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Microflora in the Soils of Temporarily Flooded Meadows

Mikroflora v půdách některých rostlinných společenstev aluviálních luk

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Abstract — During the vegetation period of 1962, 1963, 1964 the fluctuations in numbers of aerobe and anaerobe soil microorganisms have been investigated in eighteen localities of eight plant communities differing in soil moisture contents on the alluvial meadows of the Morava and Dyje rivers valley in the neighbourhood of the village of Lanžhot. The amount of soil microorganisms changes specifically during the vegetation period under individual plant communities. The changes of the amount of organisms are closely bound with floods and soil moisture contents. The absolute numbers of organisms are different in the years 1962, 1963, and 1964, but the basic tendencies of changes under individual plant communities and during vegetation period are the same.

The natural meadows of temporarily inundated areas of the lower river courses in the southern parts of Czechoslovakia are now situated mainly in the regions of the Morava and the Dyje rivers in South Moravia and the Ipel and the Slaná rivers in South Slovakia.

These roughly correspond to the maize production zones of the agricultural land classification scheme, to the *Ulmo-Fraxinetum* or *Querco-Ulmetum* of the potential natural vegetation and to the Pannonicum of the phytogeographic classification. Macroclimatically, these areas are characterized by hot dry summers and mild winters.

Soils of these meadows are alluvial; they are low humic gley and humic gley soils. Generally, the productivity and very often also the quality of hay originating from plant associations of inundated meadows is higher than the productivity of plant associations of other types of meadows (Balátová 1966), but owing to recent technical projects their future existence is uncertain.

These meadows play an important part from the landscape organization point of view, because in the periods of flood or high water level in the river (during snow melting and spring, summer, or autumn rain periods) the meadows exercise a function of reservoirs of superfluous water.

All this prompted an ecological model research programme of the Botanical Institute of the Czechoslovak Academy of Sciences. On the inundated meadows near the village of Lanžhot at the confluence of the Morava and the Dyje rivers, the synecological studies of a hydroseries of plant communities (Balátová 1966, unpublished) were conducted and followed by a comparative study concerning the microbiology of the soils.

Similar studies by other authors in the microbiology of meadow soils under different plant communities, were based on the comparison of the numbers of microorganisms found in the soil samples collected on a single date only (Klincare 1961, Zimna et Zimny 1962, Gurfel 1962, Jagnow 1961, Ambrož et Balátová 1962). Another type of approach to the study of soil microbial processes and their functional significance in the flooded meadows is represented by laboratory model experiments of Mitchell et Alexander (1962). Summarization of microbiological processes concerning N-metabolism in meadow soils was given by Harmsen et Schreven (1955).

It was considered useful to compare the microbial populations existing under characteristic plant communities of the meadows by analysing samples collected periodically during several years in order to etablish the relationships between the water regime, the plant production and the soil microbiological populations.

M a t e r i a l s a n d m e t h o d s

The situation of the habitats investigated is shown in the study map I. The climate of the region is warm and dry, as shown by the fifty year averages for temperature and for total annual precipitation.

Meteorological station	Temperature of the air (°C)	Total annual precipitation (mm.)
Břeclav	—	550
Lednice	9.0	524
Hodonín	9.5	585

Periods of drought are a regular feature.

Soils of flooded areas are generally formed by humic gleys with underlying layers of alluvial deposits of Recent Epoch origin. Gleic layers in the lower part of the soil profile are very compact and impermeable both to air and water. The total water supply, important for the growth of plants during the rainless periods in this region (Úlehla, Zichová et Baňoch 1965), mainly depends on the duration of the floods and the depth of the impermeable layers. The position of water ferrous clay beds differentiates the water regime of the habitat and the vegetation mosaic. The soils are heavy, with a high clay content, and are rich in mineral salts. The humus content varies from 4.5 to 11.7 per cent of dry soil; the pH H_2O ranges from 5.5 to 7.2. Deep synecological characterization of the habitat has been carried out by Balátová (1966, unpublished).

During the years 1962 to 1964 conditions at 18 sites under 8 characteristic plant communities were studied, showing differences in the soil water regime as well as in the amounts of vegetal matter produced per unit area.

1. The *Serratuleto-Festucetum commutatae* association Balátová-Tuláčková 1963 is typical for the driest soil conditions in the investigated area. The production of hay is 1 to 2 metric tons per hectar/year.

2. The *Galium boreale* subassociation of the *Gratiola officinalis-Carex praecox-suzae* association Balátová-Tuláčková 1963 has been found in places moister than those mentioned above. There is a lower content of soil organic matter in the upper part of the soil profile than in the soils under the wet-type plant associations. The production of high quality hay varies from 3 to 5 metric tons per hectar/year.

