

DATA TO THE MICROCLIMATE OF SOME CHARACTERISTIC GRASSLAND ASSOCIATIONS OF THE TRANSDANUBIAN MOUNTAINS

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In order to examine the complex role of the vegetation structure determining microclimate, the authors carried out temperature and relative humidity measurements in beany fens, drying fens, semidry grasslands, hayfields, steppe grasslands, rocky grasslands and open sandy grasslands of the Transdanubian mountains. In the course of this process, measurement and data recording took place annually with four repetitions (June, July, August, September) per sampling area in identical weather conditions, resulting in altogether 162 sampling occasions in 84 sampling areas on the ground surface and at a height of 10, 20, 30 and 120 cm in the grassland. In the present paper measurement data concerning the humidity of grasslands researched to a lesser extent in previous works are assessed. The comparative study ascertains that based on the relative humidity curves depicting microclimate, the samples of the examined types of grassland should be handled as separate groups in each sampling period. A further result to be seen is that in the case of several grasslands (semidry grasslands, drying fens) aspect change can also be detected in the change of microclimate (decrease of the relative humidity). The shift in relative humidity curves towards drying can be most conspicuously seen in the case of semidry grasslands.

Key words: grasslands, humidity, microclimate, naturalness, seasonal changes

INTRODUCTION

Apart from the role of basic rock, soil and exposure, the complex role of plant structure – determining microclimate – is also significant in the evolution of changes that can be observed in the microclimate of plant associations. The expression microclimate is normally used to refer to the special climatic circumstances of the air layer near the soil surface thereby differentiating it

from “substance climate”, which is the sum of the climatic factors to be found in the immediate environment of the vegetation and/or one individual plant. Since vegetation cover has a significant influence on microclimate in each examined grassland, this expression are used in our article. Numerous articles have been published concerning multiple aspects of the microclimatic conditions of different vegetation units (Schubert 1917, Braun-Blanquet 1928, 1951, Filzer 1936, Geiger 1936, 1961, Száva-Kováts and Berényi 1948, Précsényi 1956, Kovács 1958, 1962, 1966, Endrődi 1961, Horváth *et al.* 1963, Vinczeffy 1965*a, b*, Horvát and Papp 1965, Jakucs 1954, 1959, 1961, 1967, 1968*a, b*, 1972, Jakucs *et al.* 1967, 1968, Berényi and Nagy 1968, Boros and Bárány 1975, Cox and Moore 1980, Stollár and Zsoldos 1985, van Tooren *et al.* 1985, Matus and Tóthmérész 1994, Báldi 1999, Goetz *et al.* 2000, Gehlhausen *et al.* 2000, Frank 2002, Suleiman and Crago 2003, Nachabe *et al.* 2004, Smith and Johnson 2004). The examination of microclimate features of the vegetation used to and is still more focussed on agricultural areas (Vinczeffy 1965*a, b*, Stollár and Zsoldos 1985, Suleiman and Crago 2003, Nachabe *et al.* 2004) and deciduous plant associations (Jakucs 1954, 1959, 1961, 1967, 1968*a, b*, 1972, Jakucs *et al.* 1968, Kovács 1966, Berényi and Nagy 1968, Borhidi 1984, Gehlhausen *et al.* 2000). Fewer studies concentrate on natural grassland associations (Précsényi 1956, Kovács 1958, Horvát and Papp 1965, Cox and Moore 1980). The majority of botanical studies researched the temperature-related aspects of vegetation types (Endrődi 1961, Boros and Bárány 1975, Stollár and Zsoldos 1985) and fewer works deal with a detailed examination of the changes in relative humidity and other parameters (Filzer 1936, Hargitai 1942, Horánszky 1957, Kovács 1958, Cox and Moore 1980). Below we are going to present a chronological description of the most important works related to the topic, refer to approaches of different scale and methods to grassland microclimate as well as outstanding results of individual studies.

In Braun-Blanquet’s seminal phytosociological studies (Braun-Blanquet 1928, 1951) – apart from the significance of climatic factors determining vegetation – there are references to the changing microclimatic conditions (e.g. monthly relative humidity change, temperature conditions at different levels of the associations) of the vegetation types. Filzer’s publication (Filzer 1936) is of determining significance among the early works concerning the microclimate of herbaceous plant associations. His study gives an overview of the pioneering work of his contemporaries (Geiger, Heilig, Kraus, Schubert, Stocker and others), however, he significantly contributes to the knowledge of the constituents of microclimate with his own measurement results. Filzer also conveys valuable data concerning the important components determining microclimate of natural grasslands and cultivated plots. Sennikov (1953) finds the composition and structure of the plant association important for the tempera-

ture regime of individual plants. Précsényi (1956) researched the daily changes in the air temperature and evaporation of the pasture grasslands at different levels. Concerning the daily fluctuation of temperature, Précsényi stated that it is smaller and smaller as we proceed from open (*Brometum tectorum*) to more closed (*Mesobrometum*) types. Horánszky (1957) performed complex microclimate measurements in various vegetation types of the Szentmihály Hill. Vinczeffy (1965*a, b*) depicts the hydrological structure changes occurring in different grasslands due to fertilisation through the changes in the cover and number of species with a different claim of water (mesophilous, hygro-mesophilous, hygrophilous).

