

THE DISTRIBUTION OF SOME LESSER KNOWN THALASSOCHOROUS PLANT SPECIES ALONG THE BELGIAN COAST, COMPARED WITH THEIR DISTRIBUTION IN WESTERN EUROPE

by

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ABSTRACT. — In 1982 a survey of the less common beach plants was carried out along the complete Belgian coast. Four species were recorded: *Glaucium flavum*, *Atriplex laciniata*, *Beta vulgaris* subsp. *maritima* and *Crambe maritima*. Their distribution, phenology and status are discussed, in the light of the situation in neighbouring countries. The rather explosive spread in 1982 is believed to be related to the numerous operations in the framework of coastal defence (planting of brushwood, raising of the beach) and the probable large amount of seeds cast-up in 1981, due to a strong northerly current in the English Channel.

INTRODUCTION

Beach and time-mark vegetations have been the subject of many studies in NW-Europe, e.g. in Great-Britain (OLIVER, 1912; SCOTT, 1963a), in France (VANDEN BERGHEN, 1958; GÉHU, 1960; GÉHU & GÉHU, 1969), the Netherlands (BEEFTINK, 1965; WESTHOFF, 1947), Norway (NORDHAGEN, 1940), W-Europe (VANDEN BERGHEN, 1964). In Belgium little or nothing has been done on the topic, except very locally (HOQUETTE, 1927; LAMBINON, 1956). This may have something to do with the fact that the sandy, very exposed Belgian coast is by nature not very suitable for the development of drifline vegetations. Winds and waves have free play. Moreover, most seaside resorts clean their beach by summer, i.e. remove the drift-line.

When in late summer we found some plants of *Crambe maritima*, a species that was only recently discovered in Belgium, we became curious. As recent literature (DE LANGHE *et al.*, 1983; VAN ROMPAEY & DELVO-

SALLE, 1978, 1979) gives only vague information on the species concerned we became interested in making an inventory of the lesser known beach species. To emphasize the fact that their main dispersal takes place by means of the sea currents, we prefer to use the term "thalassochorous" instead of "hydrochorous". Man is a terrestrial species and much more involved with the fresh water habitat. Moreover, the total length of seacoast suitable for the development of phanerogamic (and pteridophytic) vegetation is merely a fraction of the total length of suitable 'fresh water coast' (banks of rivers, canals, lakes, open water, ...). Hence the number of species and diversity of vegetations along the latter is much higher and clearcut from the marine environment. For these reasons we propose to restrict the term "hydrochorous" to the fresh water environment.

In particular we looked out for the following species: *Glaucium flavum* CRANTZ, *Beta vulgaris* L. subsp. *maritima* (L.) ARCANG., *Atriplex laciniata* L., *Atriplex glabriuscula* EDMONDST., *Polygonum oxyspermum* MEYER & BUNGE EX LEDEB. subsp. *raii* (BAB.) D. A. WEBB & CHATER, *Polygonum maritimum* L., *Crambe maritima* L., *Lathyrus japonicus* WILLD. subsp. *maritimus* (L.) P. W. BALL and *Crithmum maritimum* L. The more common species (e.g. *Honkenya peploides* (L.) EHRH., *Salsola kali* L., *Atriplex hastata* L., *Cakile maritima* Scop., ...) were noted too, but they are not treated in this paper. Information on these species in recent literature is considered satisfactory. As we decided only late in the season to carry out the present study, the main goal was to try to complete a survey in one season along the total length of the Belgian coast, in order to get a better insight into the distribution pattern of the species. Thanks to the mild weather in autumn 1982 we succeeded.

METHODS

The field work was carried out between the 1st of September and the 10th of November 1982. Presence, number of specimens, and some phenological data, were noted per 1 km²-square. These are the same squares used as field units for compiling the "Atlas van de Belgische en Luxemburgse Flora" (VAN ROMPAEY & DELVOSALLE, 1972). The results are represented in the Atlas in so called hour-squares (4 × 4 km²) however. As this grid is orientated in a north-south direction it meets the coast under an angle. This affects the total length of the beach in each square. Taking into consideration the direction of the coastline, the length of the beach section in a 1 km²-square can theoretically vary between 0 and 1350 m. Due to the difficulty of tracing the square boundaries in the field (good landmarks

are hard to find on a uniformly sandy beach), squares that only tip the coast, i.e. with a beach length of less than 100 m, were equally divided between neighbouring squares. On the other hand squares located in a harbour or an estuary can have a considerably longer coastline, e.g. Cl. 41. 12 has 3000 m. (For an explanation of the code of numbering we refer to the introductory chapter in the Atlas (VAN ROMPAEY & DELVOSALLE, 1972).)

The species that were encountered during the survey are discussed in detail. For each species two maps are given (figs 1-4), representing the former distribution (A) and the present results (B), the latter eventually with a few additions from recent years (from 1979 onwards). The data given in the figures A were extracted from the herbaria BR, GENT, LG and NAM, from the basic species lists of the Atlas, kept in the archives of the I.F.B.L. (Meise) and from the literature. Exact localisation of these ancient citations or collected specimens often proved to be difficult. Rather than denoting all possible squares in each case, which would overload both text and map or even give a false impression of the distribution, we choose for a small scale approach. In such cases the most probable 1 km²-square is indicated, according to our personal opinion. The data on the former distribution (A) are divided into three periods: before 1930, from 1930 up to and including 1949, from 1950 up to but excluding the most recent years (1979-1982). In this way the data can be compared with respectively the British and Belgian Atlas (PERRING & WALTERS, 1962; VAN ROMPAEY & DELVOSALLE, 1972, 1979) and the Dutch Atlas (MENNEMA *et al.*, 1980 and in preparation).

The species *Atriplex glabriuscula*, *Polygonum oxyspermum* subsp. *raii*, *Polygonum maritimum*, *Lathyrus japonicus* subsp. *maritimus* and *Crithmum maritimum* are extremely rare in Belgium or have never been observed yet. Their status is briefly mentioned.

RESULTS

Glaucium flavum CRANTZ

According to DE LANGHE *et al.* (1973, 1983) the species is rare to very rare and inconstant along the French and Belgian North Sea coast. No map is given in the Atlas (VAN ROMPAEY & DELVOSALLE, 1972, 1979). The latter authors do mention it in the text volume of the Atlas as being found now and then along the coast, (B2.34 and CO.48) but as not being able to hold its locations (Van Rompaey & Delvosalle, 1978).

