Preslia, Praha, 45 : 242—249, 1973

The Density of Stomata in Leaves of Two Ecotypes of *Phragmites communis* TRIN. in Southern Bohemia

Hustota průduchů u listů dvou ekotypů rákosu *Phragmites communis* (TRIN.) v jižních Čechách

Jaroslav Pazourek

PAZOUREK J. (1973): The density of stomata in leaves of two ecotypes of *Phragmites communis* TRIN. in Southern Bohemia. — Preslia, Praha, 45 : 242—249.

The density of stomata and related characteristics were studied. In two ecotypes of *Phragmites communis*, named according to the character of their habitats „littoral" and "terrestrial". Differences were found in the total number of stomata in a leaf, in the relation of the density of stomata in the adaxial epidermis to that in the abaxial epidermis in adult plants and in the density of stomata in developing plants but none in adult plants. No differences could be found in the number of stomata per unit of the fresh or dry weight. The gradients of all characteristics except for the relation of densities on both surfaces had an increasing tendency, as had also the values during the vegetation period. The subgradients in individual leaf blades greatly resembled each other by their character.

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Introduction

Two ecotypes of *Phragmites communis* TRIN. growing in neighbouring habitats in a Southern Bohemian fishpond were examined from the point of view of their productivity and morphological and physiological characteristics (DYKYJOVÁ 1970, 1971). The present contribution deals with the study of the density of stomata and related characteristics in the same material in the years 1966, 1967 and 1969.

Material and methods

The ecotypes studied were named according to the characters of their habitats "terrestrial" and "littoral". Slides were made by the microrelief method from five parts of the leaf on the upper as well as on the lower epidermis: on the basis, in the 1/4, 1/2, 3/4 and on the tip of the leaf blade and the stomata were counted by the same methods and scheme used in the earlier works (PAZOUREK 1970, 1973). Details are given in these papers and will not be reiterated here. It should be only pointed out that the mean values in Fig. 14 are the weighted means calculated from the total number of stomata in all leaves divided by the total surface of these leaves. The leaves were numbered from the base to the apex of the shoot.

Results of experiments and discussion

The means of the height of insertion of leaves changed during growth as seen in Figs. 1, 2. This is the example from the year 1967 when a more detailed study was undertaken.

The length, width and therefore the area of leaves (Fig. 10, 11, 12) increased during the whole vegetation period with several exceptions only caused probably by the variation of the material. The leaves of the terrestrial ecotype are larger as show all named characteristics during the whole development of plant except for the earlier phases in May 1967 when this ecotype was delayed in development. These results are in agreement with those of Dykyjová (1971).

Next to it the relation of the length to the width of leaves shows that the littoral ecotype had relatively more elongate leaves (Fig. 13).

The mean density of stomata (Fig. 14) tends to be higher during the development in the littoral ecotype but this difference did not appear every year in fully developed plants.

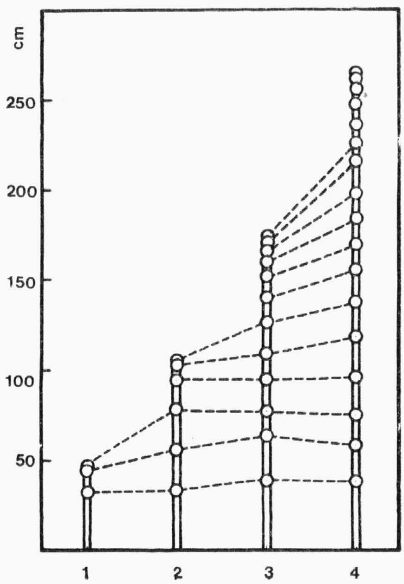

Fig. 1. — The mean height of insertion of successive leaves during the development of the shoot in the littoral ecotype. 1 . . . 9. 5. 1967, 2 . . 30. 5. 1967, 3 . . . 4. 7. 1967, 4 . . . 18. 7. 1967.

