STRUCTURE OF VEGETATION AND MICROWEATHER

A PRELIMINARY INVESTIGATION

P. J. DEN BOER and G. SANDERS

(Mededeling nr. 150 van het Biologisch Station, Wijster)

1. INTRODUCTION

During a field investigation on the spatial and temporal variation of the reproductive cycle of the carabid beetle *Calathus melanocephalus* L., considerable differences proved to exist between two subpopulations occurring on two adjacent sites of the heath of Kralo (DEN BOER et al., in preparation). Especially the ratio of the hibernated and the newly emerged individuals (cf. VLIJM and VAN DIJK, 1967) differed considerably between the two sites while these ratio's also varied between years (for the 1964 data, see DEN BOER, 1968a: Fig. 6). One of these sites is a mosaic vegetation of patches of mainly *Erica, Calluna, Empetrum, Festuca, Nardus, Luzula, Juncus, Molinia* mixed with *Cladonia*-covered places: Fig. 1 ('mosaic'), and the other a fairly homogeneous vegetation of mainly *Festuca* and *Nardus*: Fig. 2 and Fig. 11 ('grass'). Hence, it seemed plausible to suppose that 'mosaic' would show more spatial variation in microweather than 'grass'. Moreover, the heterogeneous structure of 'mosaic' is strongly accentuated by an irregular ground level with many small slopes of different gradient and exposition, whereas the fairly homogeneous 'grass' is almost completely flat (formerly 'grass' may have been used as farmland).

To evaluate the influence of these differences in vegetation structure on the subpopulations of *Calathus melanocephalus* ('spreading of risk in space', cf. DEN BOER, 1968b), it is necessary to have at least some idea of the spatial variation in microweather in 'mosaic' as compared with 'grass'. Because in 1964 adequate data recording and data processing equipment was not available, we could only measure one component of microweather very crudely at a number of positions throughout 'mosaic' and 'grass'.

Since we could not expect exactly this factor to have the most important influence on the reproductive cycle of *Calathus melanocephalus*, it was not justified to put much time and money into these introductory measurements. On the other hand, to find out anyhow something sensible on variation between and within the two sites it was inevitable to measure as frequently as possible at a number of positions. From these considerations resulted the laying out of a number of calibrated minimum thermometers which were read by the way when visiting the two sites (once a week). In spite of the crudeness of these measurements the results were so instructive and unexpected that it seems justified to publish them.

Reprint from:
Miscellaneous Papers 6, Landbouwhogeschool, Wageningen, The Netherlands. 1970.
Mededelingen van de Botanische Tuinen en het Belmonte Arboretum der Landbouwhogeschool te Wageningen Vol. XIII (1969). 1970.

Fig. 1. Example of the vegetation structure in 'mosaic' (6 × 6 m) in 1965, seen perpendicularly from above. Starting from the pitfall in the centre the c-positions (Figs. 3-10) of the different series were chosen.

2. Methods

The thermometers were of the type normally in use by meteorologists: glass thermometers of about 30 cm long filled with alcohol (calibrated by the Royal Meteorological Institute at De Bilt, The Netherlands). The great thermal capacity, and therefore the great time constant, warrants that the minimum temperatures recorded, had prevailed at the measuring position long enough to be of some importance to animals present there during that time.

The thermometers were laid under the vegetation cover with the bulb at only a few millimetres above the ground (where carabid beetles move) and

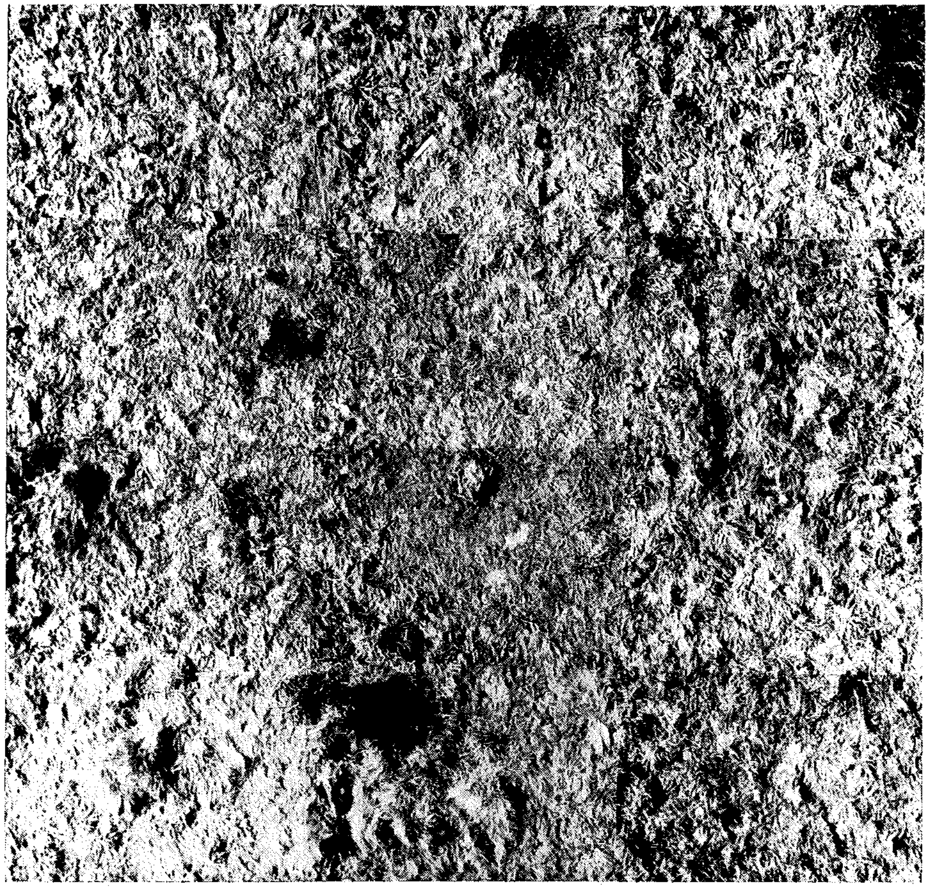


Fig. 2. Example of the vegetation structure in 'grass' (6 × 6 m) in 1965, seen perpendicularly from above. Starting from the pitfall in the centre the m-positions (Figs. 3-10) of the different series were chosen (the thermometer visible above the centre is laid upon the vegetation cover to indicate the underlaying m-position occupied in 1965–'66: Table 5).

in most series (see below) they were replaced after reading. During four years (1964–'67) minimum temperatures were recorded weekly: in 1964 at only three positions in 'mosaic' and at three in 'grass', in 1965 and 1966 at 9 positions throughout each of both sites. From Nov. 1966 to Nov. 1967 all 18 thermometers were moved at random after reading to one of four series of positions (A-D or E-H); thus at each site 36 positions were chosen of which nine were occupied at the same time. Starting from one of our pitfalls each position was established at random in one of eight directions and at a distance of 1–20 meters with a table of random rankings of 20 (Kendall, 1962).