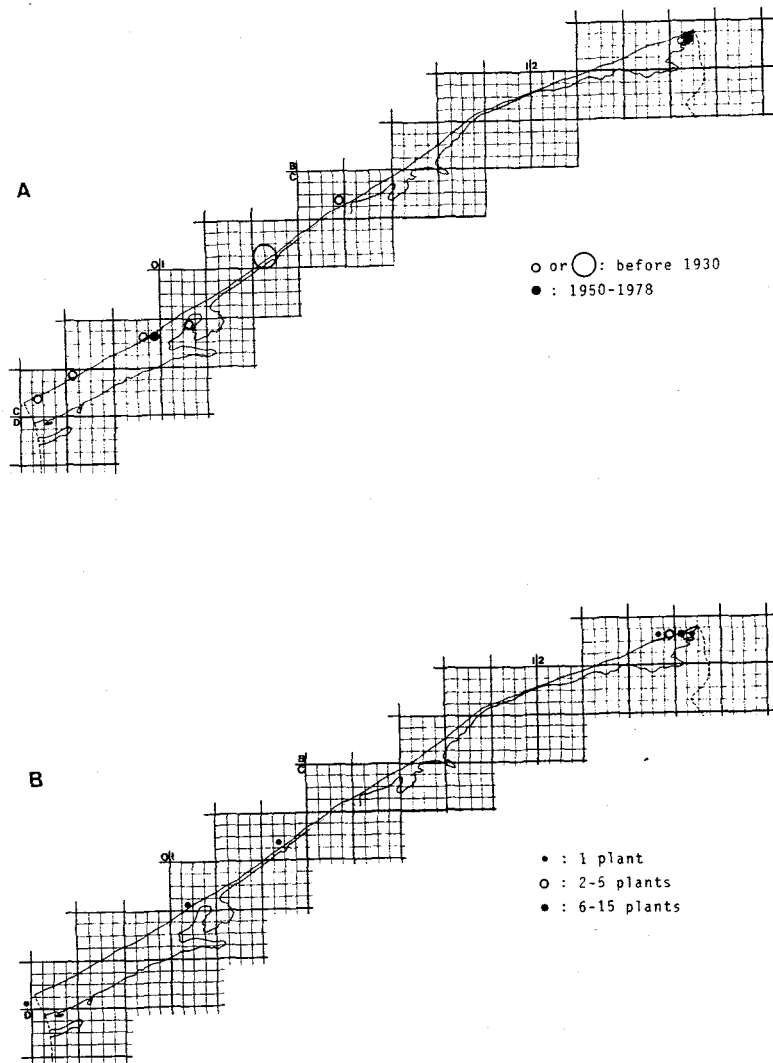


FIG. 1. - *Glaucium flavum* CRANTZ.
A. Former distribution. B. 1982 survey, with two additions (see text).

The oldest dated location is "La Panne, 8 juillet 1853" (CO.56.32), collected by Coemans and present in the herbaria **BR** and **GENT**. It had very probably been found before according to an undated specimen in the herbarium DUMORTIER (**BR**): "in maritimis intra Nieuport et Ostenda". The large open circle on fig. 1A, arbitrarily located halfway between these sites (Cl.23.3), refers to that case. Since then it has been found several times during the previous century. DE WILDEMAN & DURAND (1899) were already able to enumerate five sites, who might however bear only upon three localities. MASSART (1913) wrote about *Glaucium flavum* that it "semble avoir complètement disparu de ses habitations sur le littoral", but he neglected a find in 1911 (MAGNEL, 1914). Then it was not seen for a very long period, until 1950 and 1953 (squares mentioned by VAN ROMPAEY & DELVOSALLE, 1978). Again it disappeared, until very recently.

In the summer 1979 a flowering plant was found in a temporary sea inlet, caused by winter storms, in the dunes near the Zwin nature reserve (comm. G. W. Jansen, Terneuzen). It was absent the year after at that site (B2.34.14). In the autumn of the same year a rosette was found at Raversijde (Cl.23.32) in a somewhat sheltered corner of the strongly ruderalised dune, bordering a road and the adjacent sea promenade. It flowered the following season (RAPPÉ, 1981) and disappeared since then. In 1982 we found the species in 5 1km²-squares, distributed over 3 hour-squares. A total of 11 plants were noted, all but one rosettes. This makes it the rarest species encountered in the survey. In B2.34.13 a plant with mature capsules was present. As *Glaucium flavum* only flowers in the second season, and has no vegetative reproduction, the species must have been present in the previous season(s) too. The fact that 9 out of 10 rosettes, and 4 out of 5 1km²-squares, are situated in the same locality (Knokke) points in the same direction. Unfortunately we do not dispose of any observations from 1980 or 1981. It was found flowering in 1981 just across the border, in a storm inlet at Bray-Dunes, (CO.55.44), France, where it could not be found in 1982. Summarising we can state that, after a period of 65 years in which it was found twice, *Glaucium flavum* has been present during the past five seasons, from 1979 on, along the Belgian coast.

The species is known inland as a garden escape and as an adventive, especially along the gravel shores of the river Vesdre, in the vicinity of which an important wool (import) industry was established. There is however one find (in **BR**) in which the possible indigenous character cannot be totally ruled out: "Sables de l'Escaut, Calloo, 22 juillet 1904"

(C4.14), collected flowering by J. Hennen. The species is known to extend along rivers in Spain, Portugal and France (Scott, 1963b).

Glaucium flavum occurs on the shores of the Mediterranean, extending to the Black Sea and along the Atlantic continental shore up to the Dutch Wadden Sea. It is well distributed around the British Isles south of the Forth-Clyde line and has a northernmost outpost in the Skagerak-Kattegat area. It has been observed before 1945 on the German islands Borkum and Helgoland and the Danish island Fanø (RAABE *et al.*, 1982, PRINS *et al.*, 1983).

The Belgian coast fits well in the above described range. The species must undoubtedly be considered as indigenous there.

The reappearance on the Belgian coast can be compared with the strong recent expansion in the Netherlands : known in 1973 from 9 hour-squares since 1950, it climbed to 17 in 1979 and 20 in 1981 (QUENÉ-BOTERENBROOD & MENNEMA, 1973 ; MENNEMA & HOLVERDA, 1980 ; MENNEMA *et al.*, 1983).