Pál Jakucs's work is also outstanding in the exploration of the microclimate characteristics of different vegetation types. Within this topic, he mainly focussed on xerotherm oak forests, forest margins and was also interested in the effect of exposure (Jakucs 1954, 1959, 1961, 1967, 1968*b*, Jakucs *et al.* 1968). From the microclimatic parameters, he was mainly interested in temperature, light and evaporation. A problem frequently appearing in the presentation of results related to the topic is communicating the huge quantity of data arising in the course of the examination of the microclimate of different habitats. In order to solve this problem, Jakucs (1968*a*) recommends using such a circle diagram which – through the diverse graphic depiction of different intervals of values – clearly shows the temperature data measured in the soil, on the soil surface and at different places in the air as well as the amount of evaporation and wind broken down to hours. Researching the role played by marginal habitats and shrubs in microclimate, Jakucs (1968*b*) pointed out that the effect of adjoining vegetation of vertically different structure shows the largest divergence approximately at 20 cm above the surface. In *Cotinus* shrubs the daily average temperature is 4–5 °C higher than in closed woods and 2 °C higher than in open grasslands. In the course of the statistical examination of the data, besides the values measured at 20 cm above the surface, there was a significant difference between the values measured at 1 m during the comparison of grassland and marginal habitats. Assuming that the evaporation of open grasslands is 100%, the same value is 65% in marginal habitats, 59% in shrubs and only 29.5% in forests (Jakucs 1968*b*). It is a particularly interesting result that Jakucs *et al.* (1968) – in the course of a comparative microclimatological analysis of shrub-forests in Albania and the Carpathian Basin ascertained that evaporation – significantly influenced by microclimate – is in turn significantly affected by macroclimate. Jakucs *et al.* (1967) researched the daily temperature fluctuation of several vegetation types at different geomorphological levels (from the reeds on the lake shore to the plateau of the new Pleistocene terrace) of the southern shore of Lake Balaton. Margit Kovács – who later performed air humidity measurements at different levels (5, 20, 100, 150 cm) in

various fen associations (Bajánsenye, August 1956, Kovács 1958) – undertook an important role already in the exploration of the microclimate conditions of the studied forests in the Síkfőkkút Project led by Jakucs. In the course of this work, Kovács pointed out that the evaporation of the soil as well as the transpiration of plants have an effect on the relative humidity values evolving in grasslands. Later Kovács (1966) researched the daily (vertical) temperature fluctuations in the acidophilous forest associations of the Mátra at different levels (ground surface, 50 and 100 cm, and in the foliage). In closed beech forests (*Melitti-Fagetum*) Kovács found a vertically more homogeneous distribution of temperature, while higher temperatures characterised more open forest associations (*Genisto-Quercetum* and *Quercetum petraeae-cerris*) at lower measurement points (to 50 cm significant, to 100 cm slightly). Based on this, the author finds that exposure and the morphology of the surface are important factors in the evolution of microclimate. Horvát and Papp (1965) examined the effect of exposure in Szársomlyó. The diagrams presenting Horvát's results confirm the phenomenon – also experienced by the authors of the present article – that the daily fluctuation of relative humidity (not under quickly changing but under relatively stable weather conditions, on days without precipitation) is small and hardly changes particularly between 10–16 o'clock. Borhidi (1984) in his monograph which presents the forest associations of Zselic touch upon the microclimate of the different forests associations in spring and summer. The author researched the daily changes in the air temperature at different levels (0, 20 and 100 cm) and the results performed on clearly diagrams.

The majority of microclimate examinations published lately support the climatic differences between habitat edges (often forest's margins) and closed habitat fragments with further data and emphasise their ecological role (for example Matlack 1993, Chen *et al.* 1995, Gehlhausen *et al.* 2000). Studies dealing with such issues regularly confirm measurement data relating to those experiences that in forest edges the exposure to sunrays and the temperature of the air and the surface as well as the diversity of the vegetation is higher while relative humidity is lower than in closed forests. Báldi (1999) revealed similar phenomena in reedbed edges.

The overview above shows that Hungarian microclimate research is usually focussed on the description of forests, shrubs and habitat edges from this aspect. Publications dealing with the microclimate of grasslands also mainly focus on the assessment of temperature data. Even earlier – usually quickly implemented measurement sequences (typical in some days of one period of the vegetation) – pointed out differences between the microclimate of various types of grassland. According to our preliminary results, plant associations are characterised by markedly different temperature and relative humidity as

well as different manifestations of vertical changes at various levels of grasslands and it can also refer to the changes in their naturalness. The objective of our research is confirming this hypothesis with measurement data, drawing the characteristic relative humidity curve of some more frequent types of grassland and exploring the possible differences originating in aspect change. The present article describes the results of microclimate measurements from 84 sites which designated in beany fens (abbreviated as BF), drying fens (DF), semidry grasslands (SD), hayfields (HF), steppe grasslands (SS), rocky grasslands (RG) and open sandy grasslands (SG) in the Transdanubian mountains – pertaining to relative humidity assessed in accordance with the above-mentioned criteria.

MATERIALS AND METHODS

We performed microclimate measurements on 162 occasions in 84 sampling areas (Table 1) [air temperature and humidity (= relative humidity, the rate of the real vapour press and the vapour press of the air saturated with steam on that temperature, in percentage); instrument: Testo 615] on the ground surface and at a height of 10, 20, 30 and 120 cm in the grassland. At each sampling point (in heterogeneous stands we endeavoured at sampling representing microclimate as well as possible) data were recorded in 3–5 semirandomly selected patches on certain characteristic days from June to September (3–4 repetitions per sampling sites; altogether 5,010 measuring of air temperature and humidity). Since the effect of wind speed and evaporation related to it is strongly felt during measurements (Horvát and Papp 1965), the samplings were carried out in clear and calm periods.

