV-1939 n. 8; Haamstede, VII-1943; both by *Vervoort*.

6. **Cladophora nitida** Kütz. — Kützing, Phyc. gen. p. 269; Sp. p. 404; Tab. IV, t. 28; De Toni p. 320; v. Goor p. 123; Newton p. 84.

Localities: Medemblik, VIII-1905; Nieuwediep, IX-1885, *Heinsius*; den Helder (Wierbalg), VI-1917; ibid. (Zuidwal), VII-1917; both by *v. Goor*; Goes, *v. d. Bosch*.

7. **Cladophora crystallina** (Roth) Kütz. — Kützing, Phyc. germ. p. 213; Sp. p. 400; Tab. IV, t. 19; Hauck p. 459; De Toni p. 318; Hylmö p. 35, t. 3, f. 7; v. Goor p. 121; Hamel p. 12; Newton p. 85.

Localities: Nieuwediep, VII-1887, *Weber—v. Bosse* n. 544; den Helder (Zuidwal), VII-1916; ibid., VII-1920; both by *v. Goor*; Zeeburg, VII-1885, *Weber—v. Bosse* n. 280 en n. 499a; Rotterdam, V-1851, *Oudemans*; Goes (Harbour) IX-1841 n. 34; ibid., IX-1843; both by *v. d. Bosch*.

8. **Cladophora flexuosa** Harv. — Harvey t. 353; Hauck p. 456; De Toni p. 311; v. Goor p. 118; Hamel p. 20; Newton p. 85.

Localities: Den Helder, VII-1931, *Koster* n. 490; Nieuwediep, VI-1886, *Weber—v. Bosse* n. 166 en n. 445; ibid., VII-1939, *Koster* n. 356 en n. 362; Zandvoort, I-1852, *Buse*; Zeeburg, II-1884, *Weber—v. Bosse* n. 81; Elburg, VII-1859, *Spree*; Goes (Harbour), XI-1841, n. 36; Zandkreek, IX-1841 n. 37; ibid., VIII-1844; all by *v. d. Bosch*; Oosterschelde, *Suringar* n. 13; Den Helder (Zuidwal), V-1919; Schokland, VI-1921; Wervershoof, IX-1921; all by *v. Goor*; Nieuwediep, IX-1885, *Heinsius*.

9. **Cladophora refracta** (Roth) Kütz. — Kützing Phyc. gen. 267; Harvey p. 24; Kützing Sp. p. 398; Tab. IV, t. 10; De Toni p. 324; Lakowitz p. 158; Newton p. 85.

Localities: Stavoren, X-1921; Zeeburg, VII-1921, both by *v. Goor*; Hook of Holland, VII-1947, *Koster* n. 1050; Goes (Harbour), VI-1846 n. 333; XI-1847 n. 404; both by *v. d. Bosch;* ibid., I-1846, *Suringar*; Zandkreek, VI-1846, *v. d. Bosch*; ibid., V-1847, *Suringar* n. 1072.

10. **Cladophora utriculosa** Kütz. — Kützing Phyc. gen. p. 269; Sp. p. 393; Tab. III, t. 94; Hauck p. 454 partim.; De Toni p. 312; v. Goor p. 119; Hamel p. 1; Lakowitz p. 156; Newton p. 83.

Localities: Lemmer (Westpier), IX-1921; Nieuwediep; Den Helder (Vangdam); VII-1915; ibid. (Zuidwal), VII-1917; ibid. (ibid.), VII-1919; all by *v. Goor*; Vlieland, VIII-1947, *v. Veen*; Woensdrecht, *Sloff*; Zandkreek, IX-1842, *Suringar*; Oosterschelde, IX-1841 n. 36 en n. 37; ibid., VIII-1842; both by *v. d. Bosch*.

11. **Cladophora macallana** Harv. — Harvey t. 84; Kützing Sp. p. 392; Tab. III, t. 86; De Toni p. 313; v. Goor p. 120; Hamel p. 15; Newton p. 82.

Locality: Southcoast of Friesland, VII-1854, *Suringar* n. 113.

12. **Cladophora hirta** Kütz. — Kützing Phyc. germ. p. 208; Sp. p. 395; Tab. IV, t. 1; Hauck p. 456; De Toni p. 329; v. Goor p. 129; Hamel p. 19; Lakowitz p. 158; Newton p. 83.

Localities: Terschelling (Riepel); Monnikendam, VII-1905; both by *v. Goor*; Den Helder, VII-1939, *Koster* n. 489.

13. **Cladophora arcta** (Dillw.) Kütz. — Kützing Phyc. germ. p. 263; Sp. p. 417; Harvey t. 135; Hauck p. 445; De Toni p. 335; v. Goor p. 129; Hamel p. 31.

Localities: Den Helder, V-1868, *H. V.*; Nieuwediep, IV-1898, *Resink*.

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