3. The association of *Gratiola officinalis* and *Carex praecox-suzae*, subassociation with *Rorippa silvestris* Balátová-Tuláčková 1963 is the final member in this series typical for the more or less dry soil conditions. It produces 3 to 5 metric tons of high quality hay per hectar/year.

4. The *Lathyrus paluster-Gratiola officinalis* association Balátová-Tuláčková 1963 represents a transitional type between the dry and the wet habitats. The production of good quality hay ranges from 3 to 5 metric tons per hectar/year.

5. The *Caricetum vulpinae* association Noviński 1927 is characterized by high soil moisture and by the productivity of about 5 metric tons per hectar/year.

6. The *Caricetum gracilis* association (Graebn. et Hueck 1931), Tüxen 1937 also represents a plant community typical of bogs, with correspondingly high soil moisture. The production of bedding straw amounts to 5 metric tons per hectar/year.

7. The *Phalaridetum arundinaceae* association Libbert 1931/32 can also be found in places with a high water table. The upper parts of the soil profile contain great amounts of undecomposed organic material. Meadows of this type, when mown at early stages of plant development, yield about 7 metric tons of good quality hay per hectar/year.

8. The association with *Glyceria maxima* — *Glycerietum maximae* Graebn. et Hueck 1931 — occurs regularly in depressions with a high water table for a greater part of the growing season. The gleic horizon is situated high in the soil profile. The decomposition of organic materials proceeds for a considerable time under anaerobic conditions. The production of dry organic matter is high, about 9 metric tons per hectar/year.

Soil samples were collected on 5 occasions in 1962, 1964 and on 4 occasions in 1963. Some of the sampling sites were inaccessible during the floods in 1962.

a) The first collection of soil samples was effected after the flood,
b) the second one during the most productive phase of the plant communities,
c) the third one during the dry period in the summer,
d) the fourth one in the autumn period when the soil moisture was higher.

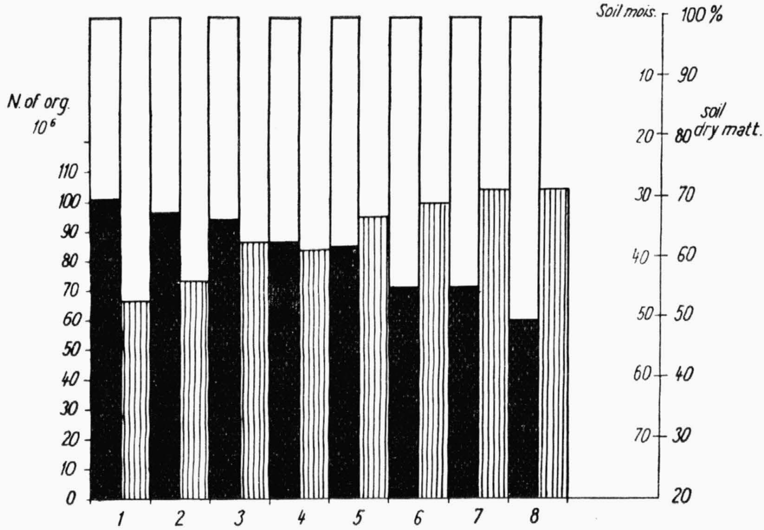


Fig. 1. — Averages of dry matter content ■, of the moisture content □ and of the numbers of all soil microorganisms ▥ found in soil samples collected on 14 to 16 occasions during the years 1962 to 1964 in eight plant communities: 1. *Serratuleto-Festucetum commutatae*, 2. *Gratiola officinalis-Carex praecox-suzae* subas. with *Galium boreale*, 3. *Gratiola officinalis-Carex praecox-suzae* subas. with *Rorippa silvestris*, 4. *Lathyrus paluster-Gratiola officinalis*, 5. *Caricetum vulpinae*, 6. *Caricetum gracilis*, 7. *Phalaridetum arundinaceae*, 8. *Glycerietum maximae*.

The numbers of microorganisms present in the samples were estimated from fresh soils by standard dilution techniques, using Taylor's agar for aerobic and anaerobic bacteria, Thornton's agar for the actinomycetes and Czapek's agar for the lower fungi. The microbiological analysis was carried out in 24 hours after soil sampling.

