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THE ALGAE OF SALINE AREAS NEAR VLISSINGEN (THE NETHERLANDS)

P. J. G. POLDERMAN

Rijksherbarium, Leiden[1]

SUMMARY

During 1971 the algae of a seepage area on the landward side of the dikes near Vlissingen (prov. Zeeland) were studied. The periodicity of the algae in three permanent sample plots was studied. Considerable seasonal differences in the cover and the composition of the algal mat could be noticed. A comparison is made of the algal flora and vegetation in two plant-communities, the *Juncetum gerardii* and the *Puccinellietum fasciculatae*. The algae appear to be of little use as characterizing species for communities based on higher plants. Combinations of certain species (especially of the genus *Vaucheria*) are probably useful units for distinguishing algal communities.

1. INTRODUCTION

In The Netherlands, especially in the North-West and South-West of the country, there are numerous saline areas on the landward side of the dikes and yet little is known about the algal vegetation of such areas, as the main investigations on benthic algal communities have nearly all been restricted to communities directly influenced by the sea (see DEN HARTOG 1959 and NIENHUIS 1970). Apart from these there are only the survey by FEEKES (1936) of the algal vegetation in the newly reclaimed Wieringermeerpolder, the article by HOCKE HOOGENBOOM (1937) on the algal flora of the coast of the new IJsselmeer, after closing of the Zuiderzee, the general information given by RAPPARD (1967) on the algae of an inland saline area in the South-West of The Netherlands, the description by POLDERMAN & PRUD'HOMME VAN REINE (1973) of the habitat of *Chrysomeris ramosa* Carter, a benthic Chrysophycea, in a similar area on the Frisian island Texel, the description by SIMONS & VROMAN (1973) of the habitat of *Vaucheria* species in "De Putten" (prov. N.-Holland), and some notes on species combinations along brackish inland waters by DEN HARTOG (1973). The present paper deals with the composition of the algal mats and the periodicity of the algae in inland salt seepage areas situated in the southern part of the island Walcheren.

The areas dealt with in this paper lie west of Vlissingen (*fig. 1*). One of them, the Nollebos (1), is now a park. Its brackish creeks were formed by inundation of seawater in the period 1944–1946. There is a halophytic vegetation in several places due to the seepage of salt water. Northwest of the Nollebos there is one

[1] Present address: Afdeling Aquatische Oecologie, Universiteit, Nijmegen.

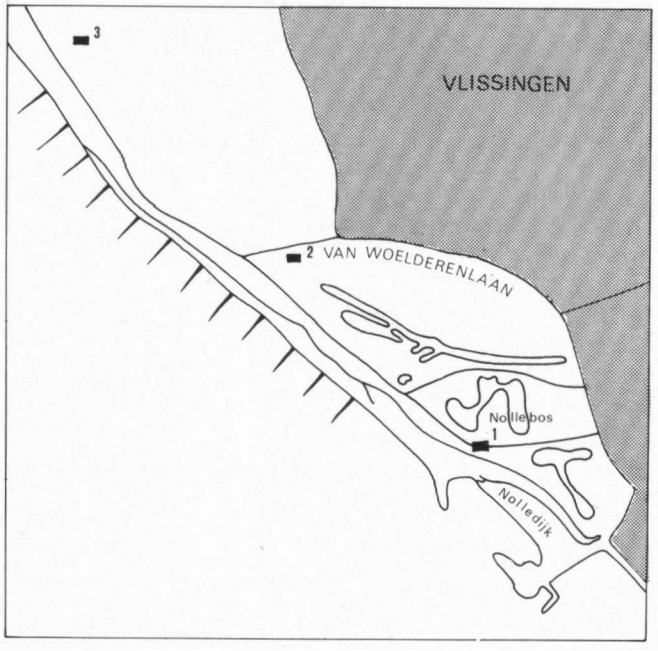

Fig. 1.Map of the area west of Vlissingen.

seepage area (2) near Van Woelderenlaan and another (3) close to the dunes west of Vlissingen.

2. METHODS

The algal vegetation in three permanent sample plots (PSP 1, 4, 5) was studied for more than a year at intervals of 6–8 weeks. Other sample plots were studied less regularly or for a shorter period. The size of each permanent sample plot was 1 m^2. In a sample plot the higher plants were surveyed by means of a modified Braun-Blanquet scale in which:

2m means very abundant but cover less than 5%,
2a means cover 5–12.5%,
2b means cover 12.5–25%.

The cover of each species of the algal layer[1] was estimated in percentages as far as possible. Three components in the algal layer could be distinguished in the field: filamentous green algae, *Vaucheria* spp., and blue-green algae. Generally the first component alone formed the algal mat, but there was sometimes a mosaic of all three. The cover of each component was estimated in percentages. From a sample plot a sample of each component was taken. The size of the samples was 2 cm^2 as it has been proved experimentally that an area of less than 2 cm^2 of any component of the algal mat contained practically all species of that component. The samples were worked out in the laboratory by examination

[1] No attention was paid to the Diatoms.

under the microscope. The cover of each separate species was established according to a combination of estimation and counting methods for micro-samples (POLDERMAN & PRUD'HOMME VAN REINE 1973). In *table 1* the quantities of each species are indicated as follows:

Symbol used	Average number of specimens in a micro-sample	
–	not found	
0	<2	cover <5%
1	2– 10	
2	10–100	
3	>100	
4	forming algal mats covering 5% or more.	