***Beta vulgaris* L. subsp. *maritima* (L.) ARCANG**

DE LANGHE *et al.* (1983) call *Beta vulgaris* subsp. *maritima* rather rare along the coast. The distribution map in the Atlas (Van Rompaey & Delvosalle, 1979) shows it to occur in 9 hour-squares, one of which is somewhat inland, in the polder area. This gives a flattering picture of the status of the species along the Belgian coast, as a closer look at the basic data, and a search in the literature revealed. CRÉPIN (1883) knew it from Ostend and Nieuport. He considered it very rare, and wondered whether it is really native. DE WILDEMAN & DURAND (1899) added one more locality. In fact the latter site and the many others mentioned since, were all isolated, temporary and most often unique finds according to the available data : 1884 (Blankenberge and Duinbergen), 1921 (Bredene), 1931 (between Ostend and Bredene), 1934 (Wenduine), c. 1935 (De Panne), 1946 (Knokke), 1948 (Heist), 1949 (Blankenberge and Zeebrugge), 1950 (De Haan), 1952 (Lombardsijde), 1954 (Zeebrugge and the Zwin). The numerous finds in the forties and the fifties reflect the intensive field work by I.F.B.-members with the intention of preparing the Atlas. *Beta vulgaris* subsp. *maritima* might have hold for a few years in the harbour of Zeebrugge (1949-1954). It has also been found on several occasions in the Dutch part of the Zwin salt marsh (B2.34.21 & 23) but only very rarely in the much larger Belgian part. Apart from these, there are only two steady populations on the Belgian coast, still existing today : the Yser

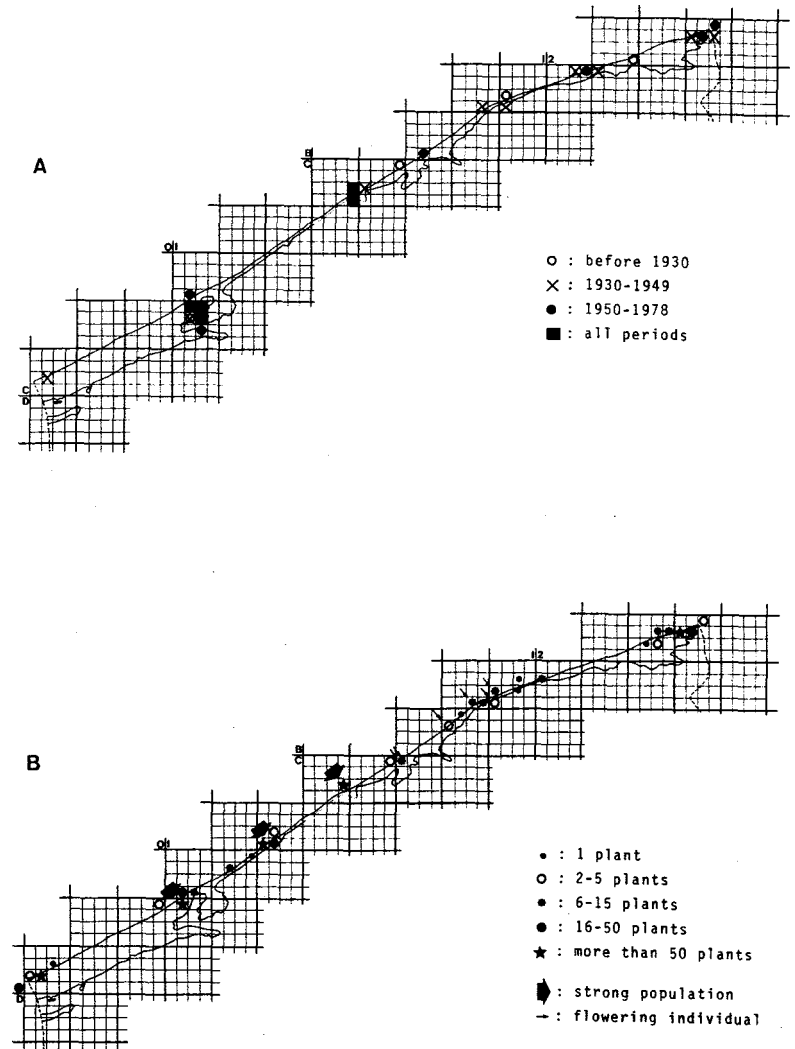


FIG. 2. - *Beta vulgaris* L. subsp. *maritima* (L.) ARCANG.
A. Former distribution. B. 1982 survey.

estuary at Nieuport and the harbour of Ostend (where it is only found on the seaward side nowadays). The former site is known since 1875 (GENT). At the latter it might have disappeared and been reestablished several times (or temporarily overlooked); it was collected for the first time around 1830 (LG), again in 1859 (BR, GENT) and not again until 1884 (LG). Since then data are regularly distributed in time.

In the present survey we found *Beta vulgaris* subsp. *maritima* in 30 1km²-squares, distributed over 15 hour-squares. Though it is the most numerous of the recorded species it is still far from common. There are only three well-established populations: the two classical sites and a third one in between, which we already discovered in 1979, together with the *Glaucium* specimen, along the road on the sea promenade between Raversijde and Middelkerke. These were the only places where numerous flowering/fruit bearing individuals were seen, accompanied by many more rosettes. Elsewhere flowering was so scarce that the individuals could be depicted on the map (fig. 2B). There are firm populations, consisting of rosettes only, at De Panne (west coast), with 59 specimens in 3 1km²-squares, and at Knokke (east coast), with 104 specimens in 6 1km²-squares.

Beta vulgaris subsp. *maritima* is a mediterranean-atlantic species that reaches its northern limit along the coasts of the British Isles and in the Netherlands. In this country it is almost entirely restricted to the Delta area and the Wadden Sea. More to the north there are recent finds at Helgoland (RAABE *et al.*, 1982) and Fanø (PRINS *et al.*, 1983). It has an isolated range in the Great Belt area (Denmark) and the Swedish west coast, where it is thought to be naturalised (HANSEN & PEDERSEN, 1968).

In the Netherlands it shows a marked spreading during the last three decades, from 27 hour-squares before 1950 to 45 hour-squares since then (MENNEMA *et al.*, 1983). This may be partly due to intensified field work. The increase is most pronounced in the West-Friesian Isles, suggesting a northward expansion (see above).

Atriplex laciniata L.

Atriplex laciniata is considered very rare along the coast by DE LANGHE *et al.* (1983). VAN ROMPAEY & DELVOSALLE (1979) know it from five hour-squares. As a therophyte this species is more susceptible to fluctuations in occurrence than the other species treated. Its habitat is also the most vulnerable of all: naked sandy beaches, on the tide mark and even in front of it. It is a pioneer together with species like *Cakile maritima* and *Salsola kali*.

