tive contributions of exponential versus linear growth during the growth period. This would result in an inversion of the generally accepted "skewness hypothesis". The model is currently being tested.

REFERENCES


Turner, M.D. & D. Rabinowitz (in prep.) - The skewing hypothesis fails a critical test.


11. Further studies on the population ecology of Plantago maritima (C.W.P.M. Blom and H.A.M. Jongeneel)

INTRODUCTION AND METHODS

Plantago maritima occurs on mud flats and beach plains. At "Kwade Hoek" (island of Goeree, The Netherlands) this species can be found in distinct zones, and the first results of demographic studies, which will be published in a next report, clearly indicate that two strategies are involved. In the high-lying zones with a sandy soil shortlived individuals, that do not live longer than 3 years, occur. These plants propagate by seed and a rapid germination and seedling establishment can be observed. On the low-lying zones with a layer of clay in the upper soil,
only long-lived individuals are found (more than 10 years old) and these plants are characterized by vegetative reproduction. At high tides these zones are often flooded by seawater, and they are also grazed by cows which is also an important determining factor. In an earlier report (Blom and van Heeswijk 1981) sowing experiments with *P. maritima* were described. These results proved that seeds that land on sandy soils are able to germinate easily and the survival rate of these seedlings is relatively high. In contrast, the germination rate of seeds landing on mud or clay spots is lower and the mortality higher. This phenomenon partly explains the patterns in distribution as found, e.g. at Kwade Hoek. Evidence from field observations indicate that grazing and inundation has a highly negative effect on the biomass production and sexual reproduction of *P. maritima*.

In this report a number of greenhouse-experiments are described that were carried out to test the hypothesis obtained in the field. In these experiments the effects of grazing on one hand and those of inundation by seawater on the other are studied in more detail.

A. Grazing-simulation experiments

In these experiments two effects of grazing on development and propagation of *P. maritima* are studied. In order to investigate the effects of clipping and trampling separately and in combination, the following four series were applied. They started six weeks after sowing.
- Weekly clipping at a height of 5 cm above the soil surface
- A trampling treatment for 5 seconds with a pressure of 0.25 kg/cm² once a day
- Weekly clipping combined with daily trampling
- Control plants, no treatment

All series consisted of 20 plants, grown separately in one litre pots filled with a sandy substrate. During the experiment nutrients were added. Light intensity at plant level was about 33 Watt/m².

Each week, length and width of the longest leaf, the number of leaves, the number of flowering plants, the number of spikes, and the number of daughter rosettes was determined.

B. Inundation-experiment

To study the effects of regular flooding with seawater, the following series of experiments were carried out. The treatments started six weeks after germination.
- Due to capillary rise, soils with *P. maritima* were saturated with seawater every other day for four hours. On the intermediate days the plants and soils were watered with fresh water to prevent the accumulation of salt in the upper soil layers. Every fortnight seawater was poured over the soil.
- In a control series freshwater was used instead of seawater.

Both series consisted of 20 plants, grown separately in one litre pots filled with a sandy substrate. During the experiment nutrients were added. In this test the light intensity at plant level was 28 Watt/m². The seawater originated from the Northsea at the "Kwade Hoek".

Plant characteristics were determined in the same way as in the grazing simulation tests.

RESULTS AND DISCUSSION

A. Grazing-simulation experiment

In Fig. 11.1 the calculated biomass production during the grazing-simulation test is given. The biomass is calculated by multiplication of the values for the length of the longest leaf with those for the number of leaves per plant. Former experiments proved that this calculation gives a reliable estimate of the biomass of the upper parts of the plants (Noë and Blom 1982). Fig. 11.1 shows that at the
end of the test, the biomass of trampled plants is significantly higher \((P > 0.05)\) than that of the control series, this was caused mainly by a significant increase in the number of leaves per rosette in the trampled series. This phenomenon was also found for trampled *P. maritima* plants (van Heeswijk and Blom 1981). In the series in which the leaves were cut, no increase in number of leaves per rosette was found.

No differences in the number of plants with daughter-rosettes were observed between the trampled and the control series at the end of the test. The mean number of rosettes per individual however, was significantly higher in the trampled series (Fig. 11.2). In contrast the number of flowering plants was significantly higher in the control than in the trampled group, whereas the mean number of spikes per plant was the highest in the trampled series. In none of the other treatments (clipping and trampling combined with clipping) did the plants flower or reproduce vegetatively.

B. *Inundation-experiment*

Fig. 11.3 shows a relative high biomass production of the inundated plants at the end of the test. In contrast, the control plants produced a higher biomass of the shoot during the first weeks of the test. In this experiment the increase in biomass can be ascribed to an increase in the number of leaves per plant as well as to an increase in the size of the leaves. Between both series no differences were found in the numbers of plants with daughter rosettes and those with spikes, but at the end of the test the inundated plants showed significantly more rosettes per plant than the controls.

In conclusion it can be stated that clipping (in the field: eating by grazing an-
Fig. 11.2. The effects of clipping and trampling on the vegetative reproduction (numbers of rosettes) of *Plantago maritima*. Group A: clipping; Group B: trampling; Group C: combined clipping and trampling; Group D: controls.

...mals) results in a reduction of biomass production and reproduction of *P. maritima*. Trampling causes an increased biomass production and a distinct increase in vegetative reproduction (Fig. 11.4)

Furthermore, inundation with seawater results in a decreased biomass production. It is remarkable that older plants of *P. maritima* seem to be more adapted to the effects of inundation with seawater.

Fig. 11.3. The effects of inundation on the calculated biomass production of *Plantago maritima*. Group E: seawater; Group F: fresh water.
Fig. 11.4. The effects of inundation on the vegetative reproduction (number of rosettes) of *Plantago maritima*. Group E: seawater; Group F: fresh water.

REFERENCES


12. Variability of some leaf characters in *Plantago lanceolata* (J. van der Toorn and H.J. ten Hove)

An experiment was started to study the variability of some morphological and phenological characteristics in 10 populations of *P. lanceolata* originating from various grasslands. The aim of this experiment was to find out if these characteristics are related to particular environmental factors and to detect a possible adaptation to the habitat.

Measurements of three leaf characteristics from two-months-old root cuttings were examined. These cuttings were root-borne plantlets that had been cultivated as follows (cf. Soekarjo 1980): The adult plants collected in the field (October 1980) were potted in sand rich in humus. The pots were placed on others filled with perlite. The latter were fertilized by placing them permanently in a thin layer of 1/4 Hoagland culture solution, which was renewed weekly. The plants were grown in the greenhouse under short day conditions (light was supplemented during 7 hours), and a temperature of about 18°C. After three months roots from the upper pots had grown into the lower ones. At that moment both pots were separated by cutting the roots. After a few weeks one or several shoots had formed on the