Results and discussion

The average counts of all microorganisms found in the soils under the individual plant communities on all sampling occasions are shown in Fig. 1. As expected, it can be seen from this figure that the lowest values of the average dry matter content of the soils characterize the plant communities as typical for wet habitats. It is in these plant communities where the highest average counts of all soil microorganisms were found. Low average number of all microorganisms and high average dry matter contents are characteristic of dry-type plant communities. The plant communities studied in the present work form the following series according to the increasing average counts of all microorganisms:

Serratuleto-Festucetum commutatae, *Gratiola officinalis-Carex praecox-suzae*, subassoc. with *Galium boreale*, *Gratiola officinalis-Carex praecox-suzae*, subass. with *Rorippa silvestris*, *Lathyrus paluster-Gratiola officinalis*, *Caricetum vulpinae*, *Caricetum gracilis*, *Phalaridetum arundinaceae*, *Glycerietum maximae*.

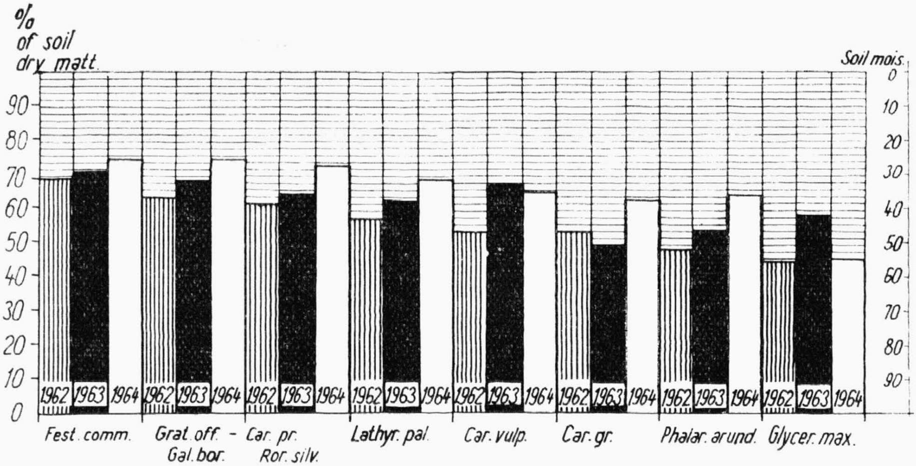


Fig. 2. — Averages of dry matter content of the soils in the eight plant communities studied for the years 1962 [vertical hatching], 1963 [black] and 1964 [white]. The numbering of plant communities as in Fig. 1. [horizontal hatching] soil moisture.

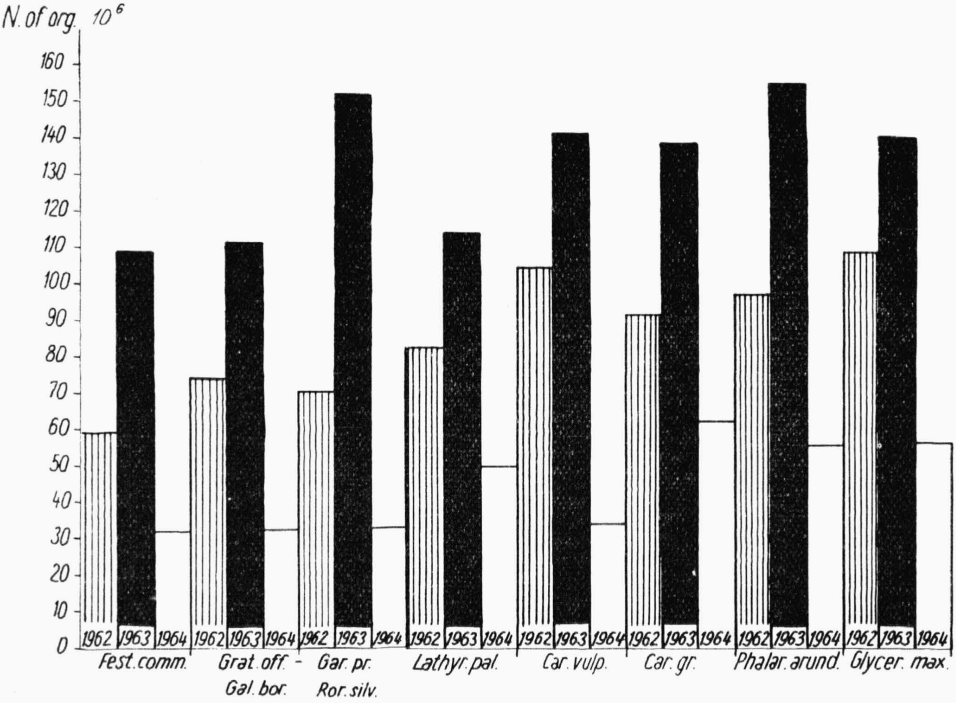


Fig. 3. — Averages of the numbers of all microorganisms in the soils under the plant communities studied in the years 1962 [vertical hatching], 1963 [black] and 1964 [white]. The numbering of the plant communities as in Fig. 1.