The grasslands and associations frequent in the Transdanubian mountains selected for microclimate measurements were the following ones:

1) Beany fens (abbreviated as BF) (Caricion davallianae Klika 1934): *Junco obtusiflori-Schoenetum nigricantis* Allorge 1921, *Caricetum davallianae* Dutoit 1924.

2) Drying fens (DF) (Molinion coeruleae Koch 1926): *Succiso-Molinietum hungaricae* (Komlódi 1958) Soó 1969, *Agrostio-Deschampsietum caespitosae* (Soó 1928) Újvárosi 1947.

3) Hayfields (HF) (Arrhenatherion Koch 1926): *Pastinaco-Arrhenatheretum* (Knapp 1954) Passarge 1964, *Anthyllido-Festucetum rubrae* (Máthé et Kovács 1960) Soó 1971, *Cirsio cani-Festucetum pratensis* Májovský et Ružičková 1975.

4) Semidry grasslands (SD) (*Bromion erecti* Br.-Bl. 1936): *Bromus erectus* or *Brachypodium pinnatum* dominated semidry grasslands, partly with unclari-

Table 1
Sampling sites

No.	Code	Settlement, locality	Height	Plant association	Date
1.	BF1	Pápakovácsi, Attyai-láprét	~189 m	<i>Orchio-Schoenetum nigricantis</i>	20.06.2003, 08.08.2003, 07.09.2003
2.	BF2	Pápakovácsi, Attyai-láprét	~189 m	<i>Orchio-Schoenetum nigricantis</i>	20.06.2003, 08.08.2003, 07.09.2003
3.	BF3	Pápakovácsi, Attyai-láprét	~189 m	<i>Orchio-Schoenetum nigricantis</i>	20.06.2003
4.	BF4	Balatonszőlős, Sötét-rét	~174 m	<i>Orchio-Schoenetum nigricantis</i>	23.06.2003, 16.07.2003, 20.08.2003
5.	BF5	Balatonszőlős, Sötét-rét	~174 m	<i>Orchio-Schoenetum nigricantis</i>	23.06.2003, 16.07.2003, 20.08.2003
6.	BF6	Pápakovácsi, Attyai-láprét	~189 m	<i>Orchio-Schoenetum nigricantis</i>	16.07.2003
7.	BF7	Pápakovácsi, Attyai-láprét	~189 m	<i>Orchio-Schoenetum nigricantis</i>	16.07.2003
8.	BF8	Lesencetomaj, Lesencei-láprét	~120 m	<i>Orchio-Schoenetum nigricantis</i>	19.06.2003, 16.07.2003, 20.08.2003, 07.09.2003
9.	BF9	Lesencetomaj, Lesencei-láprét	~120 m	<i>Orchio-Schoenetum nigricantis</i>	19.06.2003, 16.07.2003, 20.08.2003, 07.09.2003
10.	BF10	Szentbékálka, Sásdi-rét	~135 m	<i>Orchio-Schoenetum nigricantis</i>	07.16.2003, 08.20.2003, 09.07.2003
11.	BF11	Szentbékálka, Sásdi-rét	~135 m	<i>Orchio-Schoenetum nigricantis</i>	16.07.2003, 20.08.2003, 07.09.2003
12.	DF1	Tapolcafő, Tapolcafői-láprét	~187 m	<i>Succiso-Molinietum</i>	16.06.2000, 21.07.2000, 10.08.2000, 26.09.2000
13.	DF2	Pápakovácsi, Attyai-láprét	~189 m	<i>Succiso-Molinietum</i>	16.06.2000, 21.07.2000, 10.08.2000, 26.09.2000
14.	DF3	Nyirád, Sár-álló	~192 m	<i>Succiso-Molinietum</i>	16.06.2000
15.	DF4	Szentbékálka, Sásdi-rét	~135 m	<i>Succiso-Molinietum</i>	04.06.2002
16.	DF5	Szentbékálka, Sásdi-rét	~135 m	<i>Succiso-Molinietum</i>	04.06.2002
17.	DF6	Szentbékálka, Sásdi-rét	~135 m	<i>Succiso-Molinietum</i>	04.06.2002
18.	HF1	Balatonalmádi, Vödör-völgy	~225 m	<i>Cirsio cani-Festucetum pratensis</i>	26.05.2004
19.	HF2	Örvényes, Sás-rét	~105 m	<i>Cirsio cani-Festucetum pratensis</i>	29.05.2004
20.	HF3	Szentbékálka, Sásdi-rét	~137 m	<i>Pastinaco-Arrhenatheretum</i>	04.06.2002
21.	HF4	Szentbékálka, Sásdi-rét	~137 m	<i>Pastinaco-Arrhenatheretum</i>	04.06.2002
22.	HF5	Szentbékálka, Sásdi-rét	~137 m	<i>Pastinaco-Arrhenatheretum</i>	04.06.2002
23.	HF6	Hárskút, close to Klein-tanya	~450 m	<i>Anthyllido-Festucetum rubrae</i>	09.06.2002
24.	HF7	Hárskút, Gyöngyös-hegy	~480 m	<i>Anthyllido-Festucetum rubrae</i>	22.06.2003, 03.08.2003, 19.09.2003
25.	HF8	Hárskút, Gyöngyös-hegy	~480 m	<i>Anthyllido-Festucetum rubrae</i>	22.06.2003, 03.08.2003, 19.09.2003
26.	HF9	Porva, Csárda-tető	~382 m	<i>Anthyllido-Festucetum rubrae</i>	22.06.2003, 03.08.2003, 19.09.2003
27.	HF10	Porva, Csárda-tető	~382 m	<i>Anthyllido-Festucetum rubrae</i>	22.06.2003, 03.08.2003, 19.09.2003