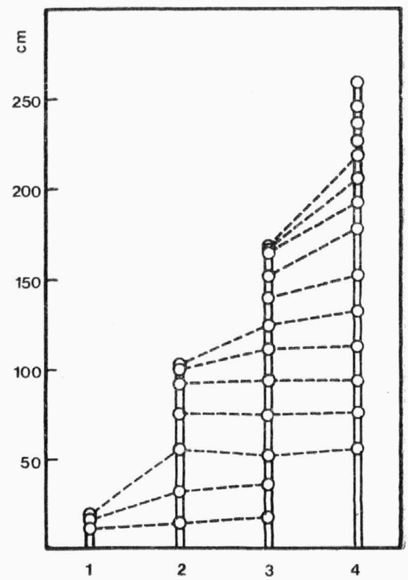

Fig. 2. — The mean height of insertion of successive leaves during the development of the shoot in the terrestrial ecotype. 1 . . . 9. 5. 1967, 2 . . . 30. 5. 1967, 3 . . . 4. 7. 1967, 4 . . . 18. 7. 1967.

The connection of this results with the production of biomass is undoubtedly to complicate to be explained merely on the basis of the characteristics studied. It is tempting hovewer to ascribe the higher density of stomata in the littoral ecotype to the fact that the high amount of available water affects similar differences as the relative drier environments. Besides other authors already Zalenskij (1904) pointed at the higher density of stomata in the marsh plants and Lundkvist (1955) demonstrated experimentally that under superoptimal water supply the plants show higher stomatal frequency and that the structure tends to xeromorphy. In contrast, observations by Salisbury (1927) showed that in plants grown in shallow water or in wet mud the density of stomata was lower in comparison with those grown in mud or in dry mud. Similarly Demidovskaja et Kiričenko (1964) found lower density of stomata in *Phragmites* plants growing in water. Because the limits of suboptimal, optimal and superoptimal water supply in terms of Lundkvist may be various in different plants it is questionable what amount of water in the observed plants was the superoptimal. It is therefore difficult to decide whether the differences between the ecotypes studied are genetically controlled or caused by the environmental conditions.

In comparison with others the density of stomata in our material is low. In adult plants the mean density of stomata in the littoral ecotype varied from 585 to 651 stomata, in the terrestrial ecotype from 557 to 654 stomata per sq. mm. In the ecotypes studied in the Netherlands (Pa-

ZOUREK 1973) the means varied from 737 to 791. BJÖRK (1967) published numerous data concerning the density of stomata. Most of them exceed 1000 stomata, in extreme cases 1500 and even 1700 stomata per sq mm. Although these data concern individual leaves, the mean values in all habitats are undoubtedly higher than 1000. Our data are comparable only with those of DEMIDOVSKAJA et KIRIČENKO (1964) with the maximum of 670 stomata per sq. mm.

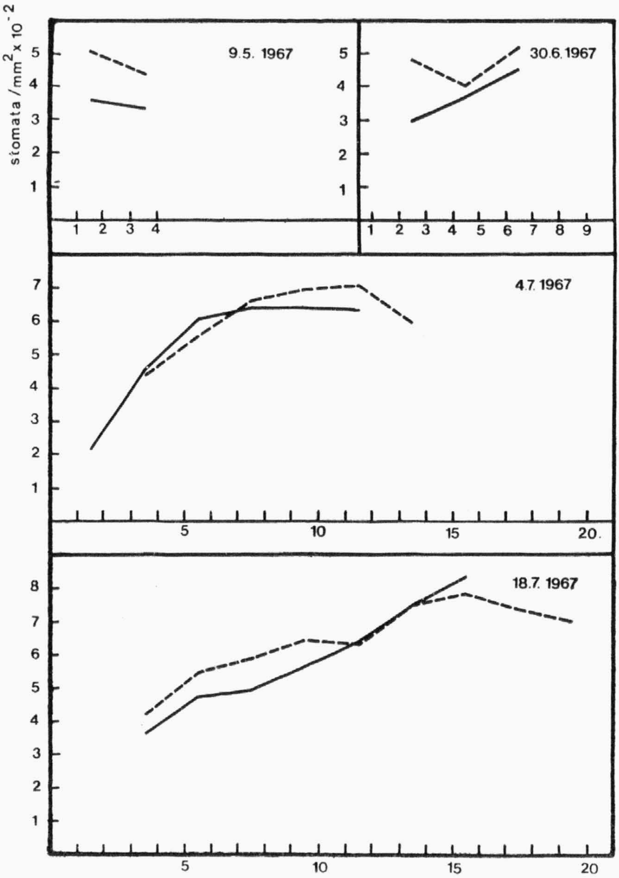

Fig. 3. — The gradients of the stomatal frequency of successive leaves in the year 1967. Abscissa: number of leaf - - - - - - - - littoral, ———— terrestrial ecotype.