The species denoted by the symbol "4" together form the algal mat. The percentage of cover then established for these species is given in brackets after the symbol. For example, in survey V3 (*table 1*) the total cover of the algal mat was 90%. The major part of it consisted of *Rhizoclonium riparium* (cover 85%). The rest (5% cover) was represented by *Coccochloris stagnina*. The amounts of the other species could not be expressed in percentages. The samples were analyzed within 14 days of collecting.

It was supposed that in a sample plot of 10,000 cm² the removal of at most 40 cm² during a year had no disturbing influence. In these heavily trodden sample plots (even PSP 1 was trodden) no disturbance as a result of sampling was noticed during the investigation.

Sometimes a *Vaucheria* layer appeared to cover a layer of *Rhyzoclonium riparium*. In such cases the cover percentages formed by the surface layer were maintained. This phenomenon was met sporadically.

Vaucheria species were often sterile in the field and had to be cultivated in order to obtain reproductive organs necessary for reliable identification. A part of a sample with sterile *Vaucheria* was placed in a closed glass jar at 12°C at a 16:8 light regime. Some distilled water was added in order to establish a favourable humidity for *Vaucheria*. In all cases the identity of the *Vaucheria* species could be established within 14 days.

3. THE COMMUNITIES OF HIGHER PLANTS

In the investigated saline areas the most important communities of higher plants are the *Juncetum gerardii* and the *Puccinellietum fasciculatae* (sensu BEEFTINK 1965). The latter plant community commonly develops in places with a higher average salinity than the places where the *Juncetum gerardii* usually develops. A schematic survey of the vegetation in the seepage area behind the Nolledijk is given in *fig. 2*. The area is intersected by two brackish ditches and an asphalt track. The vegetation is rather differentiated. Between the two ditches 26 species of higher plants were found. The aspect of the vegetation in this part is determined by *Elytrigia pungens*. However, at the site of PSP 1 and along both ditches a *Puccinellietum fasciculatae* has developed. Although *Juncus gerardii* is dominant in PSP 1, the vegetation is still classified in the last-mentioned community

Table 1. Vegetation of PSP 1, a *Puccinellietum fasciculatae* on sand, from 24-10-'71 to 21-1-'72.

Date	24-10	12-12	15-1	27-2	4-4	26-5	19-7	8-9	28-9	24-11	21-1
Collection number	V 3	V 13	V 14	V 27	V38	V 45	V 53	V 64	V 74	V 80	V 88
Total cover of higher plants in %	20	15	10	15	15	25	30	25	25	20	15
Salicornia europaea ssp. *ramosissima* Woods	1	1	1	1	–	+	2m	2a	2m	1	1
Puccinellia fasciculata (Torr.) Bickn.	+	–	–	+	–	+	–	+	–	–	–
Spergularia marina (L.) Griseb.	r	+	1	+	–	+	+	+	1	+	1
Plantago coronopus L.	+	+	r	1	1	+	+	r	r	+	+
Juncus gerardii Loisl.	2a	2a	2a	2a	2b	2b	2b	2b	2b	2b	2a
Aster tripolium L.	2m	1	1	2m	2m	2a	2m	1	1	1	r
Parapholis strigosa (Dum.) Hubbard	–	–	–	–	–	–	2m	–	–	–	–
Elytrigia pungens (Pers.) Tutin	–	–	–	–	–	–	r	–	–	–	–
Total cover of the algal layer in %	90	75	100	95	100	100	75	80	90	95	95
Vaucheria erythrospora Christ.	–	–	1	1	0	–	–	–	–	–	4(10)
Rhizoclonium riparium (Roth) Harv.	4(85)	4(75)	4(100)	4(95)	4(100)	4(100)	4(75)	4(80)	4(90)	4(95)	4(85)
Coccoid green algae	–	–	3	1	2	–	0	0	–	–	–
Apistonema	1	–	3	1	–	1	0	1	1	1	–
Anacystis montana (Lightf.) Dr. et D.	1	–	0	–	–	–	–	0	1	1	0
Anacystis dimidiata Dr. et D.	–	–	–	0	–	–	0	–	0	–	–
Coccochloris stagnina (Kütz.) Spreng.	4(5)	3	1	3	–	–	–	0	2	–	1
Spirulina subsalsa Gom.	–	0	0	2	–	–	–	–	2	0	0
Microcoleus lyngbyaceus Gom.	2	0	2	1	1	1	0	1	0	2	–
Oscillatoria brevis Gom.	–	–	–	–	–	–	–	–	0	–	–
Oscillatoria nigroviridis Gom.	2	–	0	–	1	1	2	1	2	2	1
Schizothrix calcicola Gom.	2	2	2	3	1	2	0	2	2	2	1
Calothrix aeruginaea Born et Flah.	2	–	0	–	–	1	1	1	0	0	–
Anabaena variabilis Born. et Flah.	1	0	0	2	–	0	–	–	–	–	–
Nodularia harveyana Born. et Flah.	–	0	2	1	0	–	1	1	0	0	2