Table 1 (continued)

No.	Code	Settlement, locality	Height	Plant association	Date
28.	HF11	Olaszfalu, Eperkés-hegy	~430 m	<i>Anthyllido-Festucetum rubrae</i> (degraded stand)	22.06.2003
29.	HF12	Olaszfalu, Eperkés-hegy	~430 m	<i>Anthyllido-Festucetum rubrae</i> (degraded stand)	22.06.2003
30.	HF13	Csesznek-Gézaháza, Gézaházi-kaszáló	~455 m	<i>Pastinaco-Arrhenatheretum</i>	22.06.2003
31.	HF14	Csesznek-Gézaháza, Gézaházi-kaszáló	~455 m	<i>Pastinaco-Arrhenatheretum</i>	22.06.2003
32.	HF15	Zirc, Pintér-hegy	~380 m	<i>Pastinaco-Arrhenatheretum</i>	23.06.2003, 03.08.2003, 19.09.2003
33.	HF16	Zirc, Pintér-hegy	~385 m	<i>Pastinaco-Arrhenatheretum</i>	23.06.2003, 03.08.2003, 19.09.2003
34.	HF17	Úrkút, Dozmat-rét	~440 m	<i>Pastinaco-Arrhenatheretum</i>	28.06.2003, 26.07.2003, 20.09.2003
35.	HF18	Úrkút, Dozmat-rét	~440 m	<i>Pastinaco-Arrhenatheretum</i>	28.06.2003, 26.07.2003, 20.09.2003
36.	HF19	Nagyvázsony, 7. Nyiladék	~480 m	<i>Pastinaco-Arrhenatheretum</i>	28.06.2003, 26.07.2003, 20.09.2003
37.	HF20	Nagyvázsony, 7. Nyiladék	~480 m	<i>Pastinaco-Arrhenatheretum</i>	28.06.2003, 26.07.2003, 20.09.2003
38.	HF21	Ajka-Padragkút, Segg-berek	~244 m	<i>Pastinaco-Arrhenatheretum</i>	26.07.2003, 20.09.2003
39.	HF22	Ajka-Padragkút, Segg-berek	~244 m	<i>Pastinaco-Arrhenatheretum</i>	26.07.2003, 20.09.2003
40.	HF23	Káptalanfő, Tóti-rét	~116 m	<i>Cirsio cani-Festucetum pratensis</i>	26.07.2003, 07.09.2003
41.	HF24	Káptalanfő, Tóti-rét	~116 m	<i>Cirsio cani-Festucetum pratensis</i>	26.07.2003, 07.09.2003
42.	HF25	Bakonybél, Som-hegy alja	~410 m	<i>Anthyllido-Festucetum rubrae</i>	27.07.2003, 20.09.2003
43.	HF26	Bakonybél, Som-hegy alja	~405 m	<i>Anthyllido-Festucetum rubrae</i>	27.07.2003, 20.09.2003
44.	HF27	Lókút, Óbányapuszta	~422 m	<i>Pastinaco-Arrhenatheretum</i>	04.08.2003, 19.09.2003
45.	HF28	Lókút, Óbányapuszta	~422 m	<i>Pastinaco-Arrhenatheretum</i>	04.08.2003, 19.09.2003
46.	SD1	Balatonalmádi, Vödör-völgy	~230 m	<i>Bromus erectus</i> grassland	10.06.2000, 20.07.2000, 03.08.2000, 14.09.2000
47.	SD2	Balatonalmádi, Vödör-völgy	~235 m	<i>Brachypodium pinnatum</i> semidry grassland	10.06.2000, 20.07.2000, 03.08.2000, 14.09.2000
48.	SD2.2	Balatonalmádi, Vödör-völgy	~235 m	<i>Brachypodium pinnatum</i> semidry grassland	03.08.2000, 14.09.2000
49.	SD3	Berhida, Koldustelek	~150 m	<i>Brachypodium pinnatum</i> semidry grassland	21.06.2000, 20.07.2000, 03.08.2000, 14.09.2000
50.	SD4	Berhida, Koldustelek	~150 m	<i>Brachypodium pinnatum</i> semidry grassland	21.06.2000, 20.07.2000, 03.08.2000, 14.09.2000

Table 1 (continued)

