THE VARIABILITY OF SEEDS IN SPARGULARIA MARINA
(L.) GRISEB. (= S. SALINA J.ET C. PRESL) GROWING ON SEACOAST
AND INLAND SALINE SOILS IN POLAND

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ABSTRACT

The objective of this study was to analyse Polish populations of Spargalaria marina in terms of seed variability, which was found to be independent of the environment to some degree. It was shown that the populations from industrialized and natural, but clearly unstabilized, habitats have less diversified seeds than populations from relict inland stands and some stabilized seacoast stands.

KEY WORDS: Spargalaria marina, halophytes, seeds, flora, relicts

INTRODUCTION

Spargalaria marina is a polymorphic species occurring in Poland in widely dispersed stands. The high degree of diversification of this species is manifested in, among others, its seed morphology. Seed morphology is one of the key traits by which species from the genus Spargalaria Presl are identified (Tutin et al. 1964) Lack of information about the full scale of seed and fruit variability of the species and genus in question can lead to mistakes in identifying plants.

The best known populations of S. marina in Europe are the Dutch populations, described in detail in several papers by Sterk (1969a, b, c, d). This author paid special attention to the various proportions of winged and unwinged seeds in the capsules of S. marina. Among the populations of northern Netherlands he found some that differed from the others in the proportion of capsules with predominantly winged seeds. The occurrence of a similar population was reported in Poland as early as 1963 by Wilkoń-Michalska. A detailed description of S. marina seeds was presented by Kowal (1966). However, it covered only part of the seeds of the species in question.

In the present study, the variability of S. marina seeds from populations growing in habitats differing in respect to their geographical, ecological and historical aspects is presented.

MATERIAL AND METHODS

The study was conducted on specially collected plants and on material borrowed from the following herbaria: TRN, KRAM, KRA and GDU. The capsules of 21 population samples from various regions of Poland (Fig. 1) were analyzed in detail. The samples and stands are listed below:

1. Świnoujście (N.W. Poland), saline meadow, on a sandy site near a dock, July 21, 1990
2. Southern part of Melin Island on the side of the Piastowski Canal (N.W. Poland), near a metal jetty, on a site sprayed by sea water, August 10, 1990
3. Kołobrzeg (N. Poland), among reeds (Phragmites australis) near the Parsęta River, July 15, 1982

Fig. 1. Distribution of the population samples
4. Kołobrzeg, near the stand of the previous sample, beyond the reed belt, on a grazed and trampled site, August 7, 1984.

5. Władysławowo (N. Poland), on the Puck Bay, on peat in a depression recently exposed by water, with a scant plant cover, August 7, 1978.

6. Władysławowo, near the previous stand, on a railroad embankment with scant vegetation, on a sandy loam substrate formed by several layers turned over during recent clearing of the ditch, August 24, 1988.

7. Władysławowo, near the previous stand, on peat, among very dense and low soil, August 24, 1988.

8. Władysławowo, near the previous site, on a similar stand with thick vegetation, July 25, 1989.

9. Władysławowo, in a meadow near the previous stand, but somewhat drier with a thick plant cover, July 25, 1989.


11. Mrzeżyno, in the old locality of Beka, about 80 km from the previous stand, August 7, 1988.

12. Ciechocinek (Central Poland) along the graduation works on a site sprayed by the salt spring, October 13, 1983.

13. Ciechocinek, next to the previous stand, on the west side of the graduation works, July 26, 1986.


15. Janikowo (Central Poland) on a meadow near the sodium works, on peat soil, October 11, 1983.


17. Janikowo, next to the previous stand, on a site with a poorer vegetation cover, September 5, 1988.

18. Małdyw (Central Poland), next to railroad tracks near the sodium works, October 11, 1983.

19. Małdyw, near a waste sewer from a factory, at the base of a limestone heap, July 14, 1989.

20. Małdyw, near the previous stand, in a ditch at the edge of a reed patch, July 14, 1989.

21. Barycz near Wieliczka (S. Poland) along a ditch with salt spring water, August 8, 1948.

The habitats from which most of the samples were taken are unstable. They are affected by man as well as natural factors, particularly intense near river estuaries. Only the habitats of some of the samples from Władysławowo (7, 8, 9) can be considered somewhat stable. The stands of samples from Kołobrzeg and Ciechocinek are considered relic stands, although not immune from the influence of man. The stands which surround the industrial works in Małdyw and Janikowo in the Kuja region of Poland are secondary and, to a large degree, anthropogenic.