The average density of stomata increases during the growth of the shoot. This is caused first of all by the development of new higher inserted leaves which exhibit higher density of stomata as seen in their gradients (example in Fig. 3). A similar character of these gradients was found in the ecotypes of *Phragmites* in the Netherlands (PAZOUREK 1973) and may be seen in the material of BJÖRK too.

The average total number of stomata in a leaf (Fig. 15) increases during the development too. From this point of view the relationships between the ecotypes are not clear but in the fully developed plants this characteristic was much greater in the terrestrial form in all three years. Its increasing during the growth of the shoot is probably also in connection with the increas-

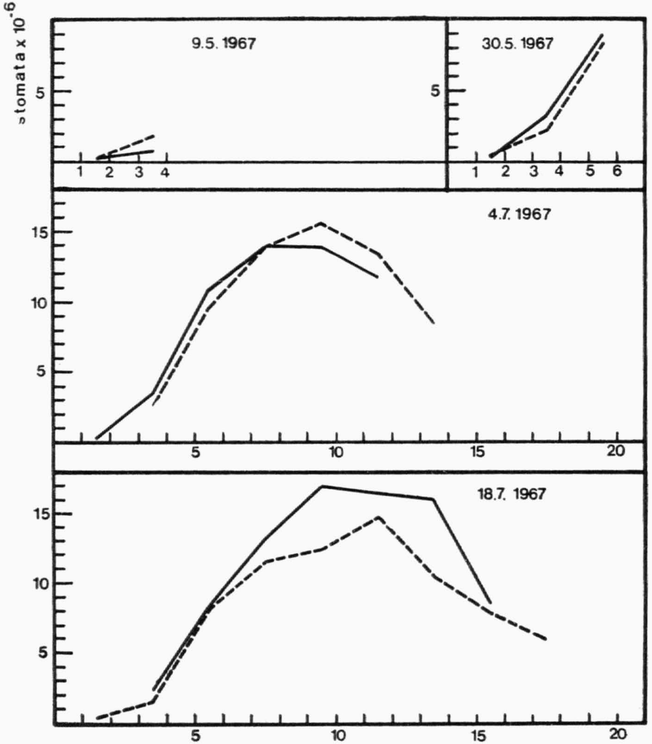

Fig. 4. — The gradients of the total number of stomata in a leaf in successive leaves in the year 1967. Abscissa: number of leaf. — - - - - - - - - littoral, ——————— terrestrial ecotype.

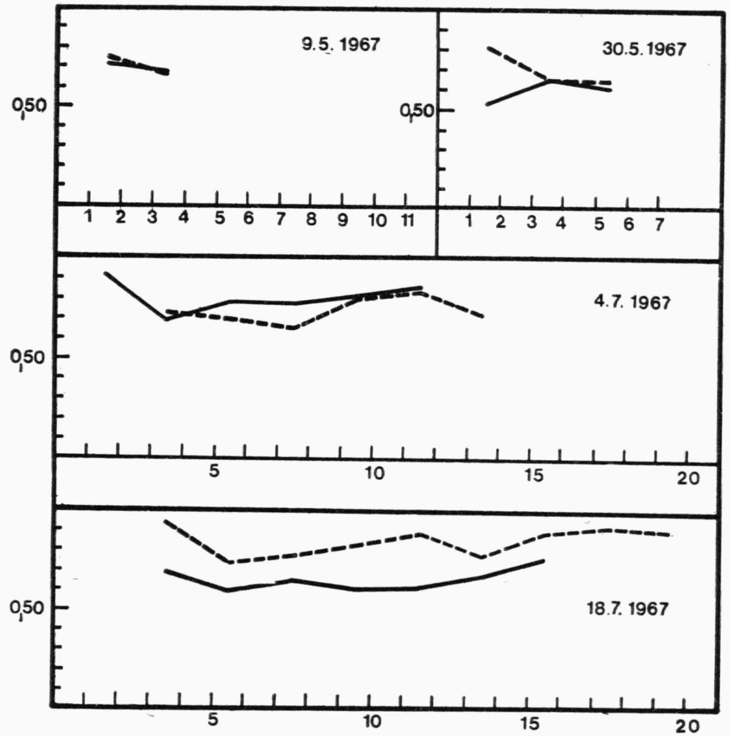

Fig. 5. — The gradients of the ratio of stomata densities in the adaxial and abaxial epidermis in 1967. Abscissa: number of leaf. - - - - - - - - littoral, ——————— terrestrial ecotype.

ing character of gradients in successive leaves (Fig. 4) although the maxima here are not in the highest leaves.