No.	Code	Settlement, locality	Height	Plant association	Date
51.	SD5	Esztergom, Strázsa-hegy	~220 m	<i>Lino tenuifolio-Brachypodietum</i>	18.06.2000, 29.07.2000, 21.08.2000, 25.09.2000
52.	SD6	Esztergom, Tábla-hegy	~240 m	<i>Lino tenuifolio-Brachypodietum</i>	18.06.2000, 29.07.2000, 21.08.2000, 25.09.2000
53.	SD7	Esztergom, Tábla-hegy	~245 m	<i>Brachypodium pinnatum</i> semidry grassland	18.06.2000, 29.07.2000, 21.08.2000, 25.09.2000
54.	SD8	Esztergom, Tábla-hegy	~245 m	<i>Brachypodium pinnatum</i> semidry grassland	29.07.2000, 21.08.2000, 25.09.2000
55.	SD9	Esztergom, Tábla-hegy	~230 m	<i>Brachypodium pinnatum</i> semidry grassland	29.07.2000, 21.08.2000, 25.09.2000
56.	SD10	Esztergom, Tábla-hegy	~240 m	<i>Brachypodium pinnatum</i> semidry grassland	29.07.2000
57.	SD11	Pápakovácsi, Attyai-láprét	~190 m	<i>Brachypodium pinnatum</i> semidry grassland	21.07.2000, 10.08.2000, 26.09.2000
58.	SS1	Berhida, Koldustelek	~150 m	<i>Salvio-Festucetum rupicolae stipetosum pennatae</i>	26.05.2004
59.	SS2	Berhida, Koldustelek	~150 m	<i>Salvio-Festucetum rupicolae inuletosum</i>	26.05.2004
60.	SS3	Tokod, Nagy-Gete	~425 m	<i>Cleistogeno-Festucetum rupicolae stipetosum pulcherrimae</i>	18.06.2000
61.	SS4	Tokod, Nagy-Gete	~425 m	<i>Cleistogeno-Festucetum rupicolae stipetosum pulcherrimae</i>	18.06.2000
62.	SS5	Tokod, Nagy-Gete	~430 m	<i>Cleistogeno-Festucetum rupicolae stipetosum pulcherrimae</i>	18.06.2000
63.	SS6	Berhida, Koldustelek	~150 m	<i>Salvio-Festucetum rupicolae</i>	21.06.2000
64.	SS6	Köveskál, Harasztos	~142 m	<i>Cleistogeno-Festucetum stipetosum pennatae Stipa pennata</i> steppe grassland	04.06.2002
65.	SS7	Köveskál, Harasztos	~142 m	<i>Cleistogeno-Festucetum stipetosum pennatae Stipa pennata</i> steppe grassland	04.06.2002

Table 1 (continued)

No.	Code	Settlement, locality	Height	Plant association	Date
66.	SS8	Köveskál, Harasztos	~142 m	<i>Cleistogeno-Festucetum stipetosum pennatae Stipa pennata</i> steppe grassland	04.06.2002
67.	SS9	Szentbékállá, Sásdi-rét	~140 m	Degradated steppe grassland with <i>Poa angustifolia</i>	04.06.2002
68.	SS10	Szentbékállá, Sásdi-rét	~140 m	Degradated steppe grassland with <i>Poa angustifolia</i>	04.06.2002
69.	SS11	Szentbékállá, Sásdi-rét	~140 m	Degradated steppe grassland with <i>Poa angustifolia</i>	04.06.2002
70.	RG1	Balatonalmádi, Kő-hegy	~255 m	<i>Seseli leucospermi-Festucetum pallentis</i>	10.06.2000
71.	RG2	Balatonalmádi, Kő-hegy	~260 m	<i>Stipo eriocauli-Festucetum pallentis</i>	10.06.2000
72.	RG3	Balatonalmádi, Megye-hegy	~265 m	<i>Seseli leucospermi-Festucetum pallentis</i>	11.06.2000
73.	RG4	Szentkirályszabadja, Rom-kúti-völgy	~270 m	<i>Seseli leucospermi-Festucetum pallentis</i>	11.06.2000
74.	RG5	Hajmáskér, Séd-völgyi sziklák	~200 m	<i>Seseli leucospermi-Festucetum pallentis</i>	22.06.2000
75.	RG6	Balatonfüred, Nagymező	~240 m	<i>Stipo eriocauli-Festucetum pallentis</i>	27.07.2000
76.	RG7	Balatonfüred, Nagymező	~240 m	<i>Stipo eriocauli-Festucetum pallentis</i>	27.07.2000
77.	RG8	Balatonfüred, Nagymező	~240 m	<i>Stipo eriocauli-Festucetum pallentis</i>	27.07.2000
78.	RG9	Litér, Mogyorós-hegy	~220 m	<i>Stipo eriocauli-Festucetum pallentis</i>	03.08.2000
79.	RG10	Királyszentistván, Hosszú-mező	~180 m	<i>Stipo eriocauli-Festucetum pallentis</i>	03.08.2000
80.	RG11	Vilonya, Külső-hegy	~185 m	<i>Stipo eriocauli-Festucetum pallentis</i>	03.08.2000
81.	SG1	Fenyőfő, Ósfenyves	~265 m	<i>Festucetum vaginatae</i>	29.06.2000
82.	SG2	Fenyőfő, Ósfenyves	~265 m	<i>Festucetum vaginatae</i>	29.06.2000
83.	SG3	Fenyőfő, Ósfenyves	~265 m	<i>Festucetum vaginatae</i>	29.06.2000
84.	SG4	Fenyőfő, Ósfenyves	~265 m	<i>Festucetum vaginatae</i>	29.06.2000

fied coenological status. *Brometum erecti* s. l., *Brachypodietum pinnati* s. l. on loess, *Lino tenuifolio-Brachypodietum pinnati* (Dostál 1933) Soó 1971.

5) Steppe grasslands (SS) (*Festucion rupicolae* Soó 1940 corr. 1964): *Cleistogeni-Festucetum sulcatae* Zólyomi 1958, *Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1964 and degraded types of these.

6) Rocky grasslands (RG) (*Bromo-Festucion pallentis* Zólyomi 1966): *Stipoteriocali-Festucetum pallentis* (Zólyomi 1958) Soó 1964, *Seseli leucospermi-Festucetum pallentis* 1936.