The relationship as shown in Fig. 1 should thus make it possible to classify the plant communities with respect to the water regime of the soils by considering average counts of all soil microorganisms.

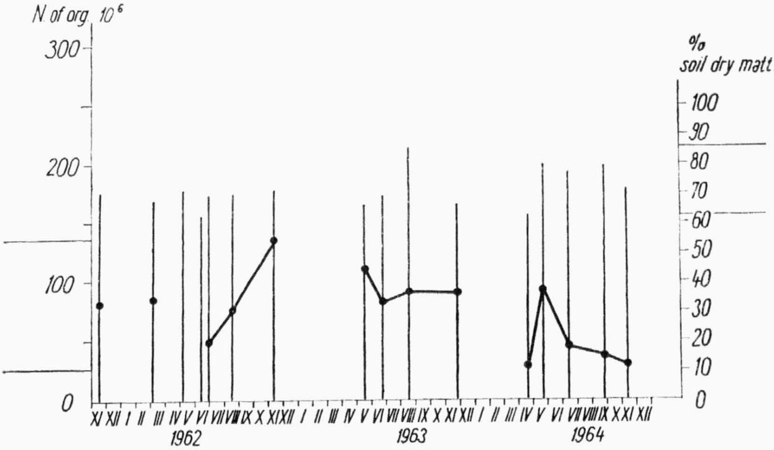


Fig. 4. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Serratuleto-Festucetum commutatae* during the years 1962 to 1964.

Figs. 2 and 3 show averages of the dry matter percentage of fresh soil and of the numbers of all microorganisms characterizing the respective plant communities for three consecutive years, 1962 to 1964.

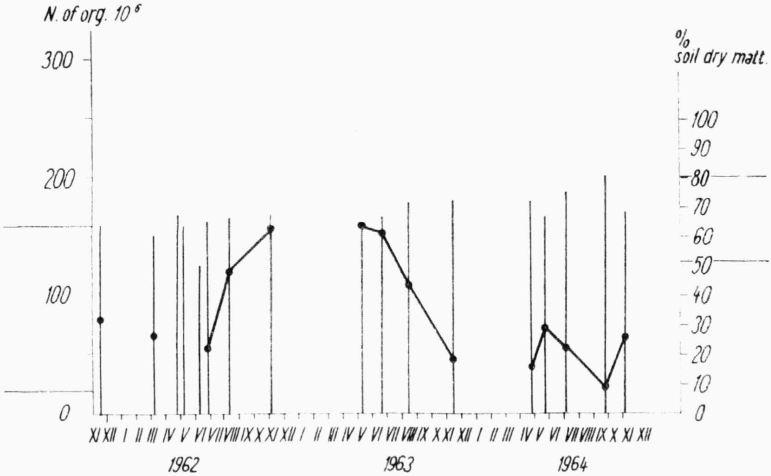


Fig. 5. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Gratiola officinalis-Carex praecox-suzae* subassociation with *Galium boreale* during the years 1962 to 1964.

Differences in the values given for the three years, in particular with respect to the dry-type plant communities, mirror the different meteorological conditions. Flooding occured twice between March and June in 1962 and the soil moisture remained relatively high throughout the year. In 1963 the duration of the floods was about normal (10 to 20 days) and the average soil moisture was generally lower than in 1962. In 1964 the floods lasted only

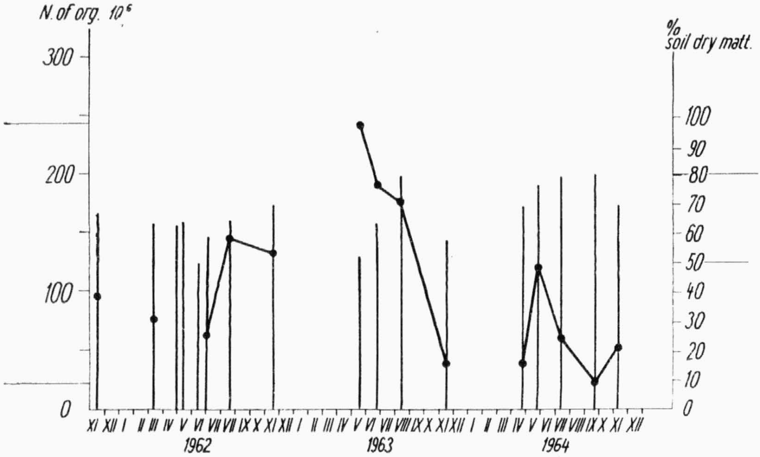


Fig. 6. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Gratiola officinalis-Carex praecox suzae* subassociation with *Rorippa silvestris* during the years 1962 to 1964.

a few days and the average soil moisture was considerably lower than in the two preceding years. Differences for the respective years, dependent on weather, were not observed in plant communities of habitats with a lasting high