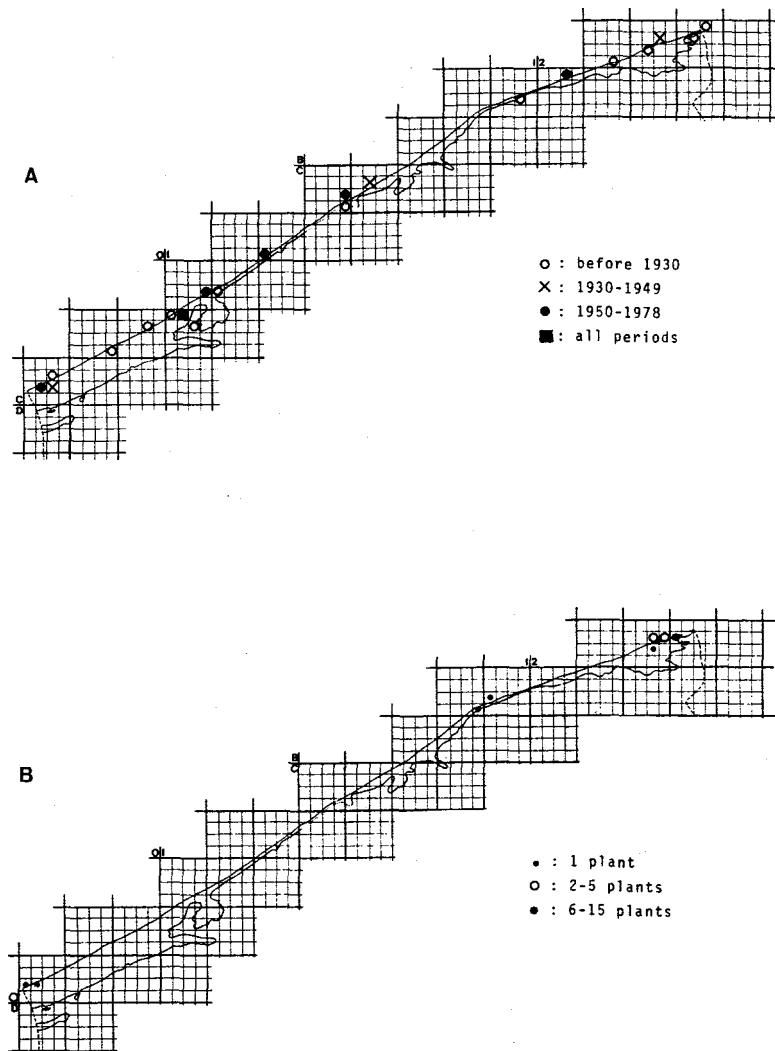


FIG. 3. - *Atriplex laciniata* L.
A. Former distribution. B. 1982 survey, with one addition (see text).

It has been found all along the coast during the last century but only rarely on more than one place in the same season. This happened to be the case in 1868, 1912 and 1928, when it was found in two localities, and in 1954 and 1955, when it was found in three. It seems to have been a rather constant species in the Yser estuary (Cl. 41), where it has been noted very regularly between 1879 and 1954. It also might have appeared often at Oostduinkerke (CO.48), one of the very rare beaches on the Belgian coast where there is a more or less constant accretion of sand. *Atriplex laciniata* can stand a moderate sand covering. It was found there in 1920 and relatively abundantly in 1928. At Knokke (B2.33) it was found several times in the thirties (1931, 1933, 1934). In the other localities *Atriplex laciniata* probably 'came and went away'.

In the 1982 survey *Atriplex laciniata* was found in 7 1km²-squares, distributed over 5 hour-squares. A single find at De Panne (CO.56.32) in 1980 (D'HONDT, 1981) is also mapped (fig. 3B). The only 'strong' site was Knokke where 19 of the 22 discovered individuals were located. As the survey was carried out late in the season, some specimens of this annual might already have completed their life cycle and disappeared by the time we passed at the site. It is possible that the described distribution picture is an underestimation. Moreover, the Belgian beaches are really crowded with people during the summer months. The zone preferred by humans happens to coincide with the habitat of *Atriplex laciniata*. The number of plants smashed, trampled or simply torn or dug out is unknown to us. Nevertheless the observed distribution is the largest ever recorded in one season. Whether this really reflects an increase remains largely a matter of conjecture. At least at Knokke the species has benefitted from certain conditions (see discussion).

Atriplex laciniata occurs along the Atlantic coast from the Pyrenees to Norway and the Shetlands. It enters the Baltic up to about 15°E. It also has an outpost along the Spanish Mediterranean coast (JALAS & SUOMINEN, 1980). In contrast to the expansion in Denmark, Sweden, Norway and Scotland (HANSEN & PEDERSEN, 1968), the species has severely decreased in number in Schleswig-Holstein (RAABE *et al.*, 1982) and to a lesser extent also in the Netherlands (MENNEMA *et al.*, 1983).

Crambe maritima L.

According to DE LANGHE *et al.* (1973) the species did not exist in Belgium, but occurs rarely in N-France and in the SW-Netherlands, where it is expanding. In 1974 we discovered a specimen on a jetty in the

harbour of Ostend (Cl.14.44) (RAPPÉ & GOETGHEBEUR, 1975), the only find that was included in later editions of the Belgian Flora (DE LANGHE *et al.*, 1978, 1983). In the winter of 1976-77 part of an inflorescence with some fruits was found in the drift line along the slope of a military dock at Nieuport (GOETGHEBEUR & RAPPÉ, 1977). As the site is inaccessible to the public no information on the species growing on the spot had reached us since. No map is given in the Atlas (VAN ROMPAEY & DELVOSALLE, 1972, 1979). In the text volume (VAN ROMPAEY & DELVOSALLE, 1978) however the two above recorded sites are mentioned, together with the communication that it would have been seen formerly at Zeebrugge (B2.41). No other trace of the latter could be found, neither in the literature, nor in the herbaria, and not even in the manuscript of the text volume (in the archives of the I.F.B.L.). As the first author died some years ago and the second author was unable to solve the problem, it must preliminarily remain undated. We tend to accept it however. Perhaps it refers to DE WILDEMAN & DURAND (1899), who included it under "espèces mal déterminées ou dues à des indications fautives". We speculate however that it might have been a separate find, considered as an adventive at the time and therefore never published. Still some people do consider finds of the species treated in this paper as adventive occurrences (STIEPERAERE & FRANSEN, 1982). Rather by coincidence some other data concerning previous records came to our knowledge during the survey. In 1962 the species was found at De Panne (CO.56.32) (DE RIDDER, 1963). The presumed cast-up inflorescence at Nieuport (Cl.41.12) proved to be from a local individual. *Crambe maritima* was known to some local naturalists to occur there since at least 1973, when three specimens were found. In 1977 14 plants were present, some flowering (comm. M. Verbouw, Oostduinkerke). In 1974 a seedling was found growing in the drift line at De Panne, but only recognized later (comm. P. Goetghebeur, Gent). Probably *Crambe maritima* has germinated on several occasions in the past, but only very rarely succeeded in reaching a full-grown state. The 1974 specimen at Ostend has managed to flower some seasons but has disappeared since.