7) Open sandy grasslands (SG) (*Festucion vaginatae* Soó 1929): *Festucetum vaginatae* Rapaics ex Soó 1929.

Based on the fact that we have less information about the relative humidity component of the microclimate of grasslands, the results related to such data will be presented in the present publication. The data row depicting the microclimate of the given site was calculated by averaging the 3 data rows per sampling point at each level. The equivalent containing the “relative values” was prepared for each data row (the value measured at 120 cm was considered as 0 and the value and sign of the other levels was determined relative to this). In order to minimise the effect the differences in the circumstances of data recording might have on the results, the comparative analyses were performed with the help of the data rows containing these relative values. Grouping the sampling results (plant associations or categories) according to vegetation type was in mutual correspondence with ordering the measured values next to each other. The curves describing the microclimate of certain grassland associations resulted from averaging the sampling results belonging to each other. The relation of the curves of different grassland associations calculated this way was determined for each sampling period (June, July, August, September). When drawing the relative humidity curves, we proceeded similarly to the former literature (Kovács 1958, Cox and Moore 1980) (x axis: the relative values of humidity (%), y axis: vertical levels of the grassland). Nomenclature of the plant associations was used after Borhidi (1996, 2003).

RESULTS

Based on the trend identities to be observed in the shape of the relative humidity curves the treatment of samples from beany fens, drying fens, semidry grasslands, hayfields, steppe grasslands, rocky grasslands and open sandy grasslands as samples belonging to different groups was justified in every sampling period (June, July, August, September). The relative humidity curves drawn following the averaging of the data rows of samples belonging together in this way, display the significant differences to be observed in the

microclimate of the examined grasslands even more markedly (Fig. 1). This is especially valid for the comparison of the results of June (Fig. 1A). It can be clearly seen in the graphs that this is the period, which is mostly responsible for the differences in the microclimate of the grasslands. Owing to the annual dynamics of physiological and metabolism processes (in the majority of grassland types) and the structural changes of the vegetation in other parts of the vegetation period decreasing differences can be seen between the individual grassland types (Fig. 1B, C).

The diagram prepared on the basis of the measurements conducted in beany fens clearly shows that from June to September (Fig. 2A) the relative humidity values in the grass are significantly higher than the ones measured at 120 cm. In these grasslands – in the case of good water supply – the ground water can be found on the surface or close to it. This fundamentally determines the higher relative humidity content of the grass and – owing to its basically tussock structure – the grass contributes to it in an indirect way. Due to its morpho-anatomical character, the dominant species (*Schoenus nigricans* L.) presumably contributes to the relative humidity content of the grass to a smaller extent directly. This is confirmed by the data rows coming from the stands of the association with periodical bad water supply (dry ground surface) – which markedly differ from the values measured in stands with suitable water supply (Fig. 3).

It can be clearly seen that the results of grasslands dominated by wide-leaved grass (drying fens, hayfields and semidry grasslands) that the most significant factor determining the relative humidity content of grass is transpiration. In spite of the difference in habitats, the lower few decimetres of

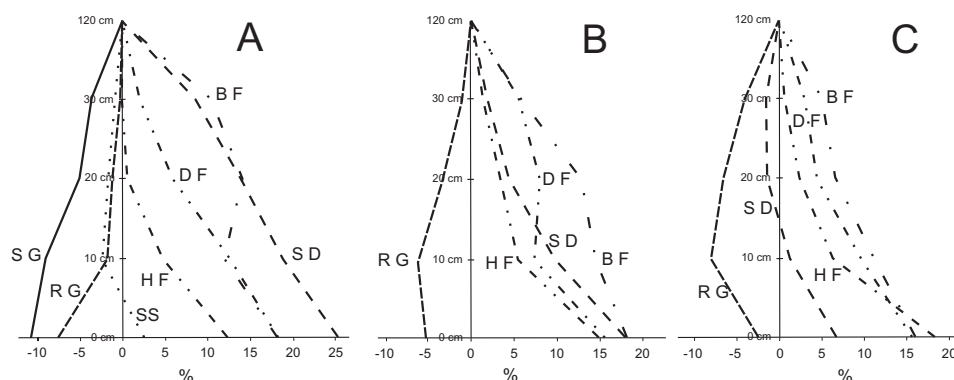


Fig. 1. Decreasing differences can be seen between the grassland types [beany fens (BF), drying fens (DF), semidry grasslands (SD), hayfields (HF), steppe grasslands (SS), rocky grasslands (RG) and open sandy grasslands (SG)] in the researched period (A: June, B: July, C: August)

the grass – relatively well protected from air motion – is more humid in these characteristically closed grasslands (Fig. 2B–D). Hardly any differences can be seen in the four measurement periods in drying fens although those deriving from the early summer and autumn aspects are minimally higher than the val-

