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Factors influencing distribution of *Cladium mariscus* in Latvia

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I studied factors influencing the distribution of *Cladium mariscus* in Latvia. Selected climate parameters, such as the mean temperature of the coldest month of the year, the mean temperature of the warmest month of the year, and the frost-free period were compared among 45 nature regions with and without *C. mariscus*. The study confirmed earlier findings that mainly low winter temperatures limit the distribution of *C. mariscus* in the northeast. However, besides low winter temperatures, also the duration of the frost-free period, historical distribution, and local factors, such as habitat availability and long-term persistence of suitable habitats influenced the distribution of *C. mariscus* in Latvia. Favourable climate conditions and good availability of optimal habitats for *C. mariscus* determined the high concentration of its occurrences in coastal regions of Latvia.

Key words: calcium-rich water bodies, *Cladium mariscus*, climate, ecology, frost-free period, habitat availability

Introduction

Cladium mariscus is a popular study object, and the number of publications devoted to this species is high (Jalas & Okko 1951, Kępczyński & Ceynowa 1968, Görs 1975, Staniewska-Zatek 1977, Balátová-Tuláčková 1991, Salmina 2003). The main distribution area of *C. mariscus* lies within Central Europe (Meusel *et al*. 1965), and in Latvia the species grows close to the eastern limit of its distribution. It is a rare and protected species in all three eastern Baltic countries (Ingelög *et al*. 1993, Kuusk *et al*. 2003), and its distribution is confined only to certain areas. There are 24 *C. mariscus* localities in Latvia and the majority of them (17) are located in the coastal lowlands; two localities are in western Latvia and five in the eastern part of Latvia (Kuusk *et al*. 2003, Salmina 2003). A similar distribution pattern is recorded in Estonia (Kuusk *et al*. 2003) and in Poland (Świeboda 1968).

Climate is one of the main factors influencing the species' distribution. The optimal climate conditions of *C. mariscus* are characterised by warm summers and a lack of intensive frost in winter (Conway 1938), present in the parts of Europe lying within the west coast marine climate zone (Ahrens 1994). It is considered that mainly low winter temperatures determine the NE limit of *C. mariscus* distribution, because temperatures below –2 °C injure the meristems (Conway 1938). Besides the temperature requirements, *C. mariscus* also prefers shallow calcium-rich, albeit nutrient-poor water bodies (Balátová-Tuláčková 1991, Rodwell 1993).

The aim of the study is to determine factors influencing the distribution of *C. mariscus* in Latvia. The nomenclature of vascular plants follows Petersone *et al.* (1980) and Gavrilova *et al.* (2000).

Methods

I compared selected climate parameters, such as the mean temperature of July, the mean temperature of February, and the number of frost-free days among 45 nature regions (Anonymous 1994a, 1994b, 1995, 1997, 1998a, 1998b) with and without *C. mariscus* in Latvia using Mann-Whitney *U*-test (Sokal & Rohlf 1995). I studied the habitats and vegetation in 22 of the 24 *C. mariscus* localities in Latvia from 1997 till 2002 (Salmina 2003). Information about the other two localities was received through personal communication (J. Kabucis & L. Engele pers. comm.).

Results and discussion

From the 45 nature regions of Latvia (Anonymous 1994b), *C. mariscus* was found in eight, and six of them were located in coastal areas. Comparison of the selected climate parameters between coastal regions with *C. mariscus* and regions without *Cladium mariscus* showed that in the coastal regions the mean temperature of February is significantly higher than in the regions without the species (Mann-Whitney *U*-test: $Z = -3.503$, $p < 0.01$), and the number of frost-free days was higher (Mann-Whitney *U*-test: $Z = -2.932$, $p < 0.01$), but there were no statistically significant differences in the mean temperature of July (Table 1). Results confirmed the importance of low winter temperatures in the determination of distribution of *C. mariscus* in northeast direction stressed by other authors (Jalas & Okko 1951). The number of frost-free days is an important factor too, because the longer the frost-free period, the longer-lasting the favourable climate conditions for *C. mariscus*. The difference in the number of frost-free days between coastal regions with *C. mariscus* and eastern regions without it reached 14 days on average (Table 1), but the maximum difference in the number of frost-free days among nature regions with *C. mariscus* was 40 days. The maximum number of frost-free days in coastal regions with *C. mariscus* was 173 days (the longest period in Latvia) recorded in Bartava Plain, located in SW Latvia, on the coast of the Baltic Sea, while the shortest frost-free period in eastern regions with *C. mariscus* was 133 days in Adzele Rise, located in the easternmost part of Latvia (Anonymous 1994a); Adzele Rise is also one of the most continental regions in Latvia (Anonymous 1994a). However, there were no significant differences in the mean temperature of July, the mean temperature of February and the length of the frost-free period among eastern regions with *C. mariscus* and eastern regions without it (Table 1). It can be concluded that

Table 1. Results of comparison of the selected climate parameters among nature regions with (Clad$^+$) and without (Clad$^-$) *Cladium mariscus* in Latvia (Anonymous 1994a, 1994b, 1995, 1997, 1998a, 1998b). Climate data published are based on long-term meteorological observations in Latvia. *N* = number of nature regions.