In 1981 two well-developed plants and a smaller one were observed at De Panne. These had multiplied, by means of horizontal rhizomes, to thirteen rosettes by 1982. During the survey that same year *Crambe maritima* was found in 16 1km²-squares, distributed over 11 hour-squares. It was also noted in two adjacent squares on French territory. In most cases it only concerned a single specimen, but in a winter drift line covered with sand, a total of no less than 56 small rosettes (3-6 leaves)

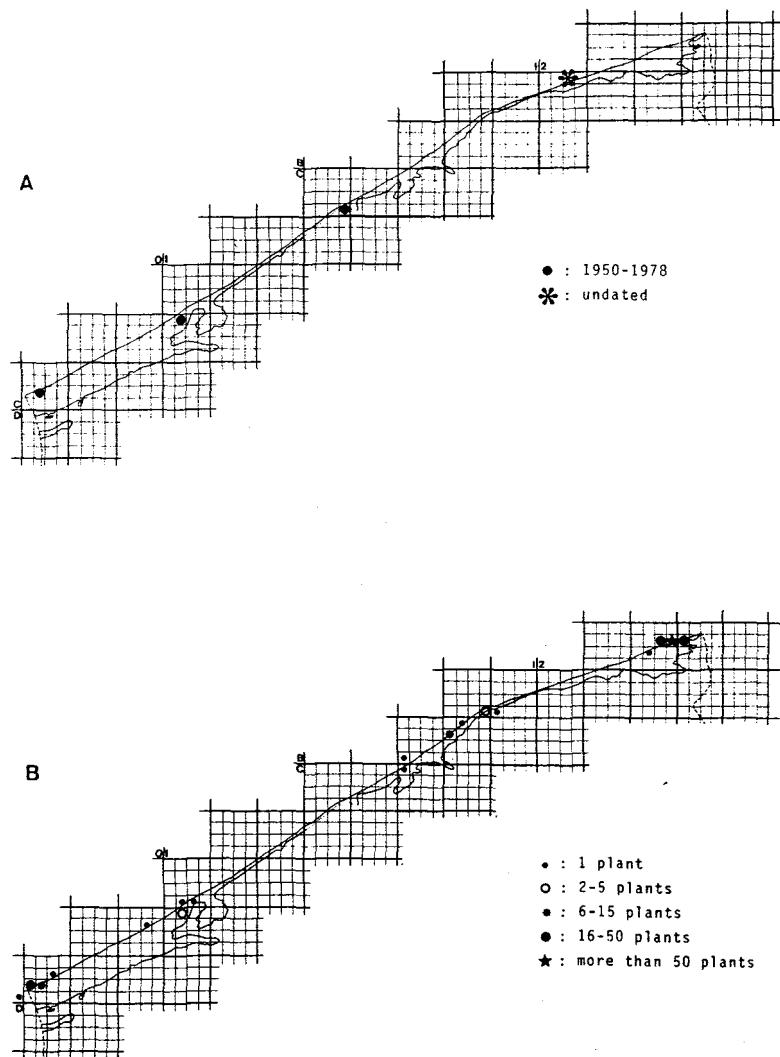


FIG. 4. - *Crambe maritima* L.
A. Former distribution. B. 1982 survey.

were noted over a distance of about 50 m, together with *Salsola kali*, at Knokke (B2.34.24). Apart from that, the latter site harboured 74% of the Belgian 'population', videlicet 103 of the 139 specimens encountered, within 4 squares. To our knowledge no flowering took place in 1982.

Crambe maritima occurs along the coasts of the British Isles, on the continent from Brittany (France), with a few scattered localities more to the south (N-Spain), to the Dutch Wadden Sea and along the Skagerak-Kattegat and Baltic coasts. It has been observed before 1945 on the East-Friesian Isle of Norderney (PRINS *et al.*, 1983). A separate race, *pontica* (STEVEN) SCHULZ, occurs on the coasts of the Black Sea and the Sea of AZOV. In contrast to the apparent decline in Ireland and England (SCOTT & RANDALL, 1976), the species has made an explosive expansion in Belgium and especially in the Netherlands. Apart from a single find in 1935, it established itself in the latter country in 1959. By 1973 it was known from 18 hour-squares and by 1982 this figure had raised to 40 (QUENÉ-BOTERENBROOD & MENNEMA, 1973; MENNEMA *et al.*, 1983)!

The following species that could have been expected to a varying extent, have not been found during the 1982 survey.

Atriplex glabriuscula EDMONDST

This is a species with a northwestern distribution in Europe, from 48°N (Brittany) to about 70°N (N-Norway, Moermansk), including the British Isles, Faeroë and Iceland. It enters the Baltic up to 60°N. It has an amphiatlantic distribution.

Although found on several occasions in N-France and the SW-Netherlands, *Atriplex glabriuscula* has never been observed with certainty along the Belgian coast (DE LANGHE *et al.*, 1979). A specimen identified as such is present in the herbarium LG. It indeed looks like it, as far as the leaf shape is concerned. Care should be taken though, as the specimen lacks mature fruits. It was collected in August 1937 at De Panne (CO. 56) by Matagne (*).

Polygonum oxyspermum MEYER & BUNGE EX LEDEB. subsp. *raii* (Bab.) D. A. WEBB & CHATER

The taxonomic status of this species is not clearcut. The present taxon is distributed locally in NW-France, the British Isles (especially the south

(*) On September 26, 1984 two specimens of *Atriplex glabriuscula* bearing mature fruits were found at De Panne (CO.56.31) by C. Westra and M. Leten. (Note added in proof).

and west coast) and from the German Bight to Kola Peninsula. According to RAABE *et al.* (1982) it also enters the Baltic. It seems to be declining everywhere in W-Europe (FITTER, 1978 ; JALAS & SUOMINEN, 1979 ; RAABE *et al.*, 1982).

The species has been found in Belgium once, viz. at Raversijde (BI.23.32 or 41), between the cinders along the tramway on the sea promenade. It was collected there on 1 October 1956 by L. Pauwels. Preserved material is kept in BR and LG. This find was considered as native by DE LANGHE *et al.* (1973, 1983).

Polygonum maritimum L.

Polygonum maritimum is a species present on all Mediterranean shores and along the Black Sea coast. It extends northward to Brittany, Normandy and the extreme southwest of England and occurs in one locality in Ireland. It has been found once in the southwest of the Netherlands, the 'Delta' area, under natural circumstances (BEEFTINK, 1964).

It has never been found in Belgium.

Lathyrus japonicus WILLD. subsp. *maritimus* (L.) P. W. BALL

This species occurs on the south and southeast coast of England, with outposts in Scotland and the Shetlands and a former one in N-Spain. It has disappeared from the French coast of the English Channel. On the continent its present range extends from the German Bight to the Kola Peninsula, and includes all Baltic coasts (BRIGHTMORE & WHITE, 1963 ; PRINS *et al.*, 1983). Very recently, in 1973, the species settled in the Netherlands (SCHENDELAAR, 1976), where it even shows a slight increase now (Mennema, 1980).

It has been found once in Belgium, in 1920 at Blankenberge (BI. 48) by V. Lambert (specimen kept in herbarium BR). DE LANGHE *et al.* (1983) treat the species as an adventive, though its British range is closer to the Belgian coast than that of *Polygonum oxyspermum* subsp. *raii*.

Crithmum maritimum L.