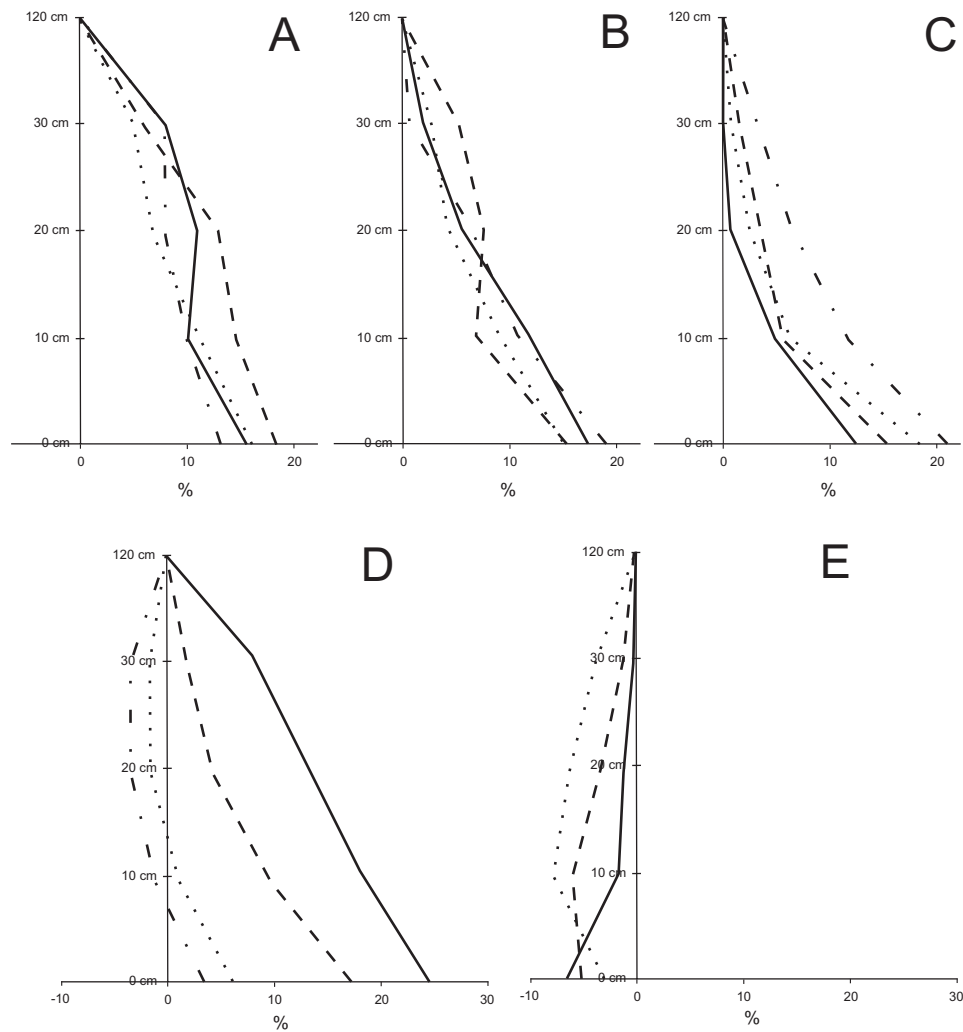


Fig. 2. Annual dynamics of relative humidity is a typical character of the grasslands [beany fens (A), drying fens (B), hayfields (C), semidry grasslands (D), rocky grasslands (E)] (Key to signs: continuous line: June, broken line: July, dotted line: August, dotted broken line: September)

ues measured in the driest summer months. Contrary to this, gradual drying out can be observed in the case of semidry grasslands (Fig. 2D). Presumably this phenomenon might result from the reduction in transpiration (phenological character) of the dominant grasses (*Brachypodium pinnatum* s.l., *Bromus erectus* s.l.) and, on the other hand, the effect of the microclimate of the habitats (forest-steppe associations) adjoining the grasslands. In the case of hayfields, the measured relative humidity values show a very large dispersion every month, which is probably due to the differences in condition of naturalness and treatment.

Open rocky and sandy grasslands – the values of relative humidity content of which are significantly lower in the grass than at 120 cm in each period – are in an extreme situation (Fig. 1). The reason for this might be the fact that – owing to the strong warming up – the upper layer of open soil and stone surfaces fully dries out in the summer months. In several rocky grasslands and sandy grasslands extremely high ground surface temperatures were measured (for example Hajmáskér, Séd-völgyi sziklák, *Seseli leucospermi-Festucetum pallentis*, 22.06.2000: 55.7 °C; Fenyőfő, Ósfenyves, *Festucetum vaginatae*, 29.06.2000: 51.6 °C). Due to the plant structure and its adaptation to the dry habitat (various morpho-anatomical and physiological characteristics of xerophilous grasses and shrubs), these did not or did only minimally contribute to the development of higher relative humidity values. In the case of steppe grasslands – also characteristic of dry habitats – the more closed structure and the species richness directly (transpiration) or indirectly (through the shelter from the wind of the lower air layers of the grass and the reduction of

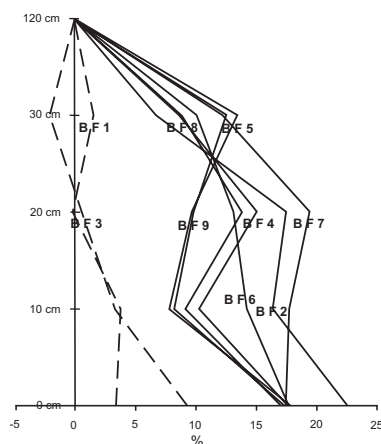


Fig. 3. Relative humidity on beany fens in June. The stands of the beany fens with periodical bad water supply (dry ground surface in June: BF1, BF3) markedly differ from the other values with suitable water supply

evaporation) result in higher relative humidity values on the soil surface and its proximity (Fig. 1).