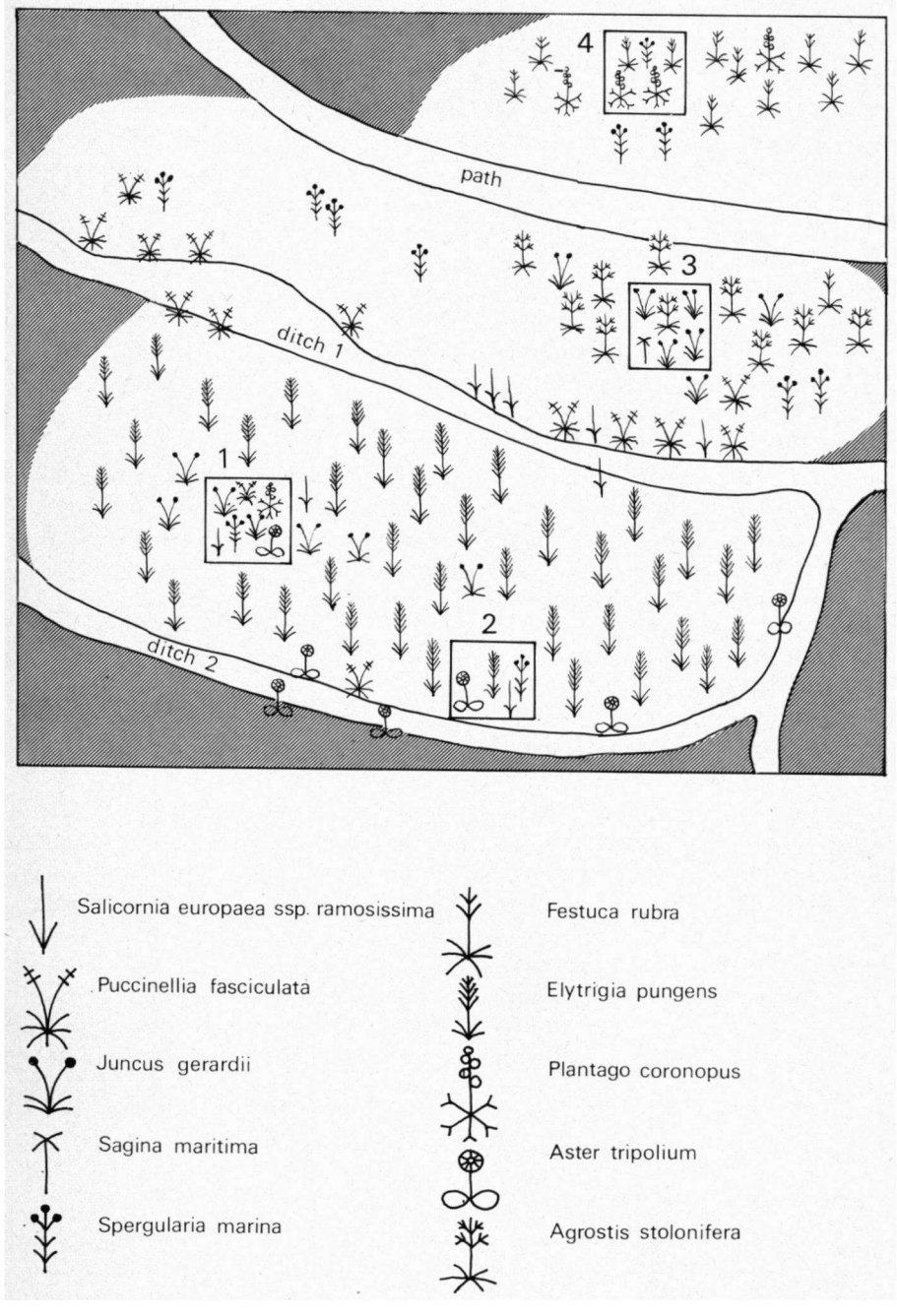

Fig. 2. Schematic survey of a brackish area in the "Nollebos".

because of the presence of *Puccinellia fasciculata*, *Spergularia marina* and *Salicornia europaea* ssp. *ramosissima (fig. 2)*. The soil of the area is sandy.

Between ditch 1 and the asphalt track a *Juncetum gerardii* (PSP 3) occurs on sandy clay. In summer elements of the *Saginetum maritimae* such as *Sagina maritima* G. Don and *Pottia heimii* (Hedw.) Fuernr. occur there. Another species appearing in summer is *Parapholis strigosa*, which is abundant in PSP 1 and 3 during the summer.