Taking several samples from the same locality was necessary not only because of the diversified nature of the stands, but also due to the visible differences in plant shapes. The populations which scantly covered the ground were usually made up of highly branched and multiflowered specimens, while those growing densely, of small, only slightly branched specimens with few flowers. The size of the plot from which specimens were collected ranged from 1 m² to tens of m², depending on the size and density of the plants in the given population.

A single sample was composed of 50 capsules collected randomly, mainly from among distal capsules, one from each plant. The seeds in each capsule were counted and classified using a Carl Zeiss Jena stereomicroscope. Selected seeds were viewed in a Biolar microscope and their images drawn using a drawing apparatus. A scanning microscope was used for photographing samples prepared by the routine gold dusting procedure.

Four categories were used in the classification of seeds. Winged seeds; seeds with border wider than 0.15 mm. Unwinged seeds; seeds with no border or a barely visible border less than 0.15 mm wide. Tuberculate seeds; seeds with nodules on their coats, similar to papillae, sometimes as high as they were wide. The remaining seeds were classified as smooth or rugose.

After drying in room temperature, 100 mature seeds from each category were weighed on an analytical scale (Zakład Mechaniki Precyzyjnej, Gdańsk).

LIST OF LOCALITIES OF SPERGULARIA MARINA (L.) GRISEB. WITH SEEDS SMOOTH AND SLIGHTLY RUGOSE


LIST OF LOCALITIES OF SPERGULARIA MARINA (L.) GRISEB WITH TUBERCULATE SEEDS


LIST OF LOCALITIES OF SPERGULARIA MARINA (L.) GRISEB. PLANTS WHOSE CAPSULES CONTAIN MAINLY BROADLY WINGED SEEDS


RESULTS

Overall variability of seeds – The length of the brown disk of borderless Spergularia marina seeds ranged from 0.6-0.9 mm, width 0.4-0.8 mm and thickness 0.2-0.4 mm. The outline of the seed can be described as inverse egg-shaped or triangular-kidney shaped.

The differentiation in seed morphology manifested itself in, among others, seed coat morphology (Figs. 2-5). In some of
the seeds the coat was more or less smooth or rugose, whereas in others it had high nodules. These nodules were located in the central part of concavely indented epidermal cells of the testa (Figs. 3a, 5a). The nodules are formed by the highly thickened cell wall, which in smooth seeds is, at most, slightly convex, whereas in tuberculate seeds, highly convex in the central part of the seed. The microscopic examination revealed a nonuniform layer of cells of the internal part of the seed coat under the testa cells. The external walls of this layer had irregular thickenings which, in tuberculate seeds, passed into thickened processes connected with the nodules of the epidermis.

The size and distribution of the nodules on the surface of the studied seeds were not the same. The largest and most numerous were on the edges and on the lateral borders of the seed.

A membranous, sometimes thin, edging (Figs. 3b, 6b, c) projected from the lateral sides of both smooth and tuberculate seeds. It usually encompassed the entire circumference with the exception of the seed attachment. Seeds in which the ends of the edging overlapped were very rarely found (Fig. 7a), whereas seeds that were only partially winged were found much more frequently and had a border encompassing less than 2/3 of their circumference (Fig. 7c, d, i). The width of the edging varied significantly. The widest, usually called wings, reached 0.3-0.6 mm, equalling or slightly exceeding the radius of the main disk of the seed. In addition to distinct-

ly winged and unwinged seeds, specimens with a barely microscopically visible, narrow band, less than 0.15 mm wide were also found. They were usually larger than unwinged seeds. The main disk of winged seeds was usually larger than of unwinged seeds. This is related to the greater average weight of winged seeds. For example, in the studied population from Władysławowo, the weight of 100 smooth, unwinged seeds equalled 0.00592 g while the weight of the same number of winged seeds equalled 0.00663 g, the weight of 100 tuberculate unwinged seeds equalled 0.0061 g and of 100 tuberculate winged seeds 0.00922 g.