By various causes not all thermometers gave reliable values each week and in some periods (Sept. '65, March/April '66, Sept. and Oct. '66) recording was even impossible. Between June and Sept. 1967 the thermometers were calibrated again.

Since the density distribution of the random variables measured was unknown, we tested our data with ranking (non parametric) tests.

a. For each week separately the sample of data recorded at 'mosaic' and that recorded at 'grass' could be compared with Wilcoxon's two-sample test (VAN DER VAART, 1950; WABEKE & VAN EEDEN, 1955; SIEGEL, 1956; DE JONGE, 1963). WILCOXON's test statistics (U, s, W or S) for separate weeks can be summarized according to:

$$z = \frac{\Sigma U_i - \frac{1}{2}\Sigma m_i n_i}{\sqrt{\sum \frac{m_i n_i (m_i + n_i + 1)}{12}}}$$

m_i and n_i: number of measurements (positions) in 'grass' and 'mosaic' respectively in the i^{th} sample. U_i: test statistic of Wilcoxon's two-sample test.

(Under the null hypothesis is z approximately normally distributed with mean 0 and stand. dev. 1). Note:

$U = s$ (VAN DER VAART, SIEGEL) $= \frac{1}{2}W$ (WABEKE & VAN EEDEN) $= nm + \frac{n(n+1)}{2} - S$ (DE JONGE). In this way the hypothesis is tested that a week-sample or the k samples (weeks) from 'mosaic' was (were) drawn from the same 'population' (of recordings) as the corresponding one(s) from 'grass' (cf. 3.1).

b. By the two-way analysis of variance by ranks – FRIEDMAN's test – (SIEGEL, 1956; KENDALL, 1962; DE JONGE, 1963) the hypothesis is tested that the k matched samples from one site (recordings during a number (k) of weeks at the same positions) were drawn from the same 'population', i.e. that the variation of recordings between positions is not significant. KENDALL's coefficient of concordance (W) measures the degree of 'individuality' of the positions in time: the greater W the more overall 'individuality', i.e. the greater the variation between positions (cf. 3.2). Because it is very tedious and time consuming to calculate the adequate test statistic from a matrix with gaps, only weeks with recordings at all positions were incorporated.

c. Referring to b. one should like to know which positions showed the greatest 'individuality' during a number of weeks (k). One can get some idea by testing all possible pairs of positions within the same site with WILCOXON's matched-pairs signed-ranks test (SIEGEL, 1956; BENARD & VAN EEDEN, 1956) and comparing the p-values. In such a comparison the test is used $\frac{n(n-1)}{2}$ times. Allthough the test is only used to detect possible differences, it seemed advisable to correct the level of significance ($\alpha = 0.05$) accordingly. The new level of significance becomes $2\alpha/n(n-1)$: TATE & CLELLAND (1959). In most series we had nine positions per site, so the corrected level of significance is then 0.00139. In this manner the chance to reject our null hypothesis (the recordings at two positions do not differ) incorrectly is small and thus our conclusions are more careful (cf. 3.3).

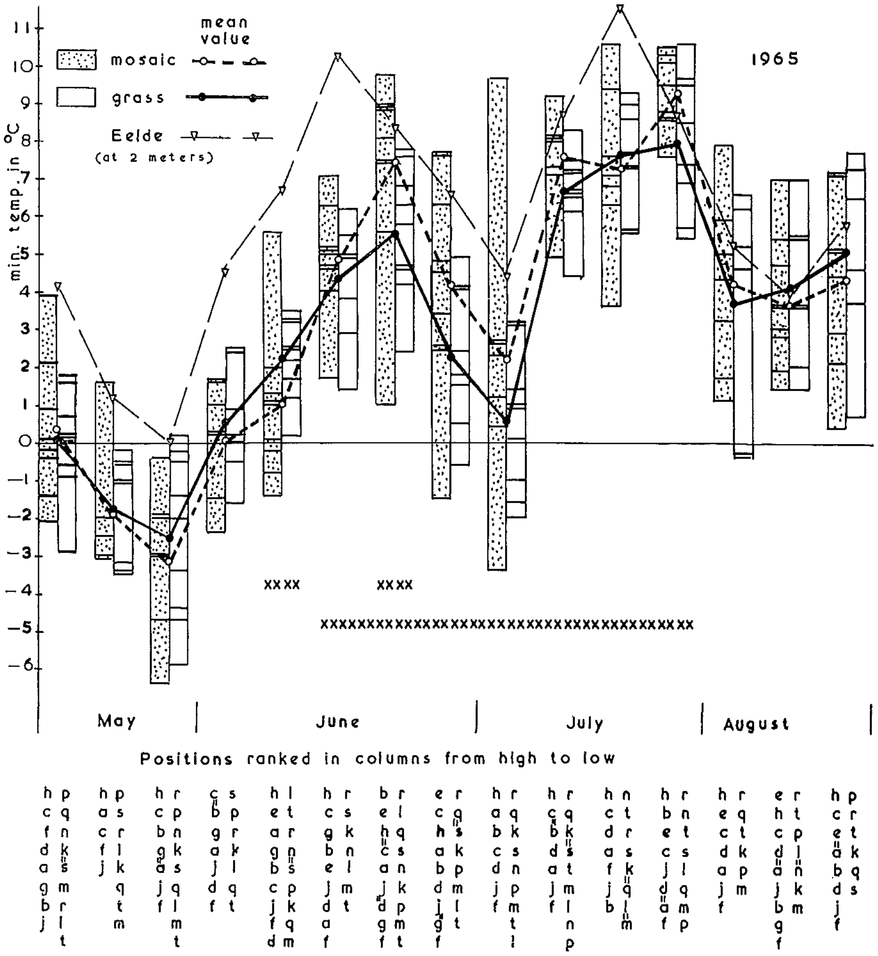


Fig. 3. Recordings of min. temp. during 15 weeks (12/5-18/8, 1965). For each week, and for 'mosaic' and 'grass' separately, all values recorded at the different positions are given, together with the weekly mean (for a comparison the lowest min. (air) temperatures recorded in the same weeks at the weather station Eelde (40 km to the North) are also given). Weeks in which the samples from 'mosaic' and 'grass' differed significantly (at 0.05-level) are indicated by xxxx (Wilcoxon's two-sample test). A row of x-es indicates a period in which the summarized test statistics (Wilcoxon) of 'mosaic' and 'grass' differed significantly. Below the figure the recording positions are ranked in columns in the same order as in the figure, by which the reader is enabled to follow the recordings at each position throughout all weeks.