Across of the asphalt track another variant of the *Juncetum gerardii* dominated by *Festuca rubra* L. (PSP 4) occurs. The soil is composed of black earth conveyed from elsewhere. In summer this type of soil dries up and it is then covered by a white crust of salt crystals.

The whole area is heavily trodden.

In two meadows north of the Nollebos there are small areas where the *Puccinellietum fasciculatae* occurs. These areas were also inundated in the period 1944–1946. They still seem to be influenced by the seepage of salt water. The areas are heavily trodden, which, according to DE VISSER (1971), is an important factor for the occurrence of *Puccinellia fasciculata*. Apart from the species characteristic for the *Puccinellietum fasciculatae*, already mentioned above, a prostrate form of *Suaeda maritima* occurs. The soil is composed of heavy compact marine clay. Consequently the rain water stagnates and forms small puddles. In such a pool in locality 3 a chlorinity of 11.54% was measured in the autumn. There was a permanent sample plot (PSP 5) near this pool. In both meadows fertilizer was strewn in spring.

4. THE ALGAE

4.1. Taxonomic notes

Rhizoclonium riparium. According to NIENHUIS & SIMONS (1971) *Rhizoclonium implexum* (Dillw.) Kütz is considered as a synonym of *Rhizoclonium riparium* (Roth) Harv.

Chrysophyta. Rather frequently algae were found which were originally identified as *Apistonema pyrenigerum* Pascher. However, PARKE (1961) has shown that several Chrysophytes can have a so-called *Apistonema*-stage. Similar problems exist for a Chrysophycea described as *Gloeochrysis maritima* by ANAND (1937) and listed by PARKE & DIXON (1964) as *Ruttnera maritima*. Since these algae require further investigation they are reported only as "*Apistonema*" and "*Gloeochrysis maritima*", respectively.

Cyanophyceae. For the coccoid Cyanophyceae the nomenclature of DROUET & DAILY (1956) is followed. For the other blue-green algae the work of LINDSTEDT (1943) is used, which is based on the system of GEITLER (1932). However, a number of reservations are made regarding the Oscillatoriaceae, for which the revision by DROUET (1968) was partly used. In this paper only the name *Microcoleus chthonoplastes* is used in the strict sense of LINDSTEDT (1943). The present author agrees with DROUET concerning the synonymy of the following LINDSTEDT taxa which he found during this investigation.

DROUET TAXA	LINDSTEDT TAXA
Spirulina subsalsa Gom.	*Spirulina subtilissima* Gom. *Spirulina major* Gom.
Microcoleus lyngbyaceus Gom.	*Hydrocoleum lyngbyaceum* Gom. *Hydrocoleum glutinosum* Gom. *Lyngbya aestuarii* Gom. *Lyngbya majuscula* Gom. *Lyngbya semiplena* Gom. *Oscillatoria bonnemaisonii* Gom. *Oscillatoria limosa* Gom.
Schizothrix calcicola Gom.	*Lyngbya infixa* Frémy *Phormidium fragile* Gom. *Phormidium gracile* Lindstedt *Phormidium minutum* Lindstedt *Plectonema norvegicum* Lindstedt *Plectonema nostocorum* Gom.
Microcoleus vaginatus Gom.	*Phormidium autumnale* Gom.

Several forms transitional between *Oscillatoria brevis* Gom., *Oscillatoria tenuis* Gom., and *Oscillatoria laetevirens* Gom. have regularly been found. In this paper they are placed together under *Oscillatoria brevis* Gom. The description of *Oscillatoria nigroviridis* Gom. by Lindstedt contains two "formae" differing by the presence of a granulation at the crosswalls. This is the basic character in the system of Drouet. In the saline areas near Vlissingen specimens of *Oscillatoria nigroviridis* Gom. (sensu Lindstedt) both with and without granula at the crosswalls were found. They did not differ in other characters. In the system of Drouet the granulated specimens would be classified as *Microcoleus lyngbyaceus*, but they differ from it by a number of "classic" characters: 1. no hyaline tip-cell; 2. at most a very thin sheath; 3. never aggregation in a common sheath; 4. the filaments are usually 7–12 μm in cross-section; 5. the length-width ratio varies between 3/4 and 1/3.

Specimens of the genus *Nostoc* were sometimes unidentifiable. With the work of FREMY (1934) some specimens could be identified as *Nostoc entophytum* and *Nostoc commune*. These identifications, however, are not satisfactory. Representatives of *Nostoc* are indicated here as *Nostoc* spp.