**Differentiation of seeds in one plant** – The plants of the species under discussion formed either smooth, at most rugose seeds or exclusively tuberculate seeds, while winged and unwinged seeds frequently occurred together (Figs. 8 and 9).

In most of the studied specimens, in agreement with the species description of *S. marina* (Tutin et al. 1964), the capsules contained unwinged or unwinged with small amounts of winged seeds at the bottom of the capsule. There was no lack, however, of plants in whose capsules the proportions of winged and unwinged seeds were reversed.

All or most of the capsules of one plant contained the same dominant type of seed, either unwinged or winged. *S. marina* plants can thus be divided into two types, those that produce mainly un-
winged seeds, and those that produce mainly winged ones. Plants that produced exclusively one type of seed were also found.

In plants producing winged and unwinged seeds, more winged seeds were usually found in the proximal capsules than in the capsules most distal from the main inflorescence axis (Sterk 1969b).

The number of stands of plants with a predominance of winged seeds were relatively few. They were found on coastal sites in Władysławowo and within the relic, inland sites of Ciechocinek and Słonawy near Szubin in the Kujawy region of Poland (Wilkoń-Michalska 1963), near Łęczyca in central Poland and in Owczary near Busko in southern Poland (Fig. 10).

In some of the plants producing mainly unwinged seeds, single capsules were found in which all of the seeds were winged. These were, however, untypical capsules, with significantly smaller amounts of seeds than usually seen in the remaining capsules of this species.

The examined capsules of S. marina contained an average of 55 developed seeds. This number was, however, significantly higher in some populations (Table 1).

**Differentiation of populations** – Both in the coastal and inland populations of Spergularia marina, specimens which produced mainly unwinged seeds with smooth or rugose coats dominated (Table 1). Plants that produced tuberculate seeds were usually a small part of some of the coastal and inland re-

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**Fig. 4. Seed coat of smooth seeds, specimen from Matwy**
- a - testa cells viewed from above, from the outside,
- b - tegmen cells viewed from the outside of the seed,
- c - cross section through the seed coat (testa and tegmen)

**Fig. 5. Seed coat of tuberculate seeds, specimen from Władysławowo**
- a - testa cells viewed from above, from the outside of the seed,
- b - tegmen cells viewed from the outside of the seed,
- c - cross section through the seed coat (testa and tegmen)

**Fig. 6. Types of Spergularia marina (L.) Griseb. seeds, specimens from Barycz near Witelczyka**
- a - unwinged seed viewed from above and side,
- b - seed with a very narrow border seen from above and side,
- c - winged seed from above and side
Fig. 7. Types of *Spergularia marina* (L.) Griseb. seeds, specimens from Władysławowo
a-f - smooth and rugose seeds,
g-k - tuberculate seeds,
a, b, g, h, - seeds with wide wings,
c, d, i - seeds partially winged,
l, j - seeds with a very narrow border,
e, k - seeds with no border

Fig. 8. The distribution of *Spergularia marina* (L.) Griseb. stands with smooth and rugose seeds, on the basis of herbaria specimens

Fig. 9. The distribution of *Spergularia marina* (L.) Griseb. stands with tuberculate seeds, on the basis of herbaria specimens

Fig. 10. The distribution of *Spergularia marina* (L.) Griseb. stands with capsules containing a predominance of winged seeds, according to herbaria specimens

 lilict populations. Only the population in Kolobrzeg (samples 3,4) produced exclusively tuberculate seeds.

Plants in which all or most of the seeds are winged usually form small and receding populations. Only in Władysławowo on the meadows on the Puck Bay was a large population found that had an exclusively winged or only a small unwinged component in the capsules of its individuals (Fig. 11).