3. Results

With the exception of 1964 (only three positions per site), the weekly recordings at all positions during all years are given in Fig.'s 3, 4, 5, 6 and 7. From these figures many kinds of special information may be drawn: variation within and between particular weeks, the seasonal trend in min. temperature together with the recordings at Eelde, recordings at a particular position, etc. This information, however, is left to the interested reader. We will confine ourselves here to some general conclusions only.

3.1. Table 1 shows that during some periods min. temp. in 'mosaic' was significantly higher than in 'grass' but during other periods it was just the reverse.

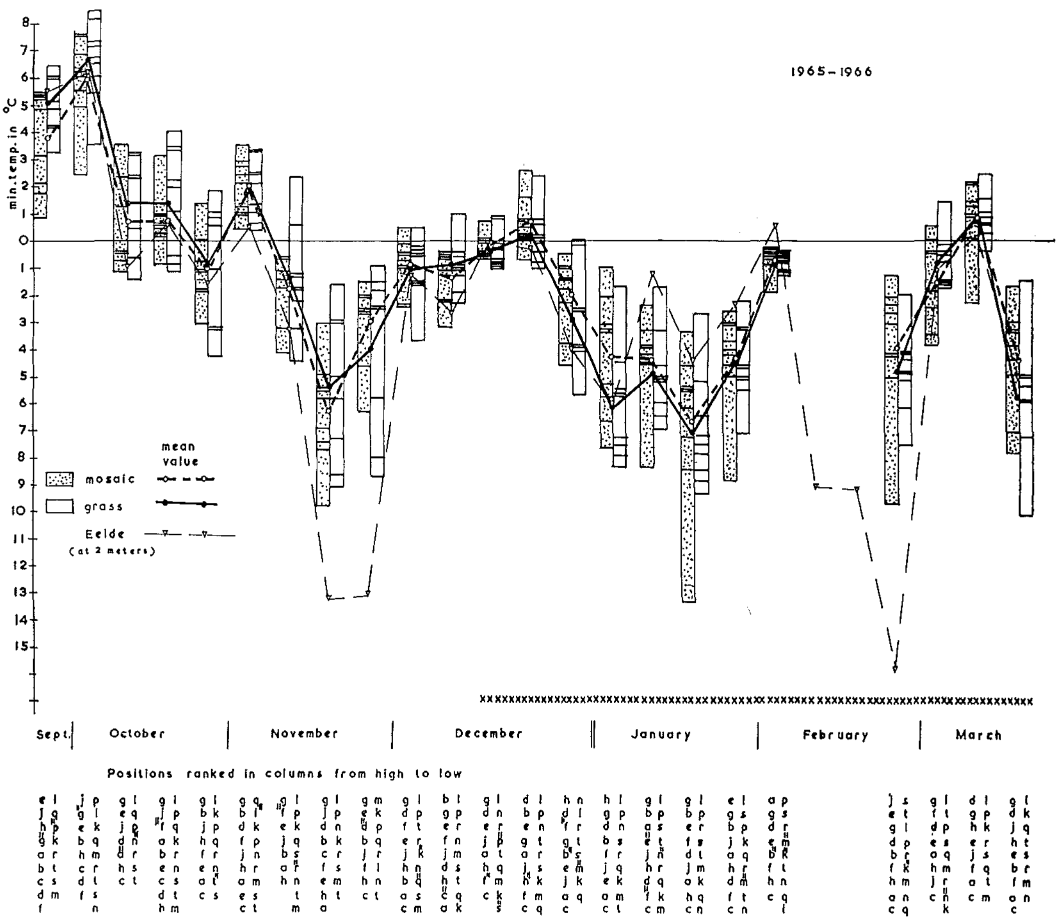


Fig. 4. Recordings of min. temp. during 25 weeks (29/9-'65-16/3-'66). For further explanation see Fig. 3.

TABLE 1. Differences between 'mosaic' and 'grass' (Wilcoxon's test statistics summarized for a number of separate weeks; cf.: 2a).

	1964	1965	1965/'66	1966	1966/'67	1967
whole period 'mosaic' higher or lower	4/3-29/7 $z = 2.89$ $p = 0.0039$ *sign. lower*	12/5-18/8 $z = 1.095$ $p = 0.2714$ (higher)	29/9-16/3 $z = 1.18$ $p = 0.2380$ (higher)	20/4-7/9 $z = 4.32$ $p = 0.0^4156$ *sign. lower*	9/11-6/7 $z = 0.132$ $p = 0.896$?	13/9-1/11 $z = 0.990$ $p = 0.322$ (lower)
June + July 'mosaic' higher or lower	$z = 2.24$ $p = 0.025$ *sign. lower*	$z = 3.06$ $p = 0.0022$ *sign. higher*		$z = 5.14$ $p < 0.0^66$ *sign. lower*		
March-May 'mosaic' higher or lower	$z = 1.88$ $p = 0.0602$ lower				$z = 1.68$ $p = 0.093$ higher	
Nov./Dec.-March 'mosaic' higher or lower			$z = 3.03$ $p = 0.00244$ *sign. higher*		$z = 1.339$ $p = 0.180$ (lower)	
		Fig. 3	Fig. 4	Fig. 5	Fig. 6	Fig. 7

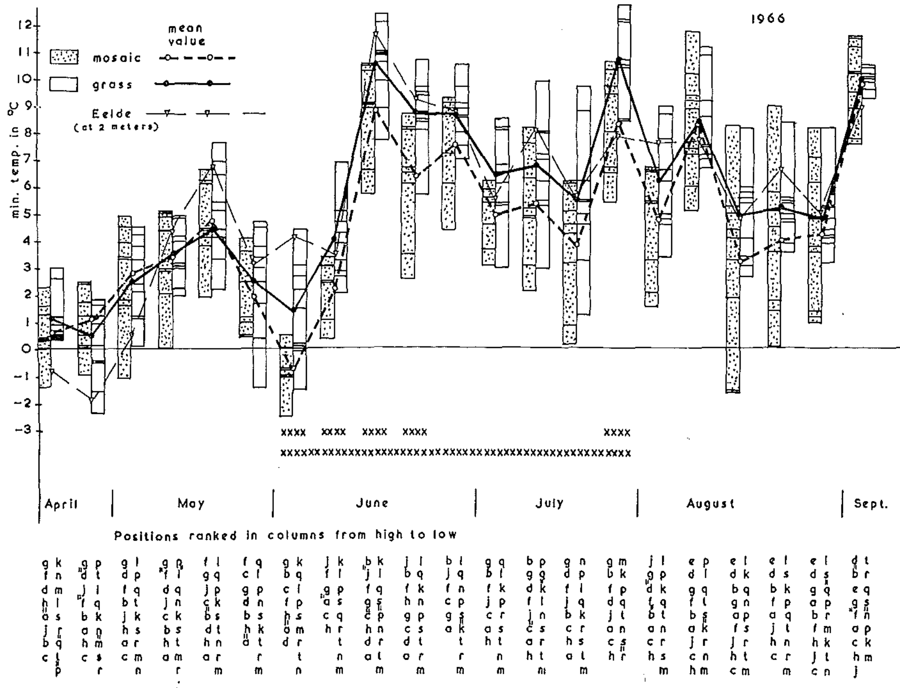


Fig. 5. Recordings of min. temp. during 21 weeks (20/4-7/9-'66). For further explanation see Fig. 3.