4.2. Composition of the algal vegetation.

In the investigated area *Rhizoclonium riparium* nearly always constituted the most important element of the algal vegetation, but was sometimes partly replaced by *Vaucheria*. This occurred in the period from medio November to June. The species involved were generally *Vaucheria erythrospora* accompanied by one or exceptionally two or three of the following *Vaucheria* species: *V. cruciata*[1], *V. frigida*[1], *V. canalicularis*[1], *V. coronata* Nordst., *V. synandra* Wor., and *V. velu-*

[1] *Vaucheria cruciata* (Vauch.) DC. = *V. debaryana Wor.*, *V. frigida* (Roth) C. Ag. = *V. terrestris* sensu Goetz, *V. canalicularis* (L.) Christ. = *V. woroniniana* Heering (cf. CHRISTENSEN 1969).

tina C. Ag. The three first mentioned species are very commonin fresh water habitats (HEERING 1921, CHRISTENSEN 1969). *Vaucheria sescuplicaria* Christ. occurred partly submerged in ditch 2. A number of other representatives of the genus *Vaucheria* (not found near Vlissingen) occur also in saline areas on the landward side of the dikes. Most of these (e.g. *V. intermedia* Nordst.) are mentioned in chapter 5. The blue-green algae *Nodularia harveyana* and *Schizothrix calcicola* were present in every sample plot, in some of them almost during the whole year. A certain periodicity of the green algae *Ulothrix subflaccida* Wille and *U. pseudoflacca* Wille is to be seen from PSP 5 *(fig. 5)*. These two species, the blue-green algae *Anacystis dimidiata*, *Coccochloris stagnina*, *Spirulina subsalsa*, *Microcoleus lyngbyaceus*, *Oscillatoria nigroviridis*, *O. brevis*, *Calothrix aeruginea*, *Anabaena variabilis* and the Chrysophyte "*Apistonema*" occurred rather frequently, but mostly in small quantities. The blue-green algae *Microcoleus chthonoplastes*, *Microcoleus vaginatus*, *Anacystis montana*, *Entophysalis deusta* (Menegh.) Dr. et D., *Nostoc* spp., and the Chrysophyte "*Gloeochrysis maritima*" were found occasionally.

Remarkable is the absence of *Percursaria percursa* (C. Ag.) Rosenv., an alga which occurs frequently in saline areas on the landward side of the dikes along the Wadden Sea and elsewhere in Zeeland.

4.3. Periodicity

During the winter and spring an algal mat covered considerable parts of the sample plots: about 95% in PSP 1 *(fig. 3)*, about 40% in PSP 4 *(fig. 4)*, and

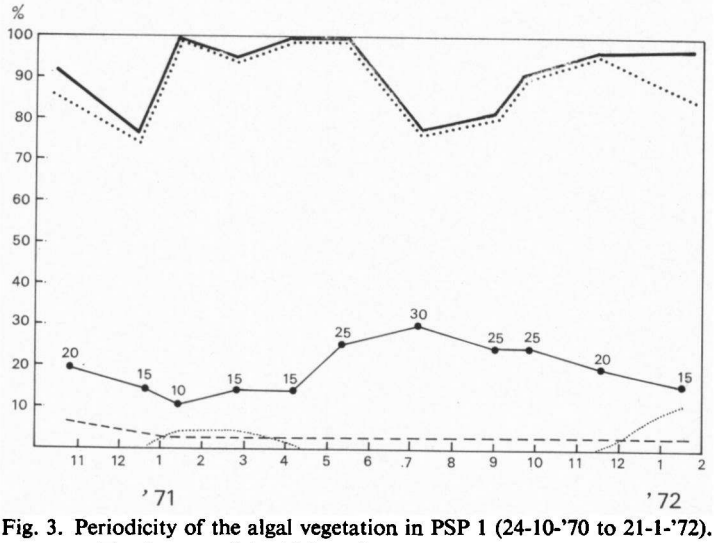

Fig. 3. Periodicity of the algal vegetation in PSP 1 (24-10-'70 to 21-1-'72).
——— Total cover of the higher plants.
——— Total cover of the algal mat.
..... Cover of *Rhizoclonium riparium*.
..... Cover of *Vaucheria erythrospora*.
– – – – – Cover of blue-green algae (various species).

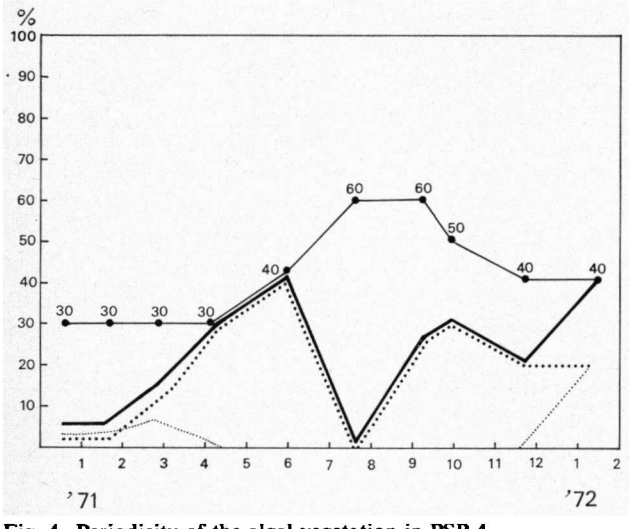

Fig. 4. Periodicity of the algal vegetation in PSP 4.
(12-12-'70 to 21-1-'73).
———— Total cover of the higher plants.
———— Total cover of the algal mat.
..... Cover of *Rhizoclonium riparium*.
..... Cover of *Vaucheria* (*V. erythrospora, V. cruciata, V. canalicularis*).