It was found that the plants producing exclusively winged and tuberculate seeds were usually more numerous in popula-
tions from stabilized habitats than in unstabilized ones. The
variability of winged seeds was much greater in populations producing mainly winged seeds than in populations with only a small number of such seeds.

The least diversified types of seeds were found in populations from industrial areas and from sites near river estuaries, in areas frequently flooded by both salt and fresh waters.

**DISCUSSION**

The results of this study (Table 1), show that the differences in plant shape do not correspond with variability in seed morphology. The populations from the same locality, although having different morphologies of their vegetative parts, were usually characterized by a similar seed morphology.

The most varied seeds were found in samples from Włodzisławowo, where alongside capsules containing predominantly winged seeds, numerous ones with predominantly smooth seeds were found. A similar diversity was found only in materials from relict stands, contained in herbaria. The populations colonizing new habitats, mainly surrounding factories, are much less diversified in respect to seed morphology. It is therefore necessary to protect the old, relict stands in spite of the new ones arising, in order to conserve the full gene pool of *Spergularia marina*.

Special attention is worth focusing on the finding that *S. marina* has both smooth and tuberculate seeds. These are traits of two sections distinguished from each other within the genus *Spergularia* Presl: *Sectio I Tuberculatae* Kowal, with tuberculate seeds, and *Sectio II Ratasile* Kowal, with smooth seeds. In face of the above finding, the division of *Spergularia* into sections should not be based exclusively on seed morphology. Kowal (1966), who distinguished the above sections, could have overlooked the tuberculate seeds in *S. marina* since they are much less common in Poland than smooth seeds. The progressing industrialization of inland saline soils may lead to an increase in the already visible predominance of smooth seeds over tuberculate ones.

Fruits with exclusively winged seeds are typical for a related species, *Spergularia media* (L.) C. Presl. Mistakes could have been made for this reason. Historical data on the occurrence of *S. media* in central Poland probably refer to *S. marina* with a predominance of winged seeds.

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**LITERATURE CITED**


ZRÓŻNICOWANIE NASION SPERGULARIA MARINA
(L.) GRISEB. (=S. SALINA J. ET C. PRESL)
W POLSCE NA SOLNISKACH NADMORSKICH I ŚRÓDLĄDOWYCH

STRESZCZENIE

W pracy przedstawiono wyniki analizy materiałów zielnikowych oraz 21 specjalnie do badań pobranych prób populacyjnych – po 50 owoców, każdy z innej rośliny. Część z tych prób pochodzi ze stanowisk sąsiednich, lecz różnych pod względem ekologicznym. Mimo znacznej różnicy w pokroju roślin w próbach z tych samych miejscowości obserwowano na ogół podobne zróżnicowanie nasion (Tab. 1). Część roślin Spergularia marina wytwarza w swoich owocach nasiona gladkie, najwyżej lekko pomarszczone (Fig. 2a), część – nasiona guzkowate (Fig. 2b). Te ostatnie spotykano w Polsce znacznie rzadziej (Fig. 9). W obu grupach, zarówno wśród gladkich, jak i guzkowatych nasion występują nasiona nieskrzydłone i oskrzydłone (Fig. 7). Większość roślin S. marina tworzy owoce, w których znajdują się wyłącznie nasiona nieskrzydłone z jednym lub kilkoma nasionami oskrzydlonymi umieszczonymi na dnie torebki nasiennej (Fig. 11). Trafią się jednak egzemplarze o owocach w których stosunek nasion oskrzydłonych do nieskrzydłonych przedstawia się odwrotnie. Najwięcej tych nietypowych egzemplarzy i najbardziej zróżnicowane nasiona S. marina stwierdzono w populacjach z Wolęsławowa, nad Zatoką Pucką. Poza tym szereg ich obserwowano w materiale zielnikowym S. marina z reliktywych placówek śródlądowych (Fig. 10). Najuboższe pod względem typów nasion okazały się populacje z terenów przemysłowych oraz obszarów położonych przy ujściu rzek, w środowisku nieustabilizowanym, zalewanych często na zmianę wodą słoną i wodą słodką.

SŁOWA KLUCZOWE: Spergularia marina, halofity, nasiona, flora, relikty