No increasing or decreasing of the density and total number of stomata could be found in the leaves of the same insertion during the time-period mentioned above. It means that no differentiation of new stomata could be established. Should they arise, it would be necessary to prove it by special experiments.

The varying data of named characteristics, especially those of the density of stomata, show that they change during the growth of the plant and that it is impossible to state a general, mean value, characteristic for a certain taxon. Data of this kind should always be supplemented by a statement of the development of the plant besides the environments which may cause considerable differences.

From the basic data the ratio of densities in the adaxial and abaxial epidermis was calculated (Fig. 16). The density in the adaxial epidermis was always lower than in the abaxial and therefore the ratio of bot densities was never higher than 1.0. For example in two highest leaves of the adult plants of the terrestrial ecotype the average density in the adaxial and abaxial epidermis was 792 and 1025 stomata per sq. mm, respectively the ratio being 0.772.

In this characteristic no tendency appeared during the growth to the regular changes nor to the differences between the ecotypes. Only in adult

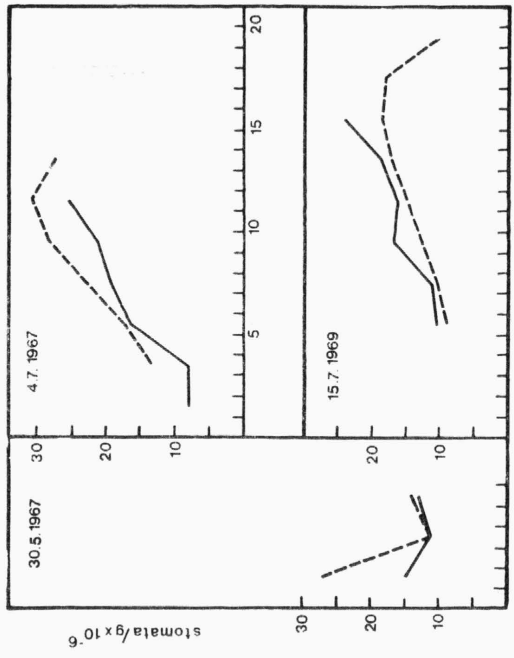

Fig. 7. — The gradients of the number of stomata per 1 g of the dry weight. Abscissa: number of leaf. - - - - - - littoral, ———— terrestrial ecotype.

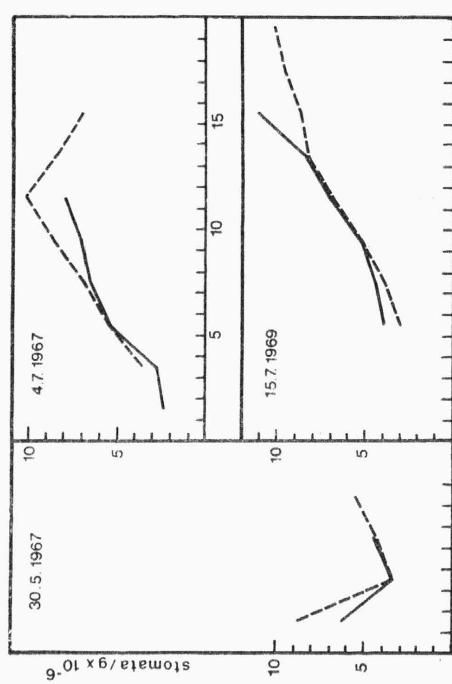

Fig. 6. — The gradients of the number of stomata per 1 g of the fresh weight. Abscissa: number of leaf. - - - - - - littoral, ———— terrestrial ecotype.