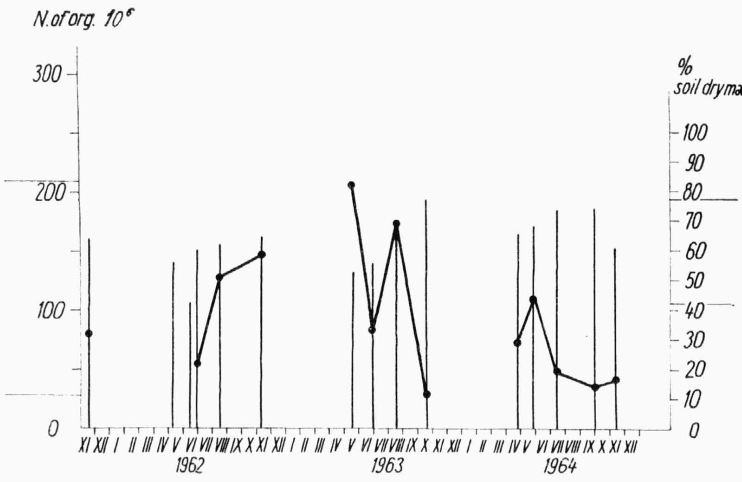
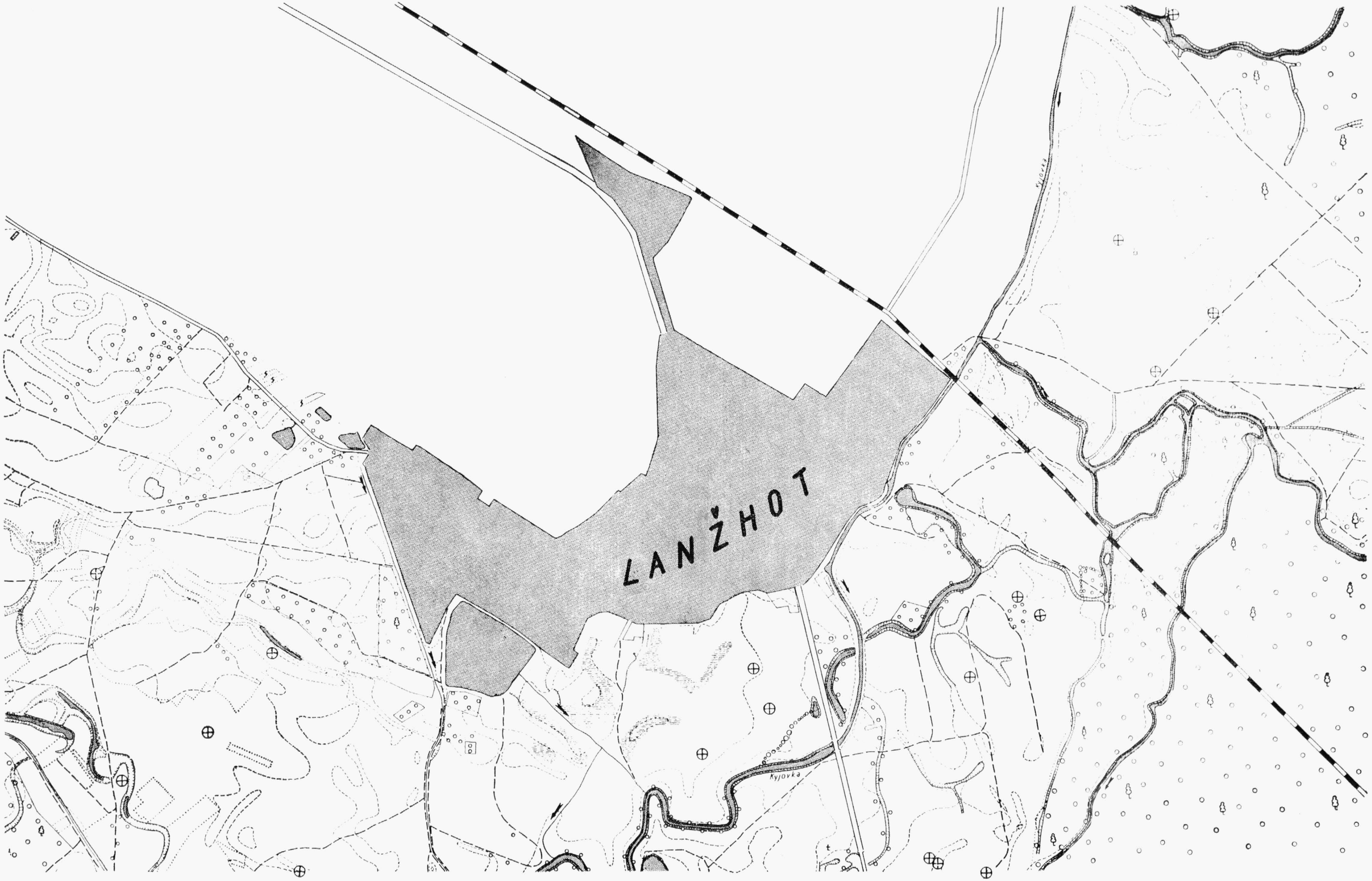


