

Development of *Plantago coronopus* L. individuals in the marginal population and hydroponic culture

Zofia Sotek

Department of Botany and Nature Conservation, University of Szczecin, Felczaka 3c, 71-412 Szczecin, Poland, e-mail: sotek@univ.szczecin.pl

Abstract: *Plantago coronopus* is a Mediterranean-Atlantic species reaching in Poland the eastern limit of its range. The plant is receding from the area of Poland and at present it is known from only one locality on the Karsiborska Kępa island. The population growing at this locality was studied in the years 1987-1992. The aim of the study reported in this paper was: (i) to compare development of *P. coronopus* individuals in the natural conditions and in a hydroponic culture, (ii) to find out whether individuals with different life history were concentrated over a certain area or their distribution was random. In the marginal population of *P. coronopus* on the Karsiborska Kępa island by far dominant was the group of perennial plants; there were much fewer biennial plants and only a few annuals. In general, the plants with different life history were rather randomly distributed. The annual plants were, however, mainly found in the disturbed or recolonised areas. The development of *P. coronopus* individuals was the fastest in the hydroponic culture conditions, especially the early developmental phases were shortened. Relative to the individuals growing in the natural conditions, those from hydroponic culture earlier produced sister rosettes.

Key words: life cycle, perennial, biennial, annual, developmental, sister rosettes

1. Introduction

Plantago coronopus is characterised by great plasticity of the life cycle and a diverse pattern of flowering. It is a Mediterranean-Atlantic species. Its localities have been found in the coastal strip and inland. The species occurs in different habitats: in the coastal strip the plants have been growing in rock clefts, on the grass-covered cliff slopes, on the dunes, the so-called salty marshes, pastures, along the roads, on the embankments, on ant hills and in puddles. Inland the presence of the species is related to saline areas (Dodds 1953). It has been also noted from the mountains in north Africa and on the Sicily (Pilger 1937).

The species *Plantago coronopus* reaches in Poland the eastern limit of its range. Recently the plant has been receding from the area of our country. From among the 7 localities noted in the coastal strip of the Baltic sea today there is only one in the reverse delta of the Świna river, on the Karsiborska Kępa island (Piotrowska 2001). For the above reasons this marginal population became a subject of my interest. The morphological and developmental characterisation of *P. coronopus* and the conditions of this population have been the subject

of an earlier paper (Sotek 2002). The aim of this work was (i) to compare development of *Plantago coronopus* individuals in the natural conditions and in a hydroponic culture, (ii) to find out whether individuals of different life history are concentrated over a certain area or their distribution is random.

2. Material and methods

The development of the individuals in the marginal population was observed from the autumn of 1987 to the end of the vegetation season of 1992 in 6 randomly delimited plots in different parts of the population area. Each plot was of 1 m². In the autumn of 1987 all seedlings in the plots selected were labelled. New individuals appearing in the plots in the next two years were also monitored. In the spring of 1989, besides the seedlings in the plots, about 200 other seedlings growing on the so-called refulates (sites covered with a layer of soil dug out during deepening of the drainage ditches) were also labelled. In the first three vegetation seasons of the experiment the individuals were observed in the periods of 6-10 days. In the next two years the observations were made once a month. In general, in the period of

the experiment, the development of 1232 plants was monitored.

The hydroponic culture was started with the seeds from the population growing in the Karsiborska Kępa. The experiment was conducted in hydroponic vases made of plastic buckets topped with 5 cm deep ceramic bowls with densely perforate bottom. The nutrient solution was that commonly used in similar experiment and proposed by Gumińska *et al.* (1980), while the litter was a mixture of deacidified garden peat and fine gravel taken at the volume ratio 1:1, of pH close to 6.4. The experiment was performed in 9 variants in which the nutrient solution was salinated with the solutions of the following salts: KCl, NaCl and a mixture of KCl+NaCl+CaCl₂, in concentrations 0.3n, 0.1n and 0.02n. Results of the study on the effect of salinity of the nutrient solution on the development of *Plantago coronopus* in the hydroponic culture have been reported in details by Sotek (2003). In the comparison presented in this paper we analysed only these variants in which no significant hindering of the plant development was observed as a result of an excess of some elements and deficiency of others. We considered only the culture with the fundamental nutrient solution and the solutions modified with the salts: 0.02n NaCl, 0.02n KCl, 0.02n salt mixture and 0.1n NaCl. Each variant of the experiment was made in 5 replications. In total we used 25 hydroponic vases with 10 seeds of *Plantago coronopus* in each. In the experiment the pH of the media was controlled and maintained in the range 6-6.5 using either a 20% solution of H₃PO₄ or a 20% solution of NaOH. The loss of the nutrient solution with time was supplemented with the proper nutrient solution. The moisture content of the litter was kept by sprinkling with water. The development of *P. coronopus* in the hydroponic culture was observed continuously from the seed sowing to mass dispersal of mature diaspores.