Especially the months June and July were interesting in this respect. Although the structural differences between the two sites may have had a clear effect on min. temp. during these months, the sign of the difference between the two sites was unpredictable: in 1964 min. temp's in 'mosaic' were significantly lower than in 'grass', in 1965 higher and in 1966 lower again. In other periods of the year comparable unpredictable differences between the two sites were indicated (Table 1). With the exception of June–July 1966 (Fig. 5) the two sites differed significantly only in a few separate weeks, e.g. twice in 1965: in the first case 'grass' significantly higher but in the second 'grass' significantly lower than 'mosaic' (Fig. 3).

Although a greater number of recording positions per site would have been advisable (cf. 3.2) and might have resulted in a greater number of 'significant weeks' and 'significant periods' (Table 1), it would not have altered our conclusion: there is a very high variation in space (within and between sites) as well as in time (within and between years).

3.2. It can be concluded from 3.1 that min. temp. in 'mosaic' might generally have been different from that in 'grass', but that this difference was not consistent, i.e. the sign of the difference could not be predicted. We are now interested in the question of whether min. temp.'s showed more spatial

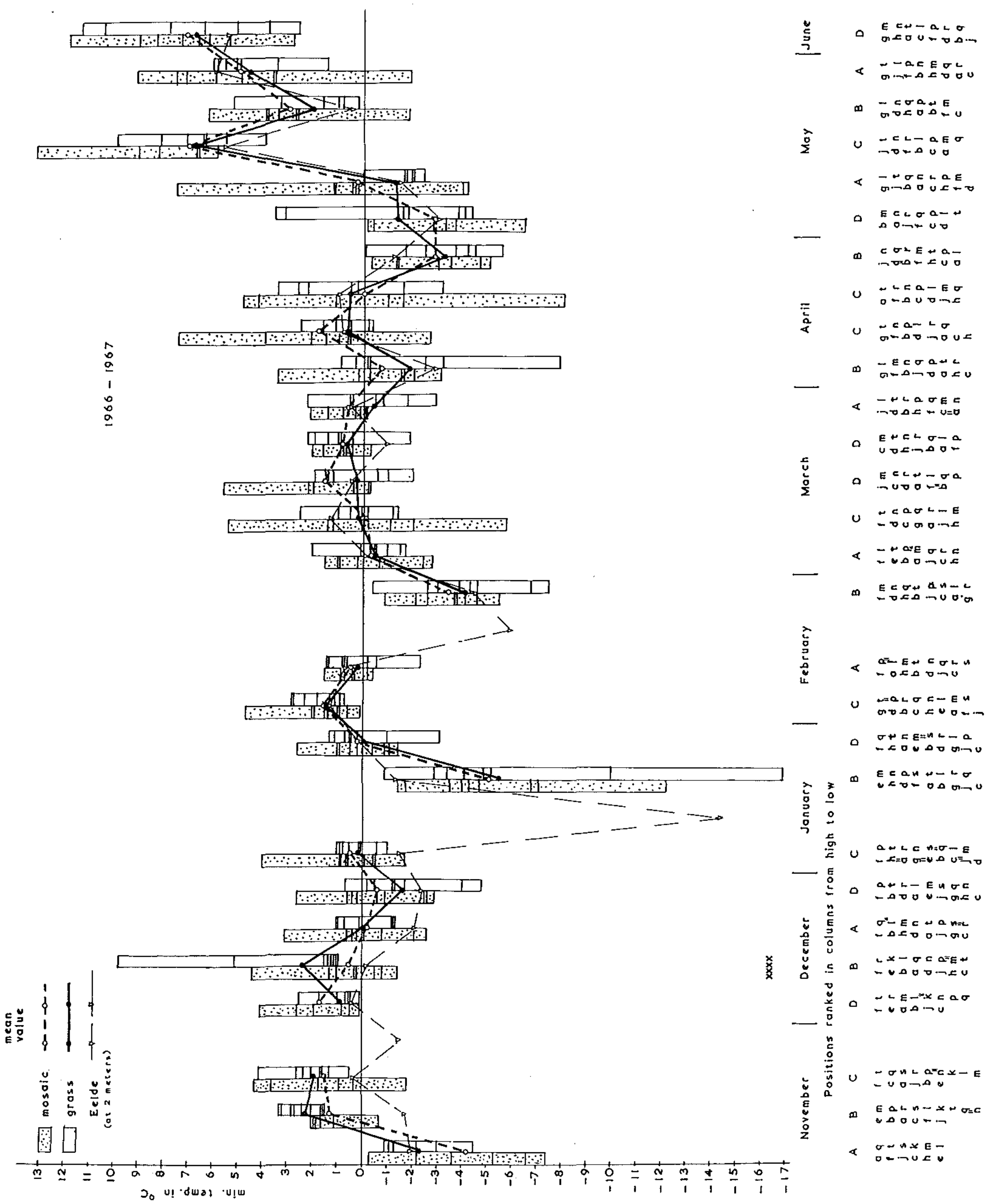
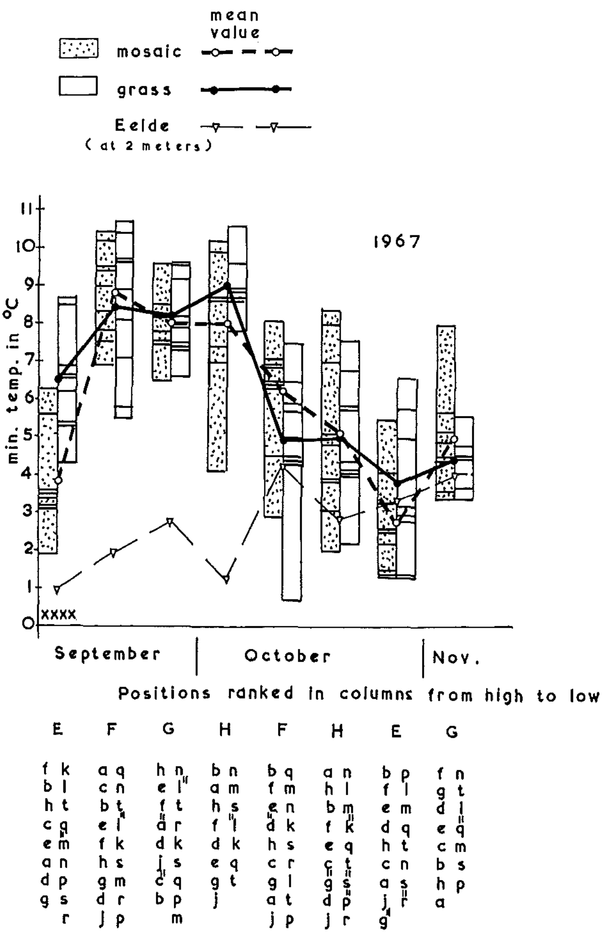


Fig. 6. Recordings of min. temp. during 31 weeks (9/11-'66-7/6.'67). For further explanation see Fig. 3. Seven times each thermometer was moved (at random) during four seccessive weeks to one of four positions (A-D) indicated by the same lower case letter; hence, each position was occupied seven times.