	Mean temp. °C July	Mean temp. °C February	Frost-free period, days
Clad$^-$ (*N* = 37)	16.87	–5.75	140
Clad$^+$Coast (*N* = 6)	16.5	–3.48	154.33
Clad$^+$ East (*N* = 2)	16.75	–6.90	133
Clad$^-$ East (*N* = 15)	17.27	–6.97	142.53
Clad$^+$ Coast *vs.* Clad$^-$			
Mann-Whitney *U*-test: *Z* value	–2.249	–3.503**	–2.932**
Clad$^+$ East *vs.* Clad$^-$ East			
Mann-Whitney *U*-test: *Z* value	–1.793	–0.419	–1.799

** $p < 0.01$

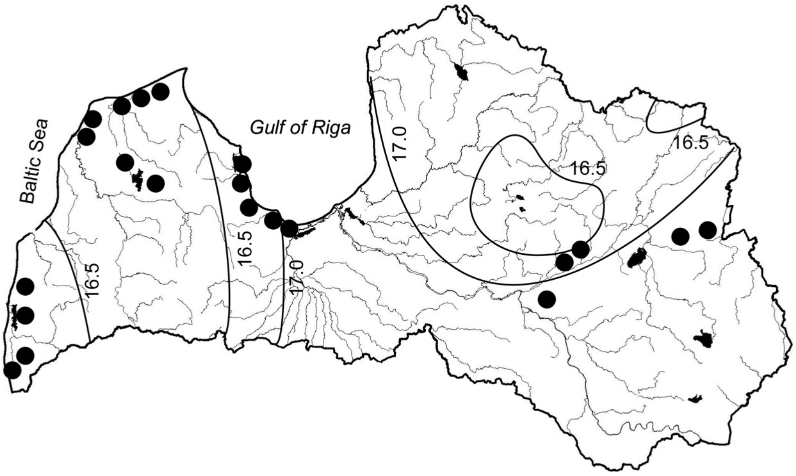

Fig. 1. Distribution of *Cladium mariscus* in Latvia (●) and July isotherms (after Krumins 1998).

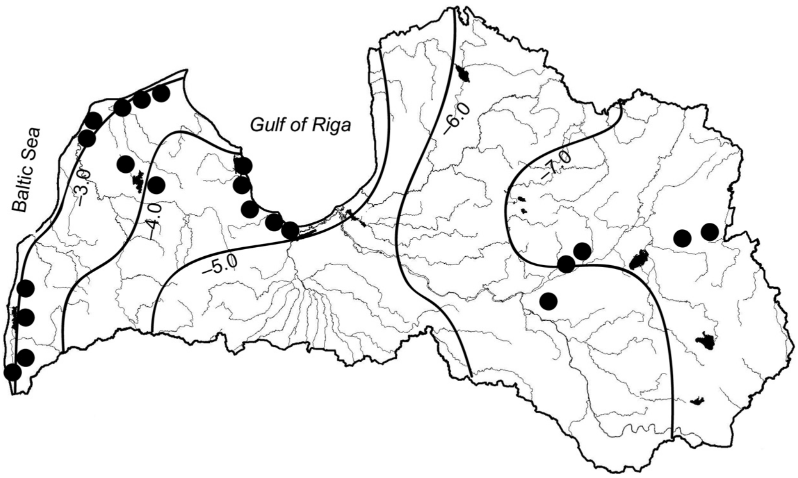

Fig. 2. Distribution of *Cladium mariscus* in Latvia (●) and February isotherms (after Krumins 1998).

climate alone does not determine the distribution of *C. mariscus* (cf. also Jalas & Okko 1951, Hafsten 1965).

The well-tolerated annual temperature range required by *C. mariscus* is considered to be between –4 °C and –6 °C in the coldest month and between +16 °C and +18 °C in the warmest month of the year (Jalas & Okko 1951), which matches most of the localities in Latvia (Figs. 1 and 2). However, in eastern Latvia *C. mariscus* (Fig. 2) is found outside these temperature ranges due to lower winter temperatures. This can be explained by the fact that water provides insulation thus protecting the frost-sensitive meristems (Conway 1938), and the species can thus survive at lower winter temperatures. All except one locality in the eastern regions were lakes, but in western regions *C. mariscus* grows also in fens. The hypothesis that in northern regions it survives due to its location under the direct influence of springs (Jalas & Okko 1951) does not seem to hold true in eastern Latvia, because none of the eastern localities were located in springs (Table 2).