Fig. 7. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Lathyrus paluster-Gratiola officinalis* during the years **1962** to **1964**.

water table, i.e. *Caricetum vulpinae, Caricetum gracilis, Glycerietum maximae, Phalaridetum arrundinaceae.*

The highest average numbers of all soil microorganisms were found in the year 1963, when the productivity of the plant stands also at its maximum.



Map I. — Places of investigation (⊕).

It is very important for the respective control exploitation of these meadows. Although the three year averages showed an increase in numbers of soil microorganisms with increasing soil moisture, their average numbers were

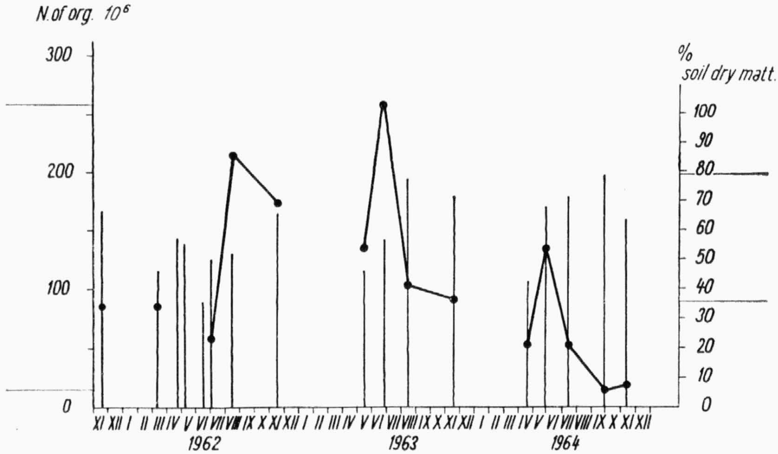


Fig. 8. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Caricetum vulpinae* during the years 1962 to 1964.

lower in 1962 than in 1963 in spite of the higher average soil moisture in 1962. This shows that in 1962 the average soil moisture was higher than the optimal one for both the growth of plants and the reproduction of soil microorganisms.

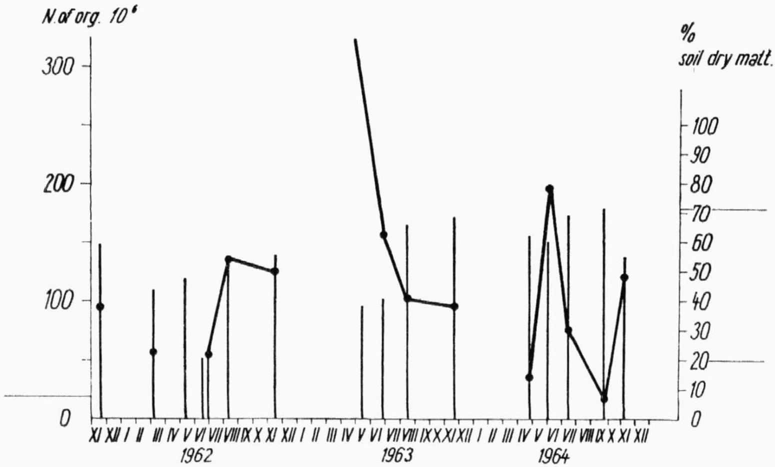


Fig. 9. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Caricetum gracilis* during the years 1962 to 1964.

In Figs. 4 to 11 the data for the dry matter contents of the soils and for the totals of all microorganisms (bacteria and actinomycetes) found on the individual sampling occasions during the three years, are presented separately for various plant communities. The data show a great variation in the characteristics studied. A considerable part of these variations is caused by the differences in the average soil humidity under the different plant communities. The prevailing conditions on the day of sampling or on the preced-