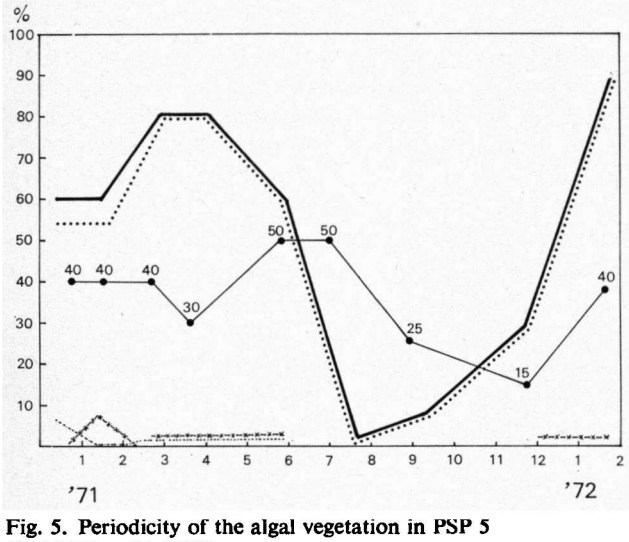

Fig. 5. Periodicity of the algal vegetation in PSP 5
(12-12-'70 to 21-1-'73).
———— Total cover of the higher plants.
———— Total cover of the algal mat.
..... Cover of *Rhizoclonium riparium*.
..... Cover of *Vaucheria* (*V. erythrospora, V. synandra, V. coronata*).
x–x–x–x Cover of *Ulothrix* (*U. subflaccida* + *U. pseudoflacca*).

about 70% in PSP 5 *(fig. 5)*. In a period of frost the algae may be killed (NIENHUIS & SIMONS 1971). Although during the time of this study there had been some frost and snow in the seepage area near Vlissingen, no decrease of the algal cover was observed. The total cover of the algae showed in many cases a sharp decrease at the end of May. The decrease can even persist till nothing of the algal mat is left, as was the case at PSP 4 *(fig. 4)*, a *Juncetum gerardii*. In 1971 the algal mat recovered only gradually from this summer breakdown, probably because of the dry autumn. In each of the graphs of the algal cover the same tendency is shown. Not every algal mat disappeared completely in summer, e.g. the cover of the algal mat in PSP 1 *(fig. 3)*, a *Puccinellietum fasciculatae*, did not drop below 75%. The difference in cover of the algal mats of PSP 1 and PSP 4 can not be explained by the difference in plant communities. Another *Puccinellietum fasciculatae* (PSP 5) had an algal cover of only 1% in summer *(fig. 5)*. The density of the higher plants, which protect the algal mat from desiccation by providing shelter, may play a role (NIENHUIS 1970). The figures 30% for the cover of higher plants and 75% for the algae in PSP 1, 80 (h. pl.) – 10 (algae) in PSP 3, 60–0 in PSP 4 and 50–1 in PSP 5, respectively, on 19.7.1971 (see also *figs. 3, 4, 5*) show that other factors are also involved. One of these is the substrate and related to this the water regime. The sandy substrate of PSP 1 is more easily penetrated by capillary seepage water than the compact sea clay of PSP 5. Moreover, PSP 1 is situated in a depression which lies almost at the same level as the water of the ditches *(fig. 2)*. The water level in ditches at locality is about 3 dm below that at PSP 5.

In some sample-plots, e.g. PSP 5 *(fig. 5)*, the cover of *Rhizoclonium riparium* is practically equal to the total cover of the algal mat during the whole year. In other sample plots, e.g. PSP 1 and 4 *(figs. 3, 4)*, *Vaucheria* formed mats (covering 5% or more) during the winter months. In these months the humidity of the soil and of the air is generally greater than during the rest of the year. *Rhizoclonium* is apparently better able to withstand the microclimatic conditions in summer and autumn, which include a higher temperature and greater evaporation. During the summer *Vaucheria* was found only in and close to ditches or in sheltered places. NIENHUIS (1970) points also to the occurrence of *Vaucheria* in the direct neighbourhood of plants and its absence in open algal vegetations. CARTER (1933), however, found that *Vaucheria* (*velutina*) maintained itself longer than filamentous green algae during persistent drought. But she also mentioned that *Vaucheria* was covered then with blue-green algae the mucous sheath material of which is also a good protection against drought. In a permanent sample plot at "De Bol" (Texel) it was observed that in the middle of July *Rhizoclonium* grew under a thin mucous cover of *Nostoc*. Blue-green algae played, however, no important role in the algal vegetation near Vlissingen and the phenomenon of covering of an algal mat by blue-green algae was not found here. As the desiccation of the environment proceeds, the sheltering plants become also the last places where *Rhizoclonium* can maintain itself, e.g., the 1% cover of *Rhizoclonium* in PSP 5 was due to filaments entangled with the leaf-bases of *Puccinellia fasciculata*.