Fig. 7. Recordings of min. temp. during 8 weeks (13/9-1/11-'67). For further explanation see Fig. 3. Two times each thermometer was moved (at random) during four successive weeks to one of four positions (E-H) indicated by the same lower case letter; hence, each position was occupied two times.



variation within the very heterogeneously structured 'mosaic' than within the fairly homogeneously structured 'grass' (cf. Fig's 1 and 2). Fig.'s 3–7 show that – with the exception of June–July 1965 – this was apparently not the case; in some separate weeks the spatial variation of min. temp.'s was even much greater in 'grass' than in 'mosaic'.

It may also be supposed that in 'mosaic' the recording positions showed more 'individuality' than in 'grass', i.e. because of the distinct patchiness of the vegetation structure in 'mosaic' the different recording positions of 'mosaic' might have shown more individual features of microweather than those of 'grass'. The degree of overall 'individuality' of different positions (variation between positions) can be measured by the coefficient of concordance W (cf. 2b) : W = 0 means that the ranking order of the recordings from different positions varies completely at random between weeks, W = 1 means that this order does not change from week to week (each position is complete-

Table 2. Degree of overall 'individuality' in time of the recording positions within 'mosaic' and within 'grass' (two-way analysis of variance by ranks: Friedman; cf. 2b).

		'mosaic'				'grass'				both sites together			
		W*	χ^{2}*	k*	n*	W	χ^2	k	n	W	χ^2	k	n
1965													
whole period		0.669	*44.15*	11	7	0.415	*23.24*	8	8	0.516	*43.34*	6	15
June + July		0.699	*33.52*	8	7	0.489	*17.12*	5	8	0.645	*38.70*	5	15
1965/'66													
whole period		0.443	*49.62*	14	9	0.418	*50.16*	15	9	0.560	*95.20*	10	18
Dec.-March		0.522	*33.41*	8	9	0.494	*31.62*	8	9	0.722	*73.64*	6	18
1966													
whole period		0.528	*55.44*	15	8	0.599	*91.05*	19	9	0.547	*113.78*	13	17
June + July		0.712	*25.63*	6	7	0.748	*35.90*	6	9	0.784	*70.56*	6	17
1966'/67	A	0.350	10.50	6	6	0.509	*18.32*	6	7	0.325	*23.40*	6	13
	B	0.498	*14.94*	6	6	0.188	6.77	6	7	0.375	*24.38*	5	14
	C	0.193	4.83	5	6	0.695	*25.02*	6	7	0.363	18.88	4	14
	D	0.025	0.75	6	6	0.310	*13.02*	7	7	0.206	14.83	6	13

*W: coefficient of concordance; χ^2 with k-1 degrees of freedom;
k: number of weeks; n: number of positions.

TABLE 3. Degree of overall 'individuality' in time of the recording positions within 'mosaic' and within 'grass' in 4 groups of six weeks between 3-11-1965 and 10-8-1966, comparable with the 4 groups of weeks (A, B, C, D) sampled between 9-11-1966 and 6-7-1967 (Table 2).

	'mosaic'				'grass'			
	W*	χ^{2*}	k*	n*	W	χ^2	k	n
A^1	0.521	*21.88*	6	8	0.460	*22.08*	6	9
B^1	0.482	*20.24*	6	8	0.379	*18.19*	6	9
C^1	0.659	*27.68*	6	8	0.502	*24.10*	6	9
D^1	0.495	*20.79*	6	8	0.606	*29.06*	6	9

*W: coefficient of concordance;
χ^2 with k-1 degrees of freedom;
k: number of weeks;
n: number of positions.

ly individual). Table 2 shows that in 1965, 1965/'66 and 1966 the positions showed a highly significant individuality at both sites. In 1965 the individuality of recording positions (W) was greater in 'mosaic' than in 'grass', but in 1965/'66 and 1966 there was no obvious difference. When testing the recordings at the positions in both sites together it appears that in 1965 there was no difference in level between the two sites (W-values lying between those for 'mosaic' and 'grass' separately), contrary to the data from Dec.-

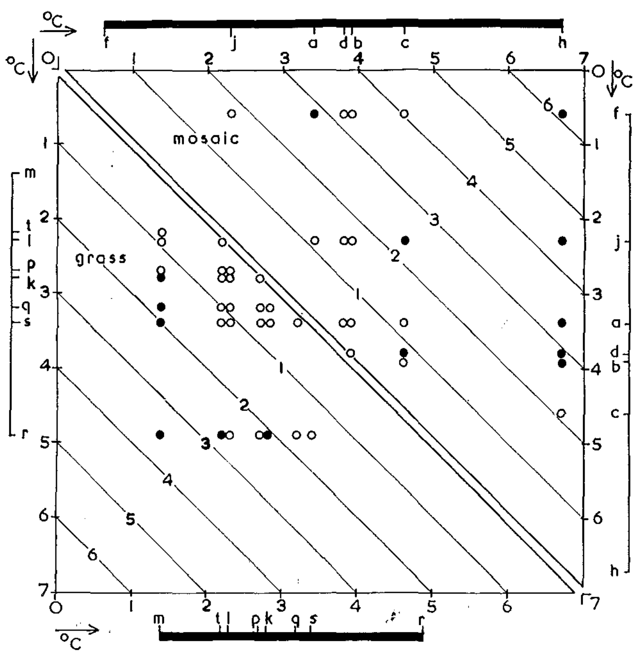


Fig. 8. Min. temp.'s at each position averaged over the period 12/5-18/8-'65. The mean min. temp. of each position in 'mosaic' is plotted against others at the upper right and those in 'grass' at the lower left. A scale of the magnitude of the differences between pairs of means (in °C) is at the diagonal from the middle to the upper right respectively to the lower left. Significant differences (WILCOXON's matched-pairs signed-ranks test: 2c) are indicated by black dots.