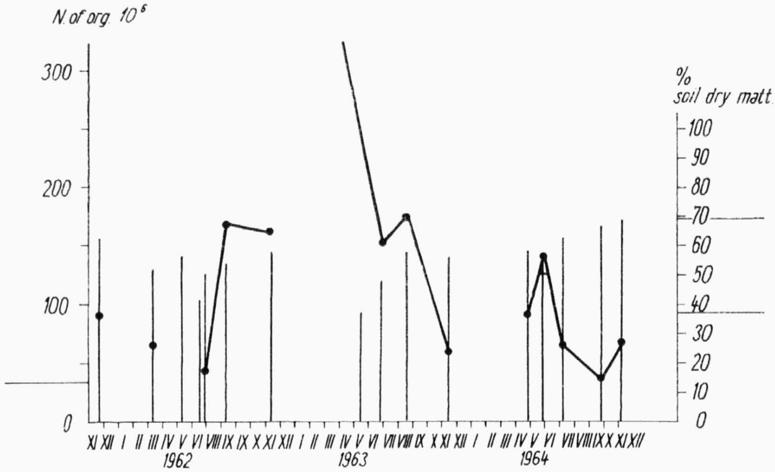


Fig. 10. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Phalaridetum arundinaceae* during the years 1962 to 1964.

ing days appear to be even more important; these cause great differences in results obtained on the consecutive sampling occasions.

Particularly after floods it was observed that an explosion-like increase in the numbers of soil microorganisms took place under the plant communities of both the dry and the wet habitats during all the three years.

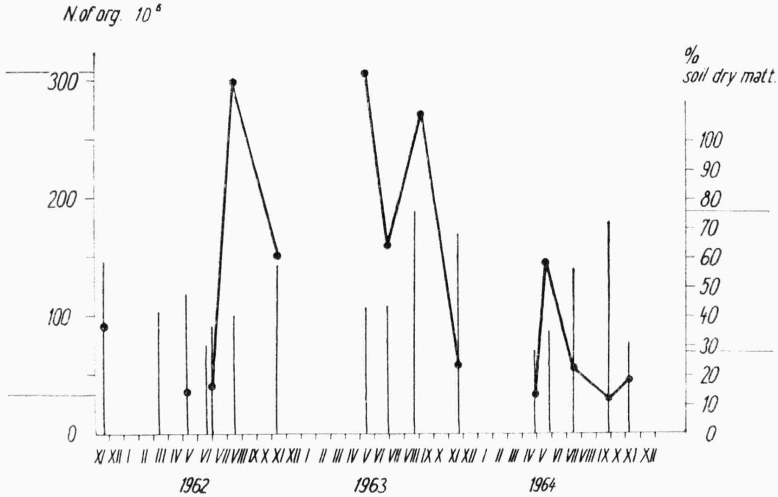


Fig. 11. — Changes in dry matter content of the soil and in the total numbers of all soil microorganisms in the plant community *Glycerietum maximae* during the years 1962 to 1964.

The data for dry matter contents on the 19th and 29th of June 1962 demostrate how quickly the soil moisture conditions are restored after the flooding has receded. On the 19th of June the plant communities 2, 3, 4, and 5 were flooded and the dry matter content of the respective soil samples was therefore low. Ten days later the dry matter content of the soil samples had increased by about 10 per cent. The change in the soil moisture was accompanied by a pronounced increase in the numbers of soil microorganisms and was closely followed by a rapid regeneration of the plant stands.

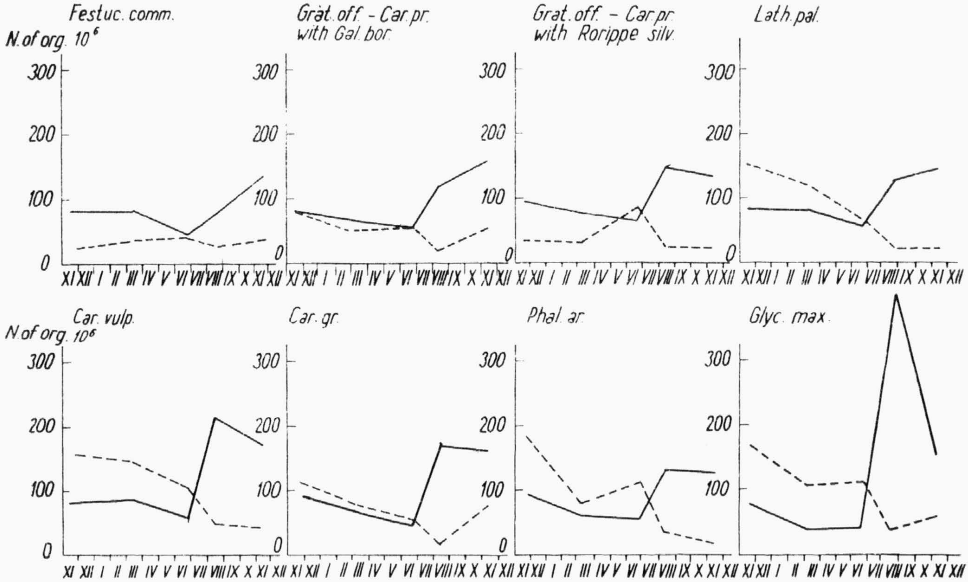


Fig. 12. — Changes in the numbers of aerobic ———— and anaerobic – – – – microorganisms in the soils during 1962. The numbering of plant communities as in Fig. 1.