Beside structure and temperature sensitivity (for which only few indications are available as yet) the mode of growth may play an important role in the difference between the periodicity of *Vaucheria* and *Rhizoclonium*. *Vaucheria* grows upright and forms cushions. *Rhizoclonium*, after initial vertical growth, continues horizontally and forms mats. The surface of a *Vaucheria* cushion is considerably larger and therefore more exposed to evaporation than that of a *Rhizoclonium* mat.

RAPPARD (1967) described the overgrowing of higher plants by *Vaucheria*. This was also observed in the polder "Het Noorden" (Texel), but not near Vlissingen. In culture it was observed that under favourable circumstances *Vaucheria* was able to overgrow other algae in a relatively short time (three weeks or a month). Because of the rather unfavourable conditions in the seepage areas near Vlissingen (drought and little shelter) overgrowing of an algal mat by *Vaucheria* was observed only a few times. In PSP 2 *(fig. 2) Vaucheria* invaded a *Rhizoclonium* vegetation from the side of ditch 2 in September. Three weeks later, however, a sudden increase of the microfauna (*Collembola* and *Orchestia*) brought an abrupt end to this process as the algal mat of this sample-plot was completely destroyed by the activities of these animals.

During the summer months representatives of *Ulothrix* were hardly found, in September only a few filaments of *U. subflaccida* were present in PSP 5. In January *Ulothrix* reached its peak with *U. pseudoflacca* covering 5% in PSP 5 *(fig. 5)*.

In salt-marshes *Ulothrix* species have a period of revival during the months of February-April (NIENHUIS 1970). During the winter small black-green spots of *Anabaena variabilis* occurred in several sample plots. *Microcoleus vaginatus* was found as an extensive crust in a dried-up puddle of stagnant rain-water. During the summer many places were covered with a white crust of salt. The only alga which could be detected in these crusts was the Chrysophyte "*Apistonema*".

5. COMBINATIONS OF SPECIES (MAINLY VAUCHERIA)

The differences in species composition of the algal vegetations of the two plant-communities, the *Juncetum gerardii* and the *Puccinellietum fasciculatae*, were rather small. Most species showed no obvious peak in either of the two associations. This was true for only one *Vaucheria* (*V. erythrospora*).

The few species with a more or less distinct affinity to one of both communities nearly all belonged to the genus *Vaucheria*.

V. frigida and *V. canalicularis* were restricted to the *Juncetum gerardii*, while *V. cruciata* and *Nostoc* spp. were mainly found in this association. *Microcoleus chthonoplastes* occurred in the *Puccinellietum fasciculatae* only and *V. velutina*, *V. coronata* and *V. synandra* were also restricted to this community. *Anacystis dimidiata* was common in the *Puccinellietum fasciculatae* and rare in the *Juncetum gerardii*.

In order to ascertain whether this distribution pattern is general in saline areas on the landward side of the dikes or whether it is just local, investigations

were carried out simultaneously in comparable saline areas in the province of North-Holland, viz. the bank of the Balgzandkanaal and the polder "Het Noorden" on Texel (POLDERMAN, unpubl. MS). In both areas there is a *Juncetum gerardii*, but the *Puccinellietum fasciculatae* is absent. However, along the Balgzandkanaal the *Puccinellietum distantis*, which like the *Puccinellietum fasciculatae* belongs to the alliance *Puccinellio-Spergularion*, was present. Both associations are comparable synecologically but they have different areas of distribution. *V. frigida*, *V. cruciata*, and *V. canalicularis* frequently occur in the *Juncetum gerardii* along the Balgzandkanaal. *Nostoc* spp. also occur considerably more frequently in this community than in the *Puccinellio-Spergularion*. *Microcoleus chthonoplastes* and *V. coronata* are also most frequent in the *Puccinellio-Spergularion*. *V. velutina* was in "Het Noorden" only found in vegetations other than the two mentioned. *V. erythrospora* is very frequent in the *Juncetum gerardii* and in the *Puccinellio-Spergularion* of the Balgzandkanaal bank. The same applies to *Anacystis dimidiata*, while *V. synandra* is relatively more frequent in the *Juncetum gerardii* than in the *Puccinellio-Spergularion*. In the polder "Het Noorden" *V. synandra* is most frequent in the *Juncetum gerardii*. *V. coronata* is also very frequent in it, but still more so in the *Puccinellietum maritimae parapholietosum*. The *Puccinellio-Spergularion* is absent in this polder. In both areas in North-Holland it appears that *V. frigida*, *V. cruciata* and *V. canalicularis* occur only in certain places in the *Juncetum gerardii*, viz. where *Bellis perennis* L. and *Trifolium repens* L. occur, which indicates a low salinity of the soil. Along the Balgzandkanaal these freshwater *Vaucheria* spp. reach their optimum in non-saline communities, such as the *Lolio-Cynosuretum* and the *Lolio-Plantaginetum*. In these communities *Nostoc* spp. were also very frequent. From these data it appears that the ecological boundaries of alga species are quite different from those of associations or alliances of higher plants, although there are sometimes obvious local similarities. The algae of the investigated areas therefore appear to be of little value in characterizing species for communities based on higher plants.