3. Results

On the basis of the results it was found that in the natural conditions the life cycle of the individuals making the population on the Karsiborska Kępa lasted from one to over 5 years. The perennials were in great majority of 74.4%, biennials constituted 22.8% while the annuals only 2.8%.

Seedlings of *Plantago coronopus* kept appearing throughout the whole vegetation season and reached the juvenile stage at the earliest after 0.5-1.5 month. The juvenile stage lasted from 1 to 2 months in a majority of plants (63.6%). In the other plants this period extended to 4-10 months, and in some it lasted up to a year and a half. The virginal stage lasted usually from 1 to 3 months, however, it could last longer even to over a year. The first to begin the generative phase were

the individuals of a very short juvenile stage. Some of them started producing generative shoots as soon as 3 months from the stage of seedling. The individuals with a long juvenile stage reached the ability to reproduce most often in the next vegetative season. All the flowers forming a single ear developed almost at the same time, starting with producing pinnate pistils and after about 18 days androecia. After reaching the generative stage the plants were blooming in each subsequent season. In the end of the vegetative season the generative shoots died, the plants became secondary vegetative and dormant in this phase. Some individuals started reaching the senile stage at the end of the second year of life. In general the senile stage was well noted only in late autumn and early spring, so in the time of intensified dying of the rosettes. In the fourth year after germination, about 60% of *P. coronopus* individuals were in the senescence phase and died in the autumn of this year or in the spring of the next year. At the end of the fifth year of life, only a few individuals remained in the generative stage. The life cycle was usually faster in the plants growing in the conditions of limited competition of the concurrent species. This phenomenon was well visible in refulates where at the lack of competition the early developmental stages of *P. coronopus* were often shortened and at the end of the first year of life; in the autumn or early spring, 22.7% of rosettes died. The other individuals went into bloom in the next season, in the autumn most of them died and only 7% survived. *P. coronopus* individuals growing in agglomerations of high density usually showed a slower pace of development. In such conditions the individuals reached the generative phase at different age. In the first year only 30% out of them produced inflorescences, in the second year 64%, and in the third – only 6%. In the case of plants with delayed reproduction, the longest juvenile stage could last even up to a year and a half.

In the Karsiborska Kępa population some individuals revealed vegetative reproduction. This process was observed no sooner than after the first blooming. The underground base of the shoot of the parent rosette underwent plagiotropic branching and its aboveground part produced a few modules (2-9) in the form of sister rosettes.

In the hydroponic culture the fastest development was observed in plants growing in the nutrient solution with addition of salt in the concentration of 0.02n (NaCl, KCl, a mixture of NaCl, KCl and CaCl₂) and in concentration of 0.1n NaCl. The life cycle of the individuals from the moment of diaspores sowing to dispersal of the first mature seeds lasted 3.5 months (Fig. 1). The first seedlings appeared 4 days after starting the culture. The shortest observed seedling stage lasted for about 12 days. After about 2 week the juvenile individuals started reaching the virginal stage. The first

generative shoots appeared in the angles of bottom leaves as soon as 1.5 month after sowing the seeds. The pinnate pistils in the flowers appeared 10-14 days earlier than androecia. The development of *P. coronopus* in the basic nutrient solution was much slower. The phase of seed dispersal started about 0.5 month later than in the solutions modified with salts and ended over 4.5 months after starting the culture. In general, in the hydroponic culture 84% of individuals entered the phase of reproduction. Some of them produced sister rosettes. New rosettes started developing even prior to the appearance of pinnate pistils in the ears of the parent rosette, from the axillary buds of the bottom leaves of the aboveground shoot. In the moment of seed dispersal some of the new rosettes had already reached the virginal stage.

competition of other species. At such sites *P. coronopus*, being a poorly competitive plant, found suitable conditions for development, which probably stimulated faster life cycle of many individuals. A similar phenomenon has been observed for other species, e.g. *Geranium robertianum* (Falińska & Pirożnikow 1983).

In the deteriorating environmental conditions, the plants characterised by plasticity of the developmental cycle often extend their lifetime (Jong & Klinkhamer 1988; Kelly 1989; Falińska 1997). This phenomenon was also observed for the plants from the Karsiborska Kępa population. At sites of high density of individuals some of them extended the early developmental stages.