Based on the measurement results, the most significant changes in the relative humidity content component of the microclimate of grasslands thus occur in the second half of the summer period (it is particularly strongly visible in semidry grasslands). In the case of open rocky grasslands and beany fens the effect of aspect change is minimal from the point of relative humidity change. In the case of grasslands under systematic cutting (drying fens, hayfields) the microclimate of the growing grass – following the early summer intervention – grows more and more humid with the growth of the plant product.

DISCUSSION

Several earlier studies have proven that the microclimate of different types of grasslands differs and the parameters concerning microclimate vertically change in grasslands. With the help of our measurements in some characteristic plant associations of the Transdanubian Mountains we have proven that the samples from beany fens, drying fens, semidry grasslands, hayfields, steppe grasslands, rocky grasslands and open sandy grasslands create a group more or less belonging together. The change in the relative humidity component (tendency and measure) of the microclimate of the researched grasslands was also characteristic of the individual types in the researched period. In the case of several types of grassland (semidry grasslands, drying fens), aspect change can also be shown in the microclimate change. The shift towards drying of the relative humidity curves can be most conspicuously seen in semidry grasslands. The reason for this is the significant transpiration and evaporation-blocking effect of the closed grassland in early summer. Results of Schoonhoven *et al.* (1998) supported by measurements related to the role of plant structure in determining the relative humidity content of grasslands can be named as the reason for the higher relative humidity values measured in the lower air layer of closed grasslands. According to these, relative humidity is much higher in the proximity of the plant leaf surface than in the air surrounding it. It seems that in the case of properly closed grass structure, this phenomenon depends on the water supply of the habitat and its environment to a lesser extent since it is also markedly manifested in semidry grasslands located in a forest-steppe environment. In closed grasslands dominated by wide-leaved grasses, relative humidity content is usually naturally higher in the lower air layers protected from wind. Research of Cox and Moore (1980) has shown that the microclimate of grasslands is relatively homogeneous up to a height of approx. 20 cm: in this region there is practically no wind, the temper-

ature of the grass is significantly below that of the air temperature and the relative humidity content is approximately by 50% higher than elsewhere. According to our results, this statement does not refer to open grasslands since significantly lower values characterise these immediately above the ground than at 120 cm. The reason for this is presumably increased evaporation.

The humidity content of the air layers of certain grasslands also depends on their degree of naturalness. This is supported by the differences in the humidity curves of patches of beany fens (with *Schoenus nigricans*) with suitable and bad water supply, calling one's attention to the determining role of evaporation in the microclimate of these associations. The state of naturalness as a determining factor (date and frequency of cutting, possible of sowing or nutrient supplies) in shaping microclimate can also be demonstrated in hayfields representing very heterogeneous samples.

The different microclimate of grasslands is presumably also of fundamental significance in the community organising processes in terms of the co-existence of species with similar ecological needs. The role of grassland associations, which provide conditions considerably different from their environment, is particularly significant and, consequently, they play an important role in the evolution of a more varied ecological environment. This is confirmed by the fact that the richness of species of semidry grasslands and forest edges in forest-steppes frequently exceeds that of the neighbouring steppe meadows, rocky grasslands and oak forests. The temperature and humidity content components of the microclimate presumably (Jakucs 1959, 1968b) also contribute to the ecotone role (Jakucs 1959, 1968b, Zólyomi 1987, Varga 1989, Fekete *et al.* 2000) of semidry grasslands, forest edges and some forest associations related to certain rocky habitats (known and emphasised for a long time), and explains their peculiar species-composition (species both from rocky-, steppe-, mesophilous grasslands and oak forests). The changes in different microclimate parameters evidently affect not only the vegetation composition but also the animal communities and their annual dynamics. Based on the results of the orthopterological samplings carried out simultaneously with the microclimate measurements, aspect change can be observed both in grasslands characterised by seasonally changing (Kenyeres *et al.* 2004) microclimate and the structure of Orthopteran assemblages (density, species composition). Rácz (1998) demonstrated the phenomenon related to the close dependence on microclimatic conditions of grasshoppers (Franz 1933, Isely 1937, Nagy 1944, Röber 1949, Marchand 1953, Jakovlev 1957, 1959, Joern 1982, Varga 1997, Ingrisch and Köhler 1998) in the effect microclimatic differences of grasslands with different succession stages have on the structure of Orthopteran assemblages. Nagy (1944) differentiates between autumn and summer grasshopper communities (aspect) of saline plant associations. The author points out that

one of the reasons for their organisation is the change in the microclimate of grass. They found that apart from temperature (Samways 1990, Coxwell and Bock 1995) – influencing ontogenetic processes to the largest extent (Wingerden *et al.* 1992) – humidity content (Forsman 2001, Harz 1957) is also a microclimatic condition of determining effect in the community organisation of Orthoptera species. In the case of other taxa, microclimatic conditions primarily determine the community organising of terrestrial species (Buxton 1932, Cloudsley-Thompson 1962, Marsh 1985, Joosse and Verhoef 1987, Hadley *et al.* 1990, etc.), particularly through the liquid demand at the larva and imago stages. In the case of more mobile taxa, however, the effect of microclimate is only visible on a larger scale than discussed here (for example Shapiro and Shapiro 1973, Rees 1983).

Based on the observed phenomena, it can be concluded that microclimate is a significant factor in the organisation and dynamics of biocoenosis, the research of which contributes to the understanding of numerous plant and animal ecological as well as conservation biological phenomena. The research of natural grassland associations from this aspect can also provide considerable assistance in the professional planning of nature conservation treatment methods.

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