Specific habitat requirements, such as calcium-rich, albeit nutrient poor and shallow waterbodies (Klosowski 1988, Balátová-Tuláčková 1991, Rodwell 1993) also influence the distribution of *C. mariscus*. The majority of the localities (17 from 24) meeting these criteria were found in coastal nature regions of western Latvia, where ancient lagoon lakes and other shallow lakes of different origins are found. A high calcium concentration is ensured due to dolomite bedrock close to the land surface (Brangulis 1998) or a high concentration of shells in the soil such as in the depressions near Engure Lake. Monodominant *C. mariscus,* which stands up to several hectares in area, was found only in shallow coastal lakes (Table 2). The western part of Latvia outside the coastal lowlands fitted the optimal macroclimate for *C. mariscus* (Figs. 1 and 2), but this part of the country is not rich in lakes (Tidrikis 1994). Furthermore, not all shallow calcium-rich lakes host *C. mariscus* in the western part of Latvia; for example, Lielauce Lake is rich in calcium, but *C. mariscus* has never been recorded there. Only two *C. mariscus* localities are known in the western inland part of Latvia (Fig. 1).

It is known that *Cladium mariscus* was more widespread throughout Europe during the Atlantic period characterised by a favourable climate and an abundance of suitable habitats for the species (Hafsten 1965, Balátová-Tuláčková 1991). According to studies in mire stratigraphy and macrofossil investigations, it was more widespread also in eastern Latvia, including the easternmost regions (Galeniece 1935). Currently there are raised bogs.

Lake terrestrialization and mire development might be the main reasons for the species' decline in the post-glacial period in Latvia. The eastern localities could be the last remnants of the species' populations from the Atlantic period, survival of which was determined mainly by local factors preventing lakes from complete terrestrialization. Studies from Norway prove that mainly filling-in of lakes and consequently peat accumulation rather than changes in climate conditions is the main reason for the decline of *C. mariscus* in the post-glacial period (Hafsten 1965). Today the *C. mariscus* community forms only a narrow belt in 11 filling-in lakes (Table 2) and is separated from the mainland by transitional mire vegetation. These localities will be the first ones to disappear in the future if the succession is allowed to continue.

It can be concluded that besides winter temperatures, the duration of a frost-free period,

Table 2. Nature regions, habitats and vegetation physiognomy of *Cladium mariscus* community in Latvia. Coastal nature regions are marked with an asterisk.

Locality	Nature region	Habitat	Vegetation physiognomy
Pape Lake	Bartava Plain*	coastal lake	large stands in water
Tosmare	Bartava Plain*	rich fen	fen-like
Kirba Mire	Bartava Plain*	rich fen	fen-like
Busnieku Lake	Ventava Plain*	coastal lake	small stands in water
Mazezers Lake	Ventava Plain*	coastal lake	fringe
Dumezers Lake	Irve Plain*	coastal lake	fringe
Makskerezers Lake	Irve Plain*	coastal lake	fringe
Skarbes Lake	Irve Plain*	coastal lake	fringe
Garezers Lake	Irve Plain*	coastal lake	fringe
Engure	Engure Plain*	rich fen, water filled depression	fen-like
Apsuciems	Engure Plain*	rich fen	fen-like
Raganu Mire	Rigava Plain*	calcareous spring	fen-like
Aklais Lake	Rigava Plain*	coastal lake	small stands in water
Kudraines Lake	Rigava Plain*	coastal lake	fringe
Dunieris Lake	Rigava Plain*	coastal lake	large stands in water
Kanieris Lake	Rigava Plain*	coastal lake	large stands in water
Pusezers Lake	Rigava Plain*	coastal lake	fringe
Pelcene Lake	Ugale Plain	inland lake	fen-like
Vienits Lake	Ugale Plain	inland lake	fringe
Baltins Lake	Arona Hilly Plain	inland lake	fringe
Lielais Plencis Lake	Arona Hilly Plain	inland lake	fen-like, fringe
Dreimanu Lake	Arona Hilly Plain	rich fen	fen-like
Mazais Kugrinu Lake	Adzele Rise	inland lake	fringe
Motrine Lake	Adzele Rise	inland lake	fringe

historical distribution, and local factors, such as habitat availability and long-term persistence of suitable habitats determine the distribution of *C. mariscus* in Latvia. Favourable climate conditions and availability of optimal habitats for the species explained the high concentration of occurrences in the coastal regions.

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