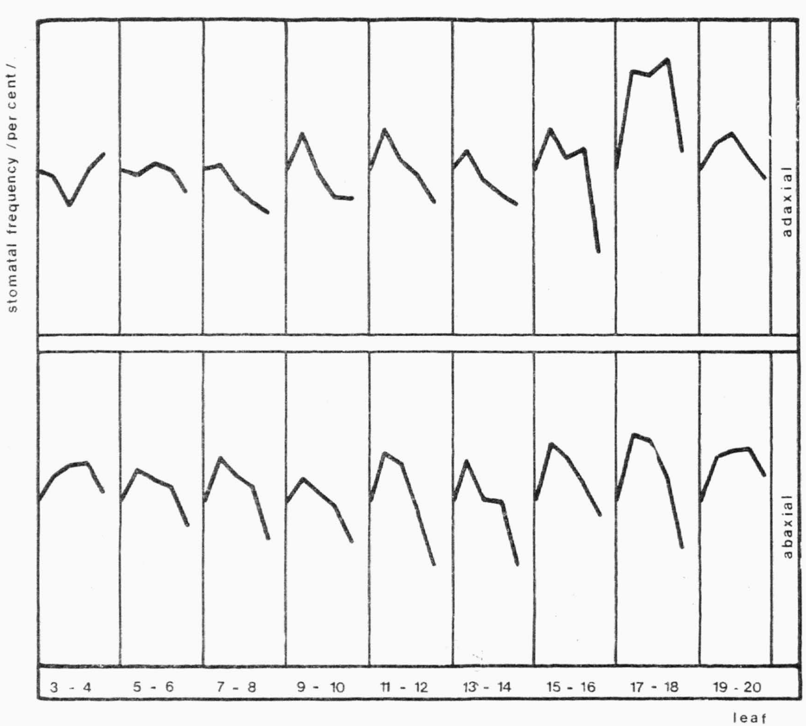

Fig. 8. — The gradients of the stomatal frequency in the adaxial and abaxial epidermis of a leaf blade in the littoral ecotype (18. 7. 1967). The relative values are given in the density of stomata on the basis of each leaf blade (= 100 per cent). In each gradient: left — basis, right — tip of the leaf blade.

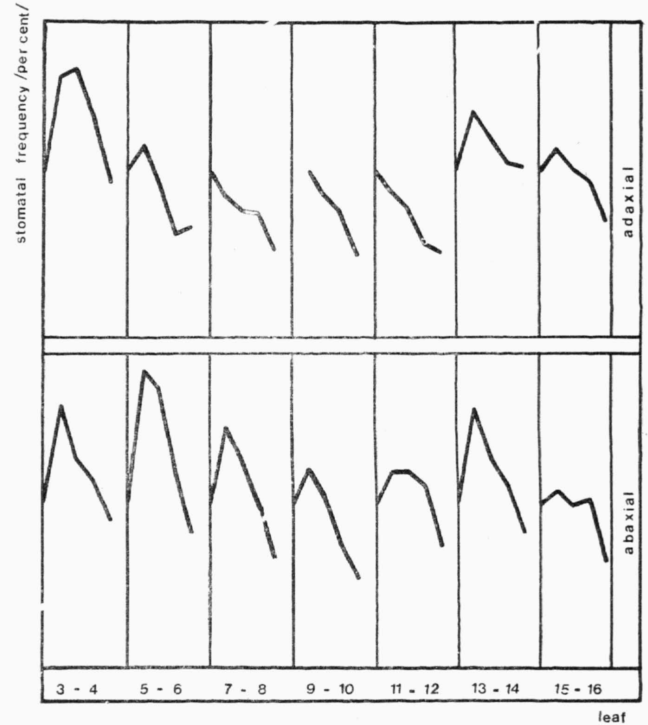

Fig. 9. — The gradients of the stomatal frequency in the adaxial and abaxial epidermis of a leaf blade in the terrestrial ecotype. (18. 7. 1967). The relative values are given in the density of stomata on the basis of each leaf blade (= 100 per cent). In each gradient: left — basis, right — tip of the leaf blade.

plants in all three years the values were higher in the littoral ecotype. This difference is not caused by the development of new leaves because the gradients show no increasing or de crea sing tendency (example in Fig. 5).

In several cases an attempt was made to relate the number of stomata to the fresh and dry weight. It appeared that during the development the number of stomata per unit of weight increases but the relationships between the ecotypes differed greatly (Figs. 17, 18). The gradients (Figs. 6, 7) also exhibit the increasing character. In contrast to the terrestrial, the littoral ecotype showed mostly a decrease in the highest inserted leaves. Generally it has been shown that to a unit of the weight the more stomata provide the gas-exchange, the higher is the leaf inserted.

From the data obtained by the numbering of stomata in different parts of leaf as mentioned above, the subgradients of the density of stomata in individual leaf blades were calculated. In order to compare their character, they have been expressed relatively in per cent of the values found in the base of the leaf blade (Figs. 8, 9). They show mostly a similar character i.e. an increase from the basis to the 1/4 or 1/2 of the leaf length and then a decrease to the apex. If generally some variations may be seen, certain regularity of differences similar to that found in an other material (Pazourek 1969, 1970) appeared in the terrestrial ecotype but only up to the 12th leaf.