The algal vegetations of the various sample-plots near Vlissingen are easily distinguished by the *Vaucheria* species occurring in them. Earlier in this paper it has already been shown that near Vlissingen two distinct combinations of species occur: *V. coronata* – *V. synandra* and *V. frigida* – *V. cruciata* – *V. canalicularis*. Too few data on *V. velutina* are available for classifying it correctly. *V. erythrospora* occurs with both combinations. In North-Holland there is also hardly any overlap between these two combinations. The second combination is amplified there by *V. dillwynii* (Web. et Mohr) C. Ag.[1] This combination of four species occurs at low salinities (close to and in freshwater habitats). Typical freshwater species, *V. prona* Christ. (cf. SIMONS & VROMAN 1973) and *V. bursata* O. F. Müll.[2] are known as companion species of the combination. As the salinity of the environment increases, the companion species disappear first, followed by *V. dillwynii* and afterwards by *V. frigida*, they are replaced by *V. erythrospora*

[1] = *V. pachyderma* Walz
[2] = *V. sessilis* Vauch.

and *V. synandra*, and should the salinity of the environment increase further, *V. cruciata* and *V. canalicularis* also disappear. The *Vaucheria* combination then becomes *V. erythrospora – V. synandra – V. coronata*. In summer *V. coronata* disappears from this combination. In the *Juncetum gerardii* of "Het Noorden" and along the Balgzandkanaal *V. intermedia* Nordst. occurs with this combination mainly in the period when *V. coronata* is not found. SIMONS & VROMAN (1973) found a rather similar sequence pattern for *Vaucheria* species in "De Putten". However, they reported the combination *V. erythrospora – V. synandra – V. sescuplicaria* instead of *V. erythrospora – V. synandra – V. coronata/intermedia*. SIMONS & VROMAN include *V. sescuplicaria* also in a species group characteristic for high soil-moisture. *V. sescuplicaria* occurred together with *V. erythrospora – V. synandra – V. coronata/intermedia* only in the most humid of the areas investigated by me ("Het Noorden"). A further investigation must show whether the two combinations can be united, in which case the combination with *V. coronata/intermedia* would be the variant of relatively dry areas and the combination with *V. sescuplicaria* the variant of moist areas. In more saline environments the combination *V. erythrospora – V. synandra – V. coronata/intermedia* is gradually replaced by still other *Vaucheria* species. For areas on the landward side of the dikes the combinations *V. coronata – V. arcassonensis* P. Dang. – *V. sescuplicaria* (POLDERMAN 1973) and *V. sescuplicaria – V. litorea – V. velutina – V. subsimplex* Crouan fr.[1] (SIMONS & VROMAN 1973) are reported. From the saltmarshes the combinations *V. coronata – V. arcassonensis – V. minuta* Blum et Conover and *V. velutina – V. subsimplex – V. vipera* Blum are known (cf. NIENHUIS & SIMONS 1971, SIMONS & VROMAN 1968). Although some overlap between these combinations exists, because of their constancy in a larger area they provide sufficient information to be useful units for a classification system for algal vegetations of saline areas.

In several publications a classification of saltmarsh algal vegetations is proposed (CARTER 1933, CHAPMAN 1937, NIENHUIS 1970). The vegetation units distinguished are not sharply defined and the data were collected in rather limited areas.

As *Rhizoclonium riparium* is dominant in the entire area near Vlissingen, the algal vegetation there can be classified in the General Chlorophyceae Community (NIENHUIS 1970). The vegetation type dominated by *Rhizoclonium* is only one of many which can be classified in this community. *Percursaria percursa*, *Enteromorpha* spp., and *Vaucheria* spp. can also occur as dominants. CHAPMAN (1937) tripartitioned this community into "Low sandy Chlorophyceae", "Sandy Chlorophyceae", and "Muddy Chlorophyceae". The algal vegetation near Vlissingen shows no obvious similarity with any of these three groups. It is closest to the second group, which is considered by CHAPMAN (1937) as the least satisfactory.

In order to establish a satisfactory classification system for algal vegetations of saline areas it is necessary for it to be based on investigations in a very large

[1] *V. subsimplex* Crouan fr. = *V. sphaerospora* Nordst.

area, with diverse terrains and in which a certain geographical variation is present. The investigations must also be made in each season and for a period of several years. This is essential for establishing whether the vegetation units found are really independent or only seasonal aspects.

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