A southern species that reaches its northern limit in the Netherlands and on the British Isles, especially along the south and west coast. It usually grows on cliffs. Though it has been found on several occasions in N-France, very near the Belgian border, and it still exists within 10 km from the eastern border, in the Netherlands (RAPPE, 1978), it was never

found in Belgium. It should be looked for on stone-covered dikes and dunes, and is in fact only to be expected in harbour areas.

DISCUSSION

The species met in the 1982 survey were all known as rare. This is mostly due to the rareness of suitable habitats and only to a small part to e.g. the distance from its main range. It has clearly been shown that the Belgian coast fits in with the main distribution pattern in Europe. So the species are to be considered as full members of the Belgian flora. There is no reason to doubt their native status. Hence we wonder why *Glaucium flavum* is not mapped in the Atlas (VAN ROMPAEY & DELVOSALLE, 1979). In the case of *Crambe maritima* its recent settling might be an appropriate explanation. The same criticism holds for the absence of *Glaucium* and *Crambe* in the 'Standardlist of Belgian vascular plants', compiled recently by STIEPERAERE & FRANSEN (1982). A sound reason for omitting species like the ones mentioned in this paper might be found in their ephemeral behaviour. In this way however all but may be one locality of *Atriplex laciniata* and all but two of *Beta vulgaris* subsp. *maritima* should have been omitted too. We do admit that there are some difficulties in describing the status of an ephemeric species properly, i.e. apart from the statement that it is such a species. In this respect table 1 and table 2 should be compared with one another. Table 1 summarizes the status in four periods, as retained in the figs 1-4. Table 2 gives the maximum number of localities (squares) observed in the same season. A good measure for rareness could be found in this 'one season' approach, retaining the

Table 1

Comparison of the number of hour-squares (16 km²) and 1 km²-squares (between brackets) in which *Glaucium flavum*, *Beta vulgaris* subsp. *maritima*, *Atriplex laciniata* and *Crambe maritima* were observed along the Belgian coast within limited periods.

	G. f.	B. v.	A. L.	C. m.
< 1930	5-6 (5-7)	5 (8-11)	10 (10-15)	-
1930-1949	-	9 (12-15)	4 (4-5)	-
1950-1978	2 (2)	6 (10-12)	6 (6-7)	3-4 (3-4)
1979-1982	4 (6)	15 (30)	5 (8)	11 (16)

Table 2

The maximum distribution (number of hour-squares) of *Glaucium flavum*, *Atriplex laciniata*, *Crambe maritima* and *Beta vulgaris* subsp. *maritima* observed in one season.

(-): low values not filled in; - : intermediate values not observed

	<i>G. f.</i>	<i>A. l.</i>	<i>C. m.</i>	<i>B. v.</i>
2 sq.	1855 ? 1979	(-)	(-)	(-)
3 sq.	1982	1954 1955	1974	(-)
4 sq.		-	-	1884
5 sq.		1982	-	1949 ?
11 sq.			1982	-
15 sq.				1982

maximum value as a reference for purposes such as the standard list. By coincidence this changes nothing to the classes in which *Atriplex laciniata* was catalogued in that list. We suggest to change the values for *Beta vulgaris* subsp. *maritima* and put it in class 4, both for northern Belgium and the complete territory. Furthermore we suggest to insert *Glaucium flavum* and *Crambe maritima* in the ecological group 3a: beaches, sea dunes and sandy tide marks. For *Crambe* the class values would then become 4 and 4, for respectively the northern part and the whole country; for *Glaucium* these would be 2 and 2 respectively.

Table 2 clearly shows that, for the four species alike, 1982 was a record year. What made that year so favourable? First of all it was the first survey covering the whole coast the same season. This however can only partly explain the observed differences. In the case of *Beta vulgaris* subsp. *maritima* and *Crambe maritima* the cumulated data of the previous three periods, covering more than a century (fig. 2A and 4A), show a lower number of squares than the survey of one season alone!

An increased local production of seed as a factor in the spreading along the Belgian coast looks highly improbable to us. Although *Beta vulgaris* subsp. *maritima* and *Crambe maritima* have flowered and set fruit several times in their habitats at Nieuport and Ostend this never led to any propagation. *Glaucium flavum* flowered and disappeared at Raversijde. The same holds for the find at Knokke in 1979, which we believe has nothing to do with the present population. Maybe this is valid on a short

term for an annual like *Atriplex laciniata* but it was practically always found single. As its habitat is the most vulnerable of all, it is hard to reach any conclusions on the subject here.

We already noted that the Belgian coast is too exposed to allow lasting settlement of these species. Judging from the results of the survey one could doubt that point. It is true though. Moreover, the sea level is rising along the southeastern coast of the North Sea. This feature and the fairly high frequency of storms during the last 15 years are responsible for a heavy erosion of the beach and foremost dunes. Various measures have been taken to prevent the erosion or to keep it as limited as possible: lengthening existing break-waters and construction of new ones, the use of huge 'sand-sausages' in the intertidal, parallel to the coast, raising the beach level or simply carrying up sand, quarried elsewhere on the beach, to the foot of the dunes. In the latter two measures, the new surfaces are planted with various types of wooden, plastic or synthetic tissue mats, rows of brush-wood, eventually combined with planting of marram grass. These measures were used over the last few years on a larger scale than ever before. Especially the rows of brushwood at the foot of the dunes, have become an integrated part of the beach landscape over several tens of kilometers now, and form a real network locally. Between the bundles and rows stability of the substratum seems to have increased to a level that allows settlement of *Beta*, *Crambe* and *Glaucium*. The planted brushwood is slowly decaying in the sand, raising its organic matter content. As most driftline species are nitrophilous to some extent, this is also a factor in favour. At Knokke, where, except for the well-established populations of *Beta*, all species had the biggest density and could often be observed together, the situation is somewhat different. In 1978 the beach was raised here with sand from the North Sea, creating a platform of 20 to 40 m broad in front of the stonecovered foot of the dunes. The sand used was coarser than the original substratum and much more silty (the original sand was not silty at all in fact). Scott (1963a) drew attention to the importance of a fine matter on the shingle beaches in Great Britain. This does not apply for a fine sediment coast like the Belgian coast but it may however play a role in this particular case of raising with a coarser material. The beach morphology too shows some resemblance to a shingle beach. There is a relatively steep slope along which the usual (summer) drift line is to be seen. At the landward side of the ridge a very slow slope leads to the winter and storms drift line, leaving a broad zone of undisturbed beach during the growth season. As the substratum is coarser it is more stable too. Here a vegetation of scattered plants of *Elymus*

farctus, *Salsola kali*, *Cakile maritima* and sometimes *Honkenya peploides*, *Atriplex laciniata* and *Beta vulgaris* subsp. *maritima* develops. In the winter drift line *Crambe maritima* germinates. Development of these vegetations however is far from ideal, due to the heavy trampling by tourists during the summer months. The more remote parts of the beach, in the direction of the Zwin nature reserve are heavily planted with long bundles of brushwood. In this zone the beach vegetation becomes infested with many nitrophytes, adventives and species of disturbed soils such as *Urtica dioica*, *Sonchus oleraceus*, *Cirsium arvense*, *Cirsium vulgare*, *Chenopodium rubrum*, *Rumex conglomeratus*, *Senecio vulgaris*, *Senecio viscosus*, *Plantago coronopus*, *Diplotaxis tenuifolia*, *Lycopsis arvensis*, ... Ironically we can conclude that the species we are concerned with here have benefitted considerably from the erosion of the Belgian coast.