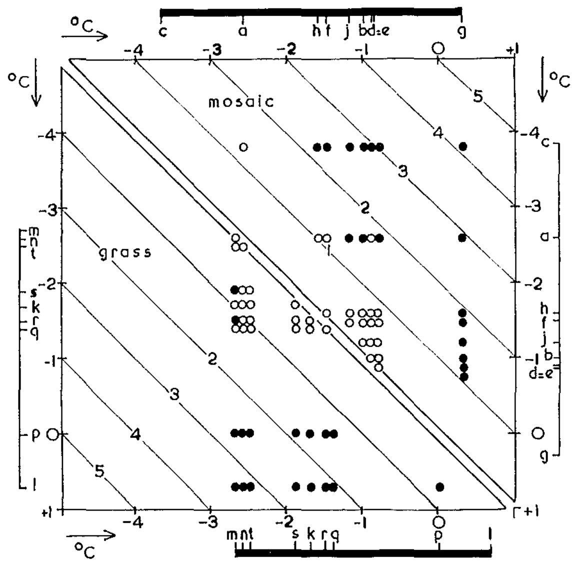


Fig. 9. Min. temp.'s at each position averaged over the period 29/9-'65-16/3-'66. For further explanation see Fig. 8.

March 1965/'66 and probably the whole period 1965/'66 and June + July 1966. Hence, also the picture of spatial variation of min. temp.'s within both sites shifted from year to year and did so in an unpredictable way. It must be noted in this connection, that in the course of 1967 and especially in 1968 the vegetation structure of 'grass'' became somewhat less homogeneous, firstly

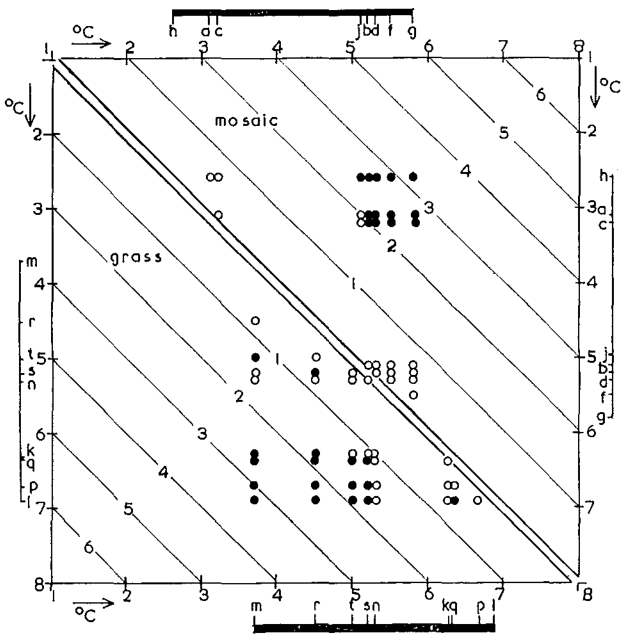


Fig. 10. Min. temp.'s at each position averaged over the period 20/4-7/9-'66. For further explanation see Fig. 8.

by the appearance of patches of *Cladonia* on decaying *Festuca* (the decaying *Festuca* disappeared gradually), and secondly by the growing out of the few tussocks of *Molinia* and patches of *Empetrum*. Changes in the vegetation structure of 'grass' were not noticed in 1966 (compare Fig.'s 2 and 11b) and were still slight in 1967. However, a possible influence of changes in vegetation structure on the annual variations in microweather in the two sites may not be excluded. In 3.3 the possible influence of recognizable structural elements of the vegetation will be discussed.

The W-values for the four series of positions (A–D) in 1966/'67 behave quite erratically for both 'mosaic' and 'grass'. This may mean that a sample of nine (in fact n was only 6–7) positions per site at a time generally was too small to be representative. It may also mean that the sampling in time in this investigation was insufficient i.e. four samples of about six separate weeks which were far apart in time, since the same series of positions (A, B, C or D) was only occupied once in four weeks on the average (cf. section 2). The latter hypothesis can be tested by grouping the recordings of 1965/'66 into four samples of six separate weeks each, in which the weeks used in each sample are about as far apart in time as in the four series (A–D) in 1966/'67. The resulting W-values are given in Table 3. The differences between the W-values are only small, showing that the sampling in time in the 1966/'67-experiment (Table 2: A–D) can at most account to a small extent for the erratic W-values. This must therefore be due to the non-representativeness of 6–7 positions per site, because, A–D in 1966/'67 differed from A^1–D^1 in 1965/'66 mainly in that A–D represents four series of different positions and A^1–D^1 represents four times the same series of positions. This conclusion is confirmed by the only slightly varying W-values for A–D when we test the recordings at the positions in both sites together (Table 2). A more detailed examination (cf. 3.3) of our recordings shows that in a series of 9 positions per site, in general 1–3 positions gave very 'individual' recordings. It was roughly estimated that with samples of about 10–25 recording positions (chosen at random) per site the chance to draw a sample without at least one highly individual position (like series D in 1966/'67: Table 2) would have been 0.05. Given the result that most phenomena discussed in 3.1 and 3.2 are statistically significant, the addition of more recording positions per site would not have altered our main conclusions importantly.

3.3. It may be concluded from Table 2 that in 'mosaic' as well as in 'grass' the degree of overal 'individuality' of the recording positions was generally high and statistically significant. We may now wonder whether this high degree of overall individuality resulted from about the same degree of individuality of the recordings at all positions or from a combination of some positions with a very high degree and some positions with a much lower degree of individuality. In the latter case we are of course interested in the structural features of the positions with very high individuality of recordings.

With the help of WILCOXON's matched-pairs signed-ranks test (cf. 2c) all possible pairs of positions within the same site were tested for three periods: May-August 1965 (Fig. 3), Sept. 1965–March 1966 (Fig. 4) and April–Sept. 1966 (Fig. 5). For each position and each period all recordings were averaged and these 'mean min. temp.'s' are plotted against those of the other positions within the same site: Fig.'s 8, 9 and 10. The magnitude of the difference between two means can be read with the help of the scale at the diagonal from the middle to the lower left respectively to the upper right of the figures; significant differences (cf. 2c) are indicated by black dots.

Fig. 8 shows that in 1965 the mean min. temp's were more apart in 'mosaic' than in 'grass', which is in accordance with Table 2 from which a greater overall individuality of positions in 'mosaic' than in 'grass' was concluded (see also Fig. 3). Such a difference does not appear from Fig.'s 9 and 10; compare also Table 2 and section 3.2. There was, on the other hand, some difference in the level of mean min. temp.'s in 1966 (Fig. 10), 'grass' showing higher mean min. temp.'s at many positions than 'mosaic' (cf. Table 1).