The fastest developmental cycle was realised by the *P. coronopus* individuals in the controlled conditions of the hydroponic culture. The early developmental

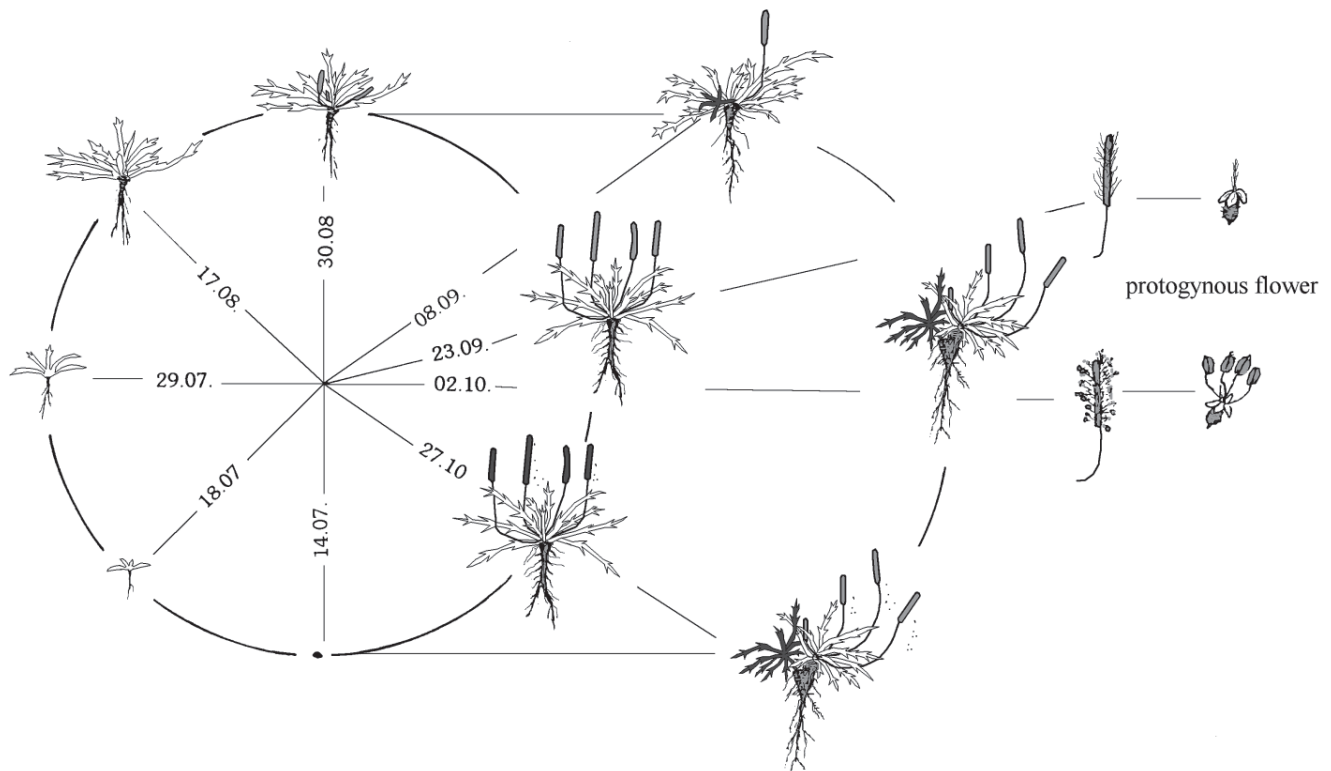


Fig. 1. The developmental cycle of *Plantago coronopus* in the hydroponic culture

4. Discussion

In the marginal population of *Plantago coronopus* on the Karsiborska Kępa island, the individuals of a few-year life cycle were by far dominant, biennials made a much smaller group and annuals made only a few percent. In general, the plants of different life history were distributed at random, similarly as in the central populations in Great Britain (Hutchings & Waite 1985), and not concentrated in a given area. In the marginal population the annuals were mainly found in the disturbed and recolonised areas and at the sites of limited

stages were much shortened and in a short time after the appearance of seedlings the plants produced the first generative shoots. The period between the production of pistils and androecia on the same individual was also shortened. The phenomenon of a faster reaching of the reproduction phase was also reported for other species growing in favourable conditions, e.g. for *Cirsium palustre* (Falińska 1997).

The individuals growing in the hydroponic culture were found to produce sister rosettes much sooner than the plants growing in the natural conditions. The new rosettes were developing in the axils of lower leaves of

the branches of the aboveground shoots and not on the underground part of the shoot. This fact is most probably related to the faster development of the individuals at such short period the mechanism of roost contraction was not able to force a part of the shoot to move under the litter. The sister rosettes developed much faster in

the hydroponic conditions than in the natural conditions.

As follows from the observations, the optimum conditions for *P. coronopus* development were those in the media of a slight salinity, which suggests that the plants prefer slightly saline conditions.

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