We want to put forward a second factor of probable (but unknown) importance, largely based on zoological evidence. Recently some southern marine organisms have shown a trend of spreading northward (e.g. COPPEJANS *et al.*, 1980; BLACKER, 1981; ADEMA & RAPPÉ, 1981; PRUD'HOMME VAN REINE & NIENHUIS, 1982). This was particularly obvious in the second half of 1981, when we believe a strong oceanic current came through the English Channel and entered the Southern North Sea (see also TURK, 1982). It brought along with it the second specimen for the North Sea of the dolphin *Stenella coeruleoalba* (VAN GOMPEL, 1982), the first tropical drift seed washed ashore on the Belgian coast (RAPPÉ & KERCKHOF, 1982) and numerous stalked barnacles (RAPPÉ & KERCKHOF, 1983). We think it to be very well possible that it also carried a larger seed pool than usual of beach plants. The species treated in this paper all happen to be common on both the French and the English coast of the English Channel. For this reason we do no longer believe that the appearance of *Crambe maritima* on the Belgian coast was due to the expansion in the Netherlands, as we exposed previously (RAPPÉ & GOETGHEBEUR, 1975), but originated independently, from the south. There happened to be an invasion of stalked barnacles in the summer of 1971. Was this a coincidence? Observe in this respect also the recent spread of *Glaucium flavum* in the Netherlands.

Finally we can question what the future behaviour of these beach plants along the Belgian coast will be. Conditions in the long run stay adverse. The true nature of the coast has not, and probably will not change: it still consists of unstable fine sediments very susceptible to erosion. At short notice everything will depend on the maintenance of the hedgerows of brushwood, which are easily damaged during winter

storms. At present Knokke may be the exception to the rule as it has a favourable beach morphology temporarily.

Atriplex laciniata has always been and will probably always be an irregular appearance on the beach. Although *Glaucium flavum* is known to be a hemicryptophyte, being able to survive by forming new rosettes, we have the impression that it behaves like a biennial along the Belgian coast. So its presence depends on its own seed production or on renewed colonisation from the south. *Beta vulgaris* subsp. *maritima* and *Crambe maritima* are long-lived perennials. They will probably be able to survive for some time, if erosion stays within certain limits. They are not as vulnerable as the previous two, because they also occur on some less exposed spots. However, to ensure the presence of *Crambe maritima*, propagation from local mature plants will probably prove necessary.

ACKNOWLEDGEMENTS

We wish to thank the directors of the Herbaria examined, prof. E. Petit (BR), prof. P. Van der Veken (GENT), prof. J. Lambinon (LG) and prof. J. L. De Sloover (NAM); dr. L. Delvosalle and Mrs. J. Saintenoy-Simon for permission to work in the archives of the I.F.B.L. (Meise); J. Mennema and Mrs. A. J. Quenè-Boterenbrood (Rijksherbarium, Leiden) for unpublished information on the distribution in the Netherlands; and last but not least R. Fabri, L. Vanhecke and H. Stieperaere (Nationale Plantentuin, Meise) and M. Leten (Gent) for their stimulating help in various ways.

REFERENCES

- ADEMA, J. P. H. M. & G. RAPPÉ (1981). Het raadsel van de Breedpootkrab langs de lage landse kusten. *Het Zeepaard* 41 : 45-49.
- BEEFTINK, W. G. (1964). *Polygonum maritimum* L. in Nederland. *Gorteria* 2 : 13-20.
- BEEFTINK, W. G. (1965). De zoutvegetatie van ZW-Nederland beschouwd in Europees verband. 167 blz. Ph. D. thesis, Wageningen.
- BLACKER, R. W. (1981). Recent occurrences of blue whiting, *Micromesistius poutassou*, and Norway pout, *Trisopterus esmarkii*, in the English Channel and the southern North Sea. *J. mar. biol. Ass. U.K.* 61 : 307-313.
- BRIGHTMORE, D. & P. H. F. WHITE (1963). *Lathyrus japonicus* Willd. (L. maritimus Bigel.). Biological Flora of the British Isles no. 97. *J. Ecol.* 51 : 795-801.
- COPPEJANS, E., G. RAPPÉ, N. PODOOR & M. ASPERGES (1980). *Sargassum muticum* (Yendo) Fensholt ook langs de Belgische kust aangespoeld. *Dumortiera* 16 : 7-13.
- CRÉPIN, F. (1883). Manuel de la Flore de Belgique. 5^e éd., Liège, 495 pp.