Inspecting Fig.'s 8, 9 and 10 we see that the high degree of overall 'individuality' (cf. Table 2) in 1965 and 1966 resulted from only a few positions with a very high degree of individuality of recordings. Table 4 shows which positions were highly individual (first column: more than one half of the differences with other positions within the same site significant). In Table 5 a short characteristic of the vegetation structure at the different positions is given. When comparing Tables 4 and 5 it will be evident, that there was no obvious relation between the degree of individuality of min. temp.-recordings and the physiognomical features of the vegetation at the recording positions, e.g.: the most extreme position (physiognomically) within 'grass', n (Table 5: Fig. 11a), did not show any individuality of recordings (Table 4), whereas a comparable position within 'mosaic', c, did (that is to say in 1965/'66 and 1966). The same occured in the physiognomically identical positions k, l and t: l (Fig. 11b) did show a high degree of individuality, whereas k and t did not. A similar situation is found in some other groups of identical positions. More detailed comparisons between the Tables 4 and 5 are left to the reader. Interesting comparisons may also be made between the last column of Table 5 and the corresponding recordings given in Fig. 6. Moreover, the fact that the same positions gave highly individual recordings

TABLE 4. 'Individuality' of different recording positions

	more than one half of the differences sign.		about one half of the differences sign.		less than one half of the differences sign.	
1965 (Fig. 8)	h	m		r	a, b, c, d, f, j	k, l, p, q, s, t
1965/'66 (Fig. 9)	c, g	l, p	a	m	b, d, e, f, h, j	k, n, q, r, s, t
1966 (Fig. 10)	a,c, h	l, m, q, r		p, s, t	b, d, f, g	k, n

Table 5. Vegetation structure at the different recording positions

	1965–'66 (Fig.'s 8, 9, 10)		1966–'67	
1 under *Cladonia*: very open situation	g		Ba[1])[2]), Cb, Ag, Bg, Dg, Aj[2])	Cp, Bq
2 under decaying grass (mainly *Festuca*) + *Cladonia*	a	p, s	De,	Ck, An, Bp, At,
3 under *Festuca* (partly decaying): rather open vegetation		k, l, t		Dk, Bl, Cl, Dr, Bs,
4 ibid: more dense vegetation		m, q, r		Ak, Bm, Cm, Bn, Cn, Aq, Dg, Cs,
5 between many small tussocks of grass			Aa, Cc[1]), Ad, Cf, Ah, Cj[1])	Dp, Ds, Ct,
6 between or within large tussocks of *Luzula* or *Nardus*	c		Ae,	Bk, Am, Dm, Dn, Br, As,
7 ibid.: *Molinia*		n		Ar, Cr,
8 at the border of a patch of *Calluna*	j			
9 under *Calluna*			Da[1])[2]), Ac, Be, Dj,	
10 at the border of a patch of *Erica* or *Empetrum*	b, d		Bc, Cd, Cg[2]), Dh,	Dl, Ap.,
11 under *Erica* (+ *Call.*)	e, f, h		Ca, Dc, Bd, Ce, Af, Bf, Df, Bh, Ch, Bj	
12 under *Empetrum*			Ab, Bb, Db,	Al, Cq, Bt, Dt,

[1]) at a higher ground level than other positions in the same site [2]) at a small slope.

Fig. 11. Two positions in 'grass' (April 1966):
a. A very extreme position (n): between the two tussocks of *Molinia* (the only extreme position in 1965-'66).

b. The most common kind of position: under grass which is partly decaying; the 1-position shown is in the centre of the picture (compare also Fig. 2: m-position).

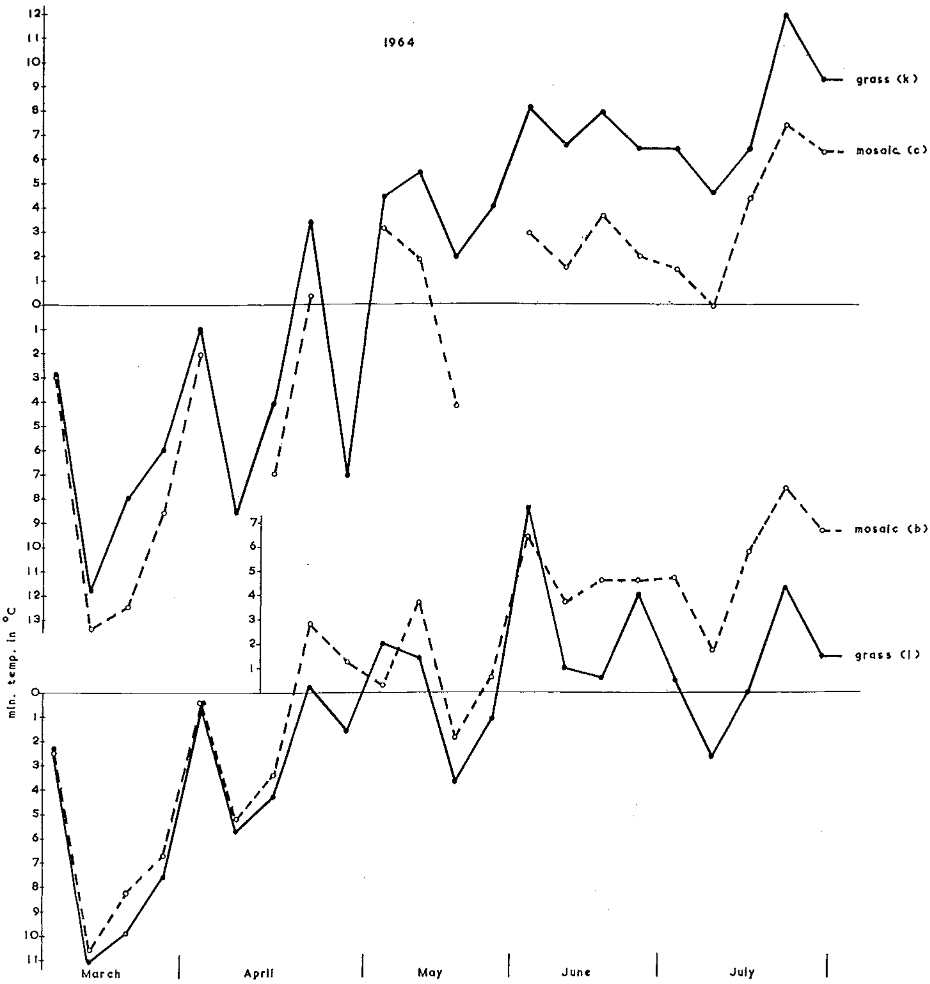


Fig. 12. Recordings of min. temp. in 1964 at two groups of two positions (4 of the 6 thermometers used in 1964). Each group represents the recordings at two position that might have been 'representative' of the 'type' of vegetation in 'mosaic' or in 'grass' respectively.

during one season but not during some other (Table 4, e.g.: h, g, q), indicates that the influence of the vegetation structure on microweather (at least on min. temp.'s) is not deterministic but probabilistic and thus unpredictable to some extent.