Souhrn

Morfologické kvantitativní znaky, které byly měřeny kromě hustoty průduchů a dalších příbuzných znaků, ukazují, že hodnoty délky, šířky a plochy listů u terestrického ekotypu byly vyšší, ale relativní tvar listů nebyl tak protáhlý jako u litorálního ekotypu.

Hodnoty, vyjadřující průměrnou hustotu průduchů, celkový počet průduchů na jednom listu a jejich počet, vztažený na jednotku čerstvé váhy a na jednotku sušiny, se během vývinu rostlin zvyšovaly, což nepochybně souvisí s růstem nových listů, jak je vidět z gradientů stoupajících se zvyšující se inzercí listů.

Pokud jde o diference mezi ekotypy, byla hustota průduchů nižší u terestrického ekotypu během vývinu, ale u dospělých rostlin nebyly zjištěny pravidelné diference. U téhož ekotypu byl však vyšší celkový počet průduchů na jednom listu a poměr hustot na adaxiální a abaxiální straně, ale v tomto případě byly tyto diference u dospělých rostlin, kdežto během vývinu byly diference nepravidelné. V počtu průduchů, vztaženém na jednotku čerstvé váhy a sušiny, nebyly mezi ekotypy zjištěny rozdíly.

Subgradienty na listových čepelích měly celkem stejný charakter; určité pravidelnější rozdíly v závislosti na inzerci se projevily u terestrického ekotypu, zvl. na adaxiální epidermis.

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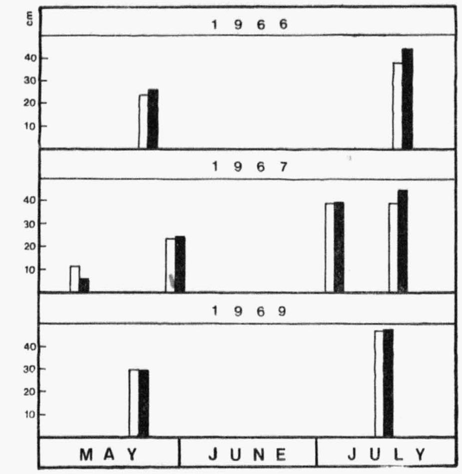

Fig. 10. — The mean length of leaf. White columns — litoral, black columns — terrestrial ecotype.

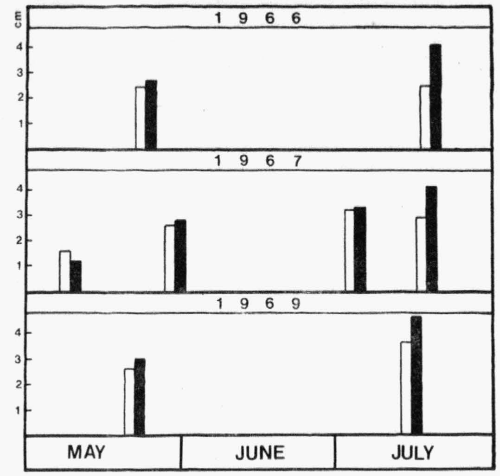

Fig. 11. — The mean width of leaf. White columns — littoral, black columns — terrestrial ecotype.

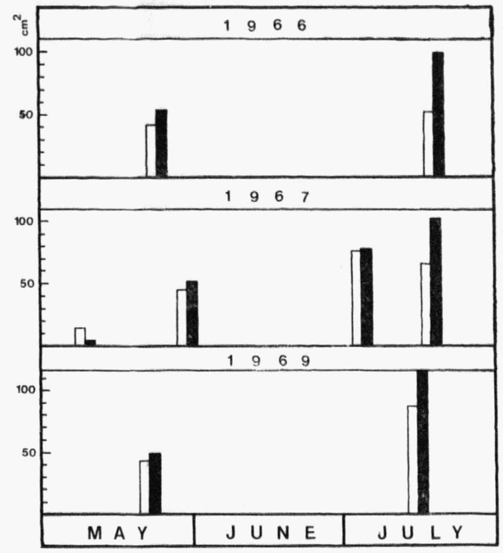

Fig. 12. — The mean area of leaf. White columns — littoral, black columns — terrestrial ecotype.