- DE LANGHE, J.-E., L. DELVOSALLE, J. DUVIGNEAUD, J. LAMBINON & C. VANDEN BERGHE (1973). Nouvelle flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des régions voisines. Bruxelles, xcvi + 821 pp.
- DE LANGHE, J.-E., L. DELVOSALLE, J. DUVIGNEAUD, J. LAMBINON & C. VANDEN BERGHE (1978). Nouvelle flore ... (2^e édition). Meise, cv + 899 pp.
- DE LANGHE, J.-E., L. DELVOSALLE, J. DUVIGNEAUD, J. LAMBINON & C. VANDEN BERGHE (1983). Flora van België, het Groothertogdom Luxemburg, Noord-Frankrijk en de aangrenzende gebieden (Pteridofyten en Spermatofyten). Meise, civ + 970 blz.
- DE RIDDER, H. (1963). Plantensociologische studie in het natuurreservaat van de Westhoek te De Panne. Unpublished thesis, Gent, 115 pp.
- DE WILDEMAN, E. & Th. DURAND (1899). Prodrôme de la Flore Belge. III. Bruxelles.
- D'HONDT, A. (1981). De vegetatie van de Westhoek, een fytosociologische studie van het staatsnatuurreservaat ten behoeve van het beheer, met vegetatiekaart, Gent, 142 pp.
- FITTER, A. (1978). An Atlas of the wild flowers of Britain and Northern Europe. London, 272 pp.
- GÉHU, J. M. (1960). La végétation des levées de galets du littoral français de la Manche. *Bull. Soc. Bot. Nord France* **13** : 141-152.
- GÉHU, J. M. & J. GÉHU (1969). Les associations végétales des dunes mobiles et des bordures de plages de la côte atlantique française. *Vegetatio* **12** : 1-95.
- GOETGHEBEUR, P. & G. RAPPÉ (1977). Nogmaals *Crambe maritima*. *Dumortiera* **7-8** : 64.
- HANSEN, A. & A. PEDERSEN (1968). Chenopodiaceernes og Amaranthaceernes udbredelse i Danmark. *Bot. Tidsskr.* **63** : 205-288.
- HOQUETTE, M. (1927). Étude sur la végétation et la flore du littoral de la Mer du Nord de Nieuport à Sangatte. *Arch. Bot. Mém.*, Caen 1.
- JALAS, J. & J. SUOMINEN (eds) (1979). Atlas Florae Europaeae. 4. Polygonaceae. Helsinki, 71 pp.
- JALAS, J. & J. Suominen (eds) (1980). Atlas Florae Europaeae. 5. Chenopodiaceae to Basellaceae. Helsinki, 119 pp.
- LAMBINON, J. (1956). Aperçu sur les groupements végétaux du district maritime belge, entre La Panne et Coxyde. *Bull. Soc. Roy. Bot. Belg.* **88** : 106-127.
- MAGNEL, L. (1914). Note sur la remarquable persistance de quelques stations de plantes rares sur le littoral. *Bull. Soc. Roy. Bot. Belg.* **52** : 167-170.
- MASSART, J. (1913). Que sont devenues nos plantes rares de 1862 ? *Bull. Soc. Roy. Bot. Belg.* **52** : 80-84.
- MENNEMA, J. (1980). Nieuws over de zeelathyrus, *Lathyrus japonicus* Willd. subsp. *maritimus* (L.) P. W. Ball. *Gorteria* **10** : 56.
- MENNEMA, J. & W. J. HOLVERDA (1980). Nieuwe vondsten van zeldzame planten in Nederland. hoofdzakelijk in 1979. *Gorteria* **10** : 81-100.
- MENNEMA, J., A. J. QUENÉ-BOTERENBROOD & C. L. PLATE (1980). Atlas van de Nederlandse Flora 1. Amsterdam, 226 pp.
- MENNEMA, J., A. J. QUENÉ-BOTERENBROOD & C. L. PLATE (1983). Atlas van de Nederlandse Flora 2. (in voorbereiding).
- NORDHAGEN, R. (1940). Studien über die maritime Vegetation Norwegens. 1. Die Pflanzengesellschaften der Tangwälle. *Bergens Mus. Årb.* **2** : 1-123.
- OLIVER, F. W. (1912). The shingle beach as a plant habitat. *New Phytol.* **11** : 73-99.
- PERRING, F. H. & S. M. WALTERS (1962). Atlas of the British Flora. London.
- PRINS, D., H. KUBHIER, A. PEDERSEN, J. MENNEMA & E. J. WEEDA (1983). Main list with indigenous or naturalised Phanerogams and Pteridophytes of the Wadden Sea area. 323-339. in K. S. Dijkema & W. J. Wolff (eds). Flora and vegetation of the Wadden Sea islands and coastal areas. Ecology of the Wadden Sea. Report 9. Rotterdam, 413 pp.
- PRUD'HOMME VAN REINE, W. F. & P. H. NIENHUIS (1982). Occurrence of the Brown Alga *Sargassum muticum* (Yendo) Fensholt in the Netherlands. *Bot. Mar.* **25** : 37-39.
- QUENÉ-BOTERENBROOD, A. J. & J. MENNEMA (1973). Zeldzame Nederlandse plantensoorten in Zuid-Holland. 's-Gravenhage, 110 pp.
- RAABE, E. W., C. BROCKMANN & K. DIERSSEN (1982). Verbreitungskarten ausgestorbener, verschollener und sehr seltener Gefäßpflanzen in Schleswig-Holstein. *Mitt. AG Geobot. Schlesw.-Holst./Hamb.* **32** : 1-315.
- RAPPÉ, G. (1978). Over enkele thalassochoren. *Het Zeepaard* **38** : 54-60.
- RAPPÉ, G. (1981). Gele hoornpapaver (*Glaucium flavum*) te Raversijde. *Stentor* **16** (3) : 78-79.
- RAPPÉ, G. & P. GOETGHEBEUR (1975). *Crambe maritima* L., nieuw voor de Belgische Flora. *Dumortiera* **3** : 10-14.
- RAPPÉ, G. & F. KERCKHOF (1982). Eerste vondst van een tropisch drijfzaad. *Entada gigas*, aan de Belgische kust. *De Strandvlo* **2** : 105-110.
- RAPPÉ, G. & F. KERCKHOF (1983). Drie recente eendemosselinvasies. *De Strandvlo* **3** : 25-32.
- SCHENDELAAR, J. K. (1976). Zeelathyrus : na 236 jaar terug van weggeweest. *Natura* **73** : 97-100.
- SCOTT, G. A. M. (1963a). The ecology of shingle beach plants. *J. Ecol.* **51** : 517-527.
- SCOTT, G. A. M. (1963b). *Glaucium flavum* Crantz. Biological Flora of the British Isles no. 90. *J. Ecol.* **51** : 743-754.
- SCOTT, G. A. M. & R. E. RANDALL (1976). *Crambe maritima* L. Biological Flora of the British Isles no. 139. *J. Ecol.* **64** : 1077-1091.
- STIEPERAERE, H. & K. FRANSEN (1982). Standaardlijst van de Belgische vaatplanten, met aanduiding van hun zeldzaamheid en socio-ecologische groep. *Dumortiera* **22** : 1-41.
- TURK, S. M. (1982). Influx of warm-water oceanic drift animals into Bristol and

- English Channels, summer 1981. (with added note). *J. mar. biol. Ass. U.K.* **62** : 487-489.
- VANDEN BERGHEN, C. (1958). Étude sur la végétation des dunes et des landes de la Bretagne. *Vegetatio* **1** : 317-324.
- VANDEN BERGHEN, C. (1964). La végétation terrestre du littoral de l'Europe Occidentale. Les Naturalistes Belges, Bruxelles, 115 pp.
- VAN GOMPEL, J. (1982). Zeezoogdieren aan de Belgische kust in 1981. met een beschrijving van de eerste vondst in België van een Gestreepte Dolfsijn (*Stenella caeruleoalba*). *De Wielewaal* **48** : 263-266.
- VAN ROMPAEY, E. & L. DELVOSALLE (1972). Atlas van de Belgische en Luxemburgse Flora. Bruxelles, 1530 fig.
- VAN ROMPAEY, E. & L. DELVOSALLE (1978). Atlas van de Belgische en Luxemburgse Flora. Tekstgedeelte. Meise, 116 pp.
- VAN ROMPAEY, E. & L. DELVOSALLE (1979). Atlas van de Belgische en Luxemburgse Flora. Tweede uitgave, Meise, 1542 fig.
- WESTHOFF, V. (1947). The vegetation of dunes and salt marshes on the Dutch islands of Terschelling, Vlieland and Texel. 's-Gravenhage, 131 pp.

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