A transient high increase in the numbers of soil microorganisms is inevitably accompanied by a corresponding increase in the rate of metabolic transformations of the organic matter present in the soil. The influence of floods on the soil microbial populations was studied under laboratory conditions by Mitchell et Alexander (1962). These authors arrived at the conclusion that flooding of meadow soil results in pronounced changes in the numbers of the microbial populations. The floods exert a profound influence on the microbial populations of the soils by changing their aeration and their biogeocycles. In flooded soils the relative numbers of anaerobic bacteria increase and those of the aerobic bacteria decrease. This is illustrated by the field data obtained in 1962 (Fig. 12). The experimental area was flooded in March and April, and then again during the end of May and the beginning of June. In the case of three plant communities of the driest habitats, i.e. *Festucetum commutatae* and both subassociations with *Gratiola officinalis* and *Carex praecox-suzae* the numbers of anaerobic bacteria in the soils were lower than those of the aerobic ones during the whole year. But during the period of floods the anaerobic bacteria in the soils under the remaining five communities were present in considerably higher numbers than the aerobic ones.

The microbial processes in flooded soils may be influenced by other factors besides the changed aeration. Mitchell et Alexander (1962) have shown that application of sulphur-containing compounds to the flooded soils increases the utilization of soil organic matter. The decomposition of organic matter is in this case related to the metabolic transformations of the sulphur-containing compounds. According to MITCHELL et ALEXANDER, in flooded meadow soils, substances with antifungal activity are produced which have beneficial effects on the health status of the soil microbial population.

Figs. 4 to 11 illustrate the differences between various plant communities encountered in the range of variation (ecological amplitude). Whilst the data for the plant communities of the dry habitats show a relatively narrow range of variation, the data for the plant communities of boggy habitats show a much wider scattering. This is true for the variation in the numbers of soil microorganisms. The rates of microbial processes taking part in the soils of dry habitats are thus characterized by a greater stability than those in the soils of habitats with a higher average soil moisture.

The degree of variation of the data obtained on different sampling occasions clearly demonstrates the profound changes in the microbial populations. Single samples are therefore likely to be unreliable as general indicators of overall processes. Attempts to compare microbial populations in soils under different plant communities, based on an analysis of samples collected on a single occasion, appear to be unjustified. Regular sampling extended over several years should provide not only sufficient data for a more relevant classification of plant communities, with respect to microbial data, but should also provide additional information about the range of variation to be expected for the respective habitats and the particular conditions of the water regime.

Souhrn

V průběhu let 1962, 1963 a 1964 v lužní nivě řeky Moravy a Dyje v katastru obce Lanžhot byla studována půdní mikroflóra na osmnácti lokalitách u osmi různých lučních rostlinných společenstev, které se mezi sebou liší především vlhkostními podmínkami stanoviště. Fytocenologické zpracování a synekologický výzkum těchto stanovišť provedla BALÁTOVÁ-TULÁČKOVÁ (1966). Půdní mikroflóra byla studována u těchto společenstev:

1. *Serratuleto-Festucetum commutatae* BAL.-TUL. 1963
2. *Gratiola officinalis-Carex praecox-suzae* subas. s *Galium boreale* BAL.-TUL. 1963
3. *Gratiola officinalis-Carex praecox-suzae* subas. s *Rorippa silvestris* BAL.-TUL. 1963
4. *Lathyrus paluster-Gratiola officinalis* BAL.-TUL. 1963
5. *Caricetum vulpinae* NOWIŃSKI 1927
6. *Caricetum gracilis* (GRAEBN. et HUECK 1931) TX. 1937
7. *Phalaridetum arundinaceae* LIBBERT 1931
8. *Glycerietum maximae* GRAEBN. et HUECK 1931

Bylo zjištěno, že množství i kvalita mikroorganismů se liší pod jednotlivými rostlinnými společenstvy. Nejpronikavější změny v počtech půdní mikroflóry nastávají během záplavy a po záplavě. Po opadnutí záplavové vody nastává u všech společenstev populační výbuch aerobní mikroflóry.

Počet organismů i produkce jednotlivých společenstev se značně liší v jednotlivých letech a je zase silně ovlivněn délkou a četností záplavy. Celková tendence změn půdní mikroflóry během vegetačního období u jednotlivých rostlinných společenstev zůstává v jednotlivých letech obdobná, ačkoliv počet organismů je různý.

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