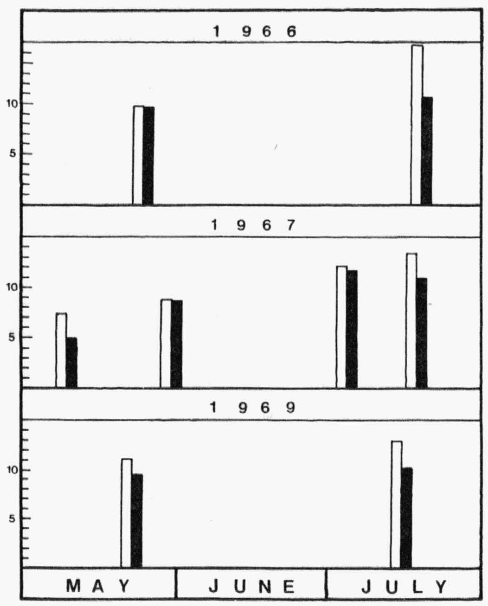

Fig. 13. — The mean relative shape of leaf given as the ratio length/width. White columns — littoral, black columns — terrestrial ecotype.

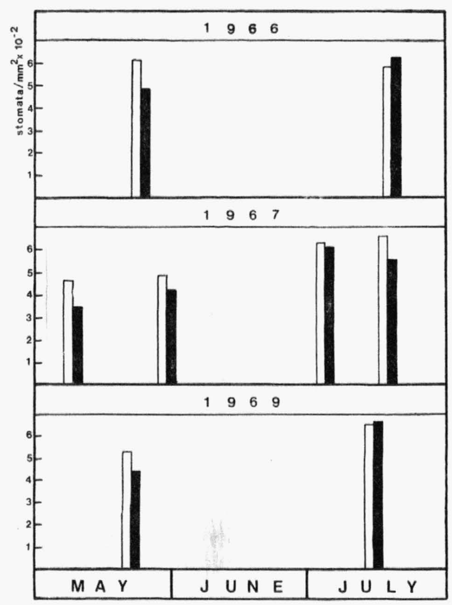

Fig. 14. — The mean stomatal frequency. White columns — littoral, black columns — terrestrial ecotype.

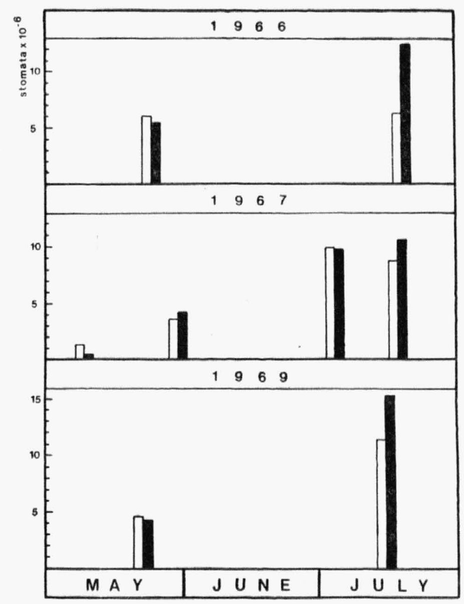

Fig. 15. — The mean of the total number of stomata in a leaf. White columns — littoral, black columns — terrestrial ecotype.

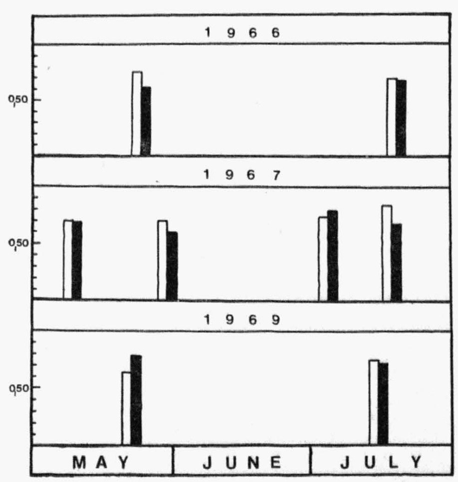

Fig. 16. — The mean ratio of the stomatal densities in the adaxial and abaxial epidermis. White columns — littoral, black columns — terrestrial ecotype.