For students who are inclined to attach importance to differences between mean values without testing them, it may be useful to point to Fig. 8: differences between mean min. temp's of the magnitude 2–3 °C gave 7 significant and 3 unsignificant values, whereas differences of the magnitude 3–4° C gave 2 significant and 3 unsignificant values, etc.

4. Discussion

Ecologists generally agree that the measurement of environmental factors is necessary to understand the ecological processes that occur in the field. One also agrees that it is very difficult to know which measurements are needed and what adequate techniques are available. We fully accord with most of the contributors to Wadsworth (1968) that the problem of instrumentation can only be solved by automation of the recording and handling of data. We are not sure, however, whether every ecologist is aware why automation is in fact unescapable.

Let us suppose that the characteristics of our min. temp. recordings are not exceptional, that is, comparable features may be expected sometimes to be encountered when measuring other components of microweather in more or less natural sites. Then our preliminary investigation may teach us something about the possible relations between the structure of the vegetation and microweather or at least warn us against a kind of optimistic assumptions sometimes adopted by ecologists.

The most surprising result from our recordings is that the spatial variation of microweather (at least of min. temp.'s) need not be smaller in a fairly homogeneously structured vegetation like 'grass' (Fig. 2) than in a very heterogeneously structured one like 'mosaic' (Fig. 1), although during a certain period (e.g.: summer 1965: Fig.'s 3 and 8) a difference may be indicated that points into the a priori expected direction (cf. 3.3). Another surprising result is that visually recognizable components of vegetation need not show individual features of microweather (Tables 4 and 5). That is, the features of microweather (at least of min. temp.'s) within some specimen of such a component can hardly be predicted from measurements within other specimens of the same vegetation component. It therefore seems not sensible to do measurements of microweather at a position that is assumed to be 'representative' of some 'type' of vegetation structure.

The kind of 'conclusions' that may be arrived at when one proceeds in this way is clearly illustrated by Fig. 12 in which the recordings of two groups of two min. thermometers are shown (4 of the 6 thermometers used in 1964). Each group represents two positions that might have been selected as 'representative' (although chosen at random) of some 'type' of vegetation, 'mosaic' or 'grass', respectively. From Table 5 the reader can select as many pairs of supposedly 'representative' positions as he likes to follow the concerning recordings in the Fig.'s 3–6 and to check our conclusion.

In spite of the two results discussed so far, the two sites seemed to show important differences in microweather (at least in min. temp.'s) in most seasons (cf. 3.1: Table 1). This is the more evident when we realize that the number of positions sampled per site was still rather small (cf. 3.3). However, the influence of the vegetation structure on the relation between macro- and microweather is apparently very complex and of a stochastic nature. At each position microweather results from an interplay between a number of more or less variable factors. This result does not only vary in time with differing combinations of weather components, but will also vary between positions with a visually similar structure. It will be evident that owing to this, microweather will even be less predictable than macroweather. Of course, we do not exclude the possibility that for some factors at certain positions the predictability of the level of the recordings might be much better. We only intend to warn against assuming a priori such an almost invariable situation; it will always be necessary to investigate during some period the degree of spatial variation at positions chosen at random.

When we study the influence of physical factors on ecological processes in the field, it is necessary to have some knowledge of the spatio-temporal variation of the respective components of microweather during the period of investigation. That is, it is necessary to record as frequently as possible at not too small a number of positions within the site the values of a number of factors. The amount of data on microweather to be recorded and to be handled thus will generally be so large as to make automation unescapable.

ACKNOWLEDGMENTS

It gives us great satisfaction to dedicate this paper to the director of the Biological Station, Prof. Dr. H. J. VENEMA (Wageningen), who has often shown to be able to understand the difficulties encountered by the field ecologist and who has enabled the procuring of automatic recording equipment in Wijster.

We want to thank Mr. E. MEELIS (Leiden) for statistical advices.

SUMMARY

To get some idea of the spatial variation in microweather in two adjacent sites at the heath of Kralo – a very heterogeneously structured site 'mosaic' and a fairly homogeneously structured one 'grass' – a preliminary investigation was carried out:

laying out and weekly reading (during four years: 1964–'67) of a number of minimum thermometers at randomly chosen positions throughout both sites. If we suppose that the general characteristics of the results from our investigation may sometimes be encountered when measuring other components of microweather, it may be concluded:

1. The spatial variation of microweather need not be smaller in a fairly homogeneously structured vegetation like 'grass' than in a very heterogeneously structured one like 'mosaic'.
2. Visually recognizable components of vegetation need not show individual features of microweather.
3. In the course of time the possible differences between two sites may change in an unpredictable way.

In general: the influence of the vegetation structure on the relation between macro- and microweather is apparently very complex and of stochastic nature.

Hence, to get some knowledge of the possible influence of microweather components on ecological processes, it will be necessary to record during the period of investigation as frequently as possible at not too small a number of positions the values of the respective components, i.e. automation of the recording and handling of data is unescapable.

References

Benard, A. & C. van Eeden. 1956. Handleiding voor de symmetrietoets van Wilcoxon *Rapport S 208 (M 76) van Mathematisch Centrum, Amsterdam.*

De Jonge, H. 1963. Inleiding tot de medische Statistiek, *I, 2de druk. Ned. Inst. Praeventieve Geneeskunde, afd. Statistiek.*

Den Boer, P. J. 1968a. Zoölogisch onderzoek op het Biologisch Station, Wijster, 1959–1967. *Miscellaneous Papers 2. Landb. Hogeschool Wageningen: 161–181.*

Den Boer, P. J. 1968b. Spreading of risk and stabilization of animal numbers. *Acta Bioth. XVIII: 165–194.*

Kendall, M. G. 1962. Rank correlation methods. *3rd ed., London.*

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. *Mc. Graw Hill. New York.*

Tate, M. W. & R. C. Clelland. 1959. Nonparametric and shortcut statistics. *Danville, Illinois.*

Van der Vaart, H. R. 1950. Gebruiksaanwijzing voor de toets van Wilcoxon. *Rapport S 32 (M 4) van Mathematisch Centrum, Amsterdam.*

Vlijm, L. & Th. S. van Dijk. 1967. Ecological studies in Carabid beetles. II. General pattern of population structure in Calathus melanocephalus (Linn.) at Schiermonnikoog. *Z. Morph. Oekol. Tiere, 58: 396–404.*

Wabeke, D. & C. van Eeden, 1955. Handleiding voor de toets van Wilcoxon. *Rapport S 176 (M 65) van Mathematisch Centrum, Amsterdam.*

Wadsworth, R. M., 1968. The measurement of environmental factors in terrestrial ecology. *Symp. Brit. Ecol. Soc. Blackwell. Oxford.*