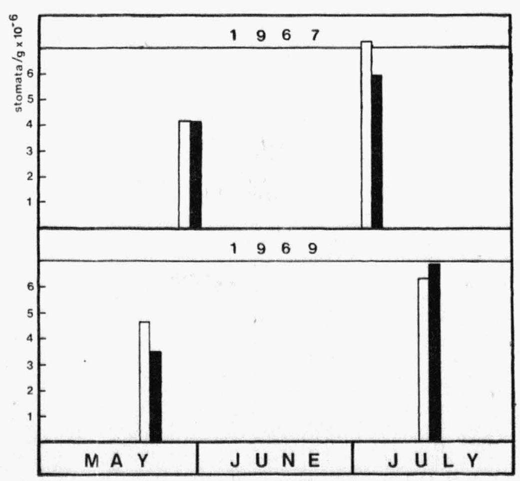

Fig. 17. — The mean number of stomata per 1 g of the fresh weight. White columns — littoral, black columns — terrestrial ecotype.

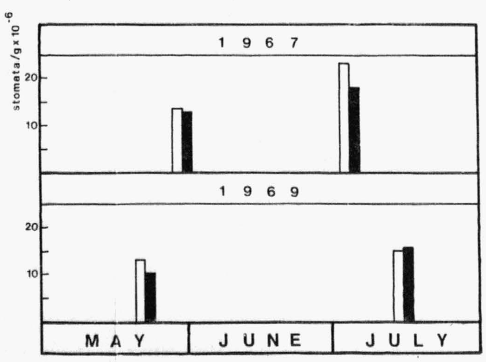

Fig. 18. — The mean number of stomata per 1 g of the dry weight. White columns — littoral, black columns — terrestrial ecotype.

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Received November 17, 1972
Recenzent: D. Dykyjová

F. Weberling et H. O. Schwantes:

Pflanzensystematik

Einführung in die Systematische Botanik, Grundzüge des Pflanzensystems
Uni-Taschenbücher Bd. 62. — Verlag Eugen Ulmer, Stuttgart 1972, 381 str., 104 obr., cena váz. 19,80 DM. (Kniha je v knihovně ČSBS.)

Drobná knížka (v ohebné vazbě), která vychází z H. WALTERA (Grundlagen des Pflanzensystems. Einführung in die Phytologie II, 1961). Využívá všech jeho dobrých zkušeností, avšak její text je značně přepracován. Knížka má dvě části, obecnou a systematickou. První část obsahuje po předmluvě dvě kapitoly: 1. Základy, cíle a metody systematické botaniky a 2. Stupně morfologické organizace a rozmnožování v rostlinné říši (životní cykly). Tyto partie napsali oba autoři společně. Systematická část začíná pojednáním o krytosemenných rostlinách (včetně jejich přehledného systému), které jsou začátečníkovi v botanice rozhodně bližší. Také důvody historické vedly autory k tomuto postupu. Teprve potom následují „hlavní skupiny" rostlinné říše. Autoři rozlišují pět hlavních skupin, v nichž probírají systém jednotlivých oddělení: I. *Schizobionta* (s odděleními *Schizophyta, Cyanophyta*), II. *Phycobionta (Chlorophyta, Euglenophyta, Pyrrhophyta, Chromophyta, Rhodophyta)*, III. *Mycobionta (Myxomycota, Eumycota)*, IV. *Bryobionta (Bryophyta)* a V. *Cormobionta (Pteridophyta, Spermatophyta)*. První tři hlavní skupiny (nižší rostliny) zpracoval H. O. SCHWANTES, další dvě (vyšší rostliny) F. WEBERLING. Závěr publikace tvoří výběr doporučené literatury a podrobný rejstřík.

Výběrem a podáním látky je to zdařilý úvod do soustavné botaniky a přehledný systém rostlinné říše (viz podtitul), který se čte velmi dobře a začátečníkovi nebude dělat při studiu potíže. K tomu značně přispívají instruktivní obrázky (převážně perokresby), jejichž reprodukce je opravdu kvalitní. Přitom knížka obsahuje spoustu konkrétních dat, která poslouží i pokročilým studentům, a navíc dobře informuje o problematice moderní systematiky rostlin. Proto si ji se zájmem přečtou jistě i specialisté z různých botanických disciplín. Ruší v ní pouze nečetné drobnosti, např. skutečnost, že autoři nazývají taxóny nejvyšších stupňů taxonomické hodnoty nedůsledně (v přehledech oddělení, v textu kmen; třída má různý význam apod.).

Z. Černohorský