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Artikel: Phenological methods in permanent plot research : the indicator value of phenological phenomena : a study in limestone grassland in Northern Switzerland = Phänologische Methoden bei Dauerquadratuntersuchungen : der prognostische Wert phänologischer Phänomene : eine Untersuchung in Halbtrockenrasen (Mesobrometum) in der Nordschweiz

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Kapitel: 3: Methods

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3. Methods

3.1. *Experimental design and treatments*

Within each of the four study areas, 18 plots were delineated, each mesuring 5 m x 10 m. The following six treatments were carried out:

A) cutting in mid June every year

B) cutting in mid June every second year

C) cutting in mid June every fifth year

D) cutting in early October

E) burning in March

F) no management at all.

The study having been carried out for a rather limited period of time, treatment C and F to date yielded the same results; thus the effects of these two treatments are not discussed apart. Treatment B was very similar to treatment A and sometimes provided no additional information; therefore, the effects of treatment B are not always separately presented.

Taking into account possible gradients occurring in the study areas, three replicas were laid out for each treatment - bar two surfaces within study area 4 that had been burnt in March (Figs 5, 6). To examine small scale changes within a given stand, a 1 m^2 plot was marked in each 50 m^2 surface.

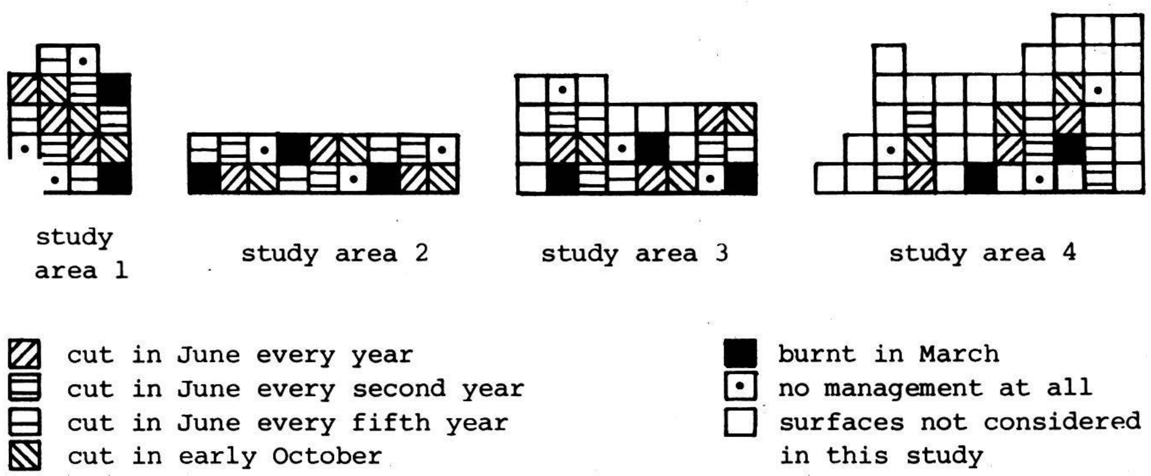

Fig. 5. Management of the four study areas.

Fig. 6. The study area 2 just after burning.

3.2. *Distribution maps, relevés and 'species value'*

The distribution maps are based upon the 50 m^2 relevés taken in 1977 when the study areas 2, 3 and 4 were experimentally managed for the first time. The relevés in study area 1 only data back to 1978, when experimental management was started in this area. Due to technical factors, the rectangular 50 m^2 plots are indicated in the distribution maps by squares. The different cover values are marked as shown in Table 3.

Phytosociological relevés were taken once a year, for plots cut in mid June this occurred just prior to cutting, for all other plots relevés were taken in August. In 1977, the vegetation in the 1 m^2 as well as in the 50 m^2 plots was recorded according to the BRAUN-BLANQUET method (e.g. BRAUN-BLANQUET 1964, MUELLER-DOMBOIS and ELLENBERG 1974). From 1978 onwards, the finer scale of LONDO (1975) was used; LONDO's values can easily be transformed into BRAUN-BLANQUET's cover-abundance values. Plant nomenclature follows HESS, LANDOLT and HIRZEL (1967, 1970, 1972) for phanerogams and BERTSCH (1966) for bryophytes.

Table 3. Code replacement for the mathematical analysis of the phytosociological data.

a) BRAUN-BLANQUET's scale

Code	Mean cover (%)	Frequency table (Ordinal scale)	Trend analysis		Signature in distribution maps
			qualitative (Signum-transformation)	quantitative	
(blank)	0	0	0	0	
+/r	1.0	1	1	10	•
1	2.5	2	1	25	•
2	15.0	5	1	150	●
3	37.5	7	1	375	●
4	62.5	8	1	625	●
5	87.5	9	1	875	■

b) LONDO's scale

(blank)	0	0	0	0	
0.1	1.0	1	1	10	•
0.2	2.0	2	1	20	•
0.4	4.0	3	1	40	
1	10.0	4	1	100	●
2	20.0	6	1	200	
3	30.0	6	1	300	●
4	40.0	7	1	400	
5	50.0	8	1	500	
6	60.0	8	1	600	●
7	70.0	8	1	700	
8	80.0	9	1	800	
9	90.0	9	1	900	■
10	97.5	9	1	1000	

'Species value'. According to the group value of TÜXEN and ELLENBERG (1937) the importance of a species in a community can be expressed as:

'species value' = frequency (%) x mean cover degree (%) / 100

The species value rises with increasing frequency and/or mean cover degree and can maximally be equal to 100. For computing the mean cover degree, BRAUN-BLANQUET's and LONDO's sale respectively were converted to cover-percentages as indicated in Table 3.

3.3. *Mathematical processing of the phytosociological data*

Phytosociological data was processed to obtain a frequency table; in addition, possible developmental trends appearing throughout the experiment within the vegetation (relevés) were considered to be better assessed with the help of mathematical methods.

The frequency table (Table 1) is based upon 72 relevés of 50 m^2 each; 18 relevés per study area were considered, for the study areas 2, 3 and 4 those taken in 1977, for the study area 1 those taken in 1978. Rare species occurring only once or twice have not been included in the mathematical processing. For the analysis the FORTRAN-IV programme package described by WILDI and ORLÓCI (1980) has been applied; the programme names referred to are those used by these authors. As a first step, the raw data consisting of BRAUN-BLANQUET (1964) or LONDO (1975) codes had to be transferred to numerical data. For this, the ordinal scale proposed by VAN DER MAAREL (1979) with no further transformation was chosen (Table 3). The ordination co-ordinates of the relevés were computed by principal component analysis (programme PCAB) based upon the cross product matrix but not on the correlation matrix as is usual (ORLÓCI 1978). The scatter diagrams of the relevés were printed by programme ORDB. In order to find a group structure within the set of species, the cross product matrix (programme RESE) was subjected to cluster analysis (minimum variance clustering, programme CLTR) yielding a dendrogram. Finally the frequency table (Table 1) was printed by programme TABS.

In an attempt to assess developmental trends appearing in the vegetation throughout the experiment, the 1 m^2 relevés were used, because they provide more reliable cover estimations than the 50 m^2 relevés. Within a given study area, the relevés of all surfaces and of all years were processed together.

The phytosociological data was analysed in a twofold way. To reveal possible *qualitative* alterations of the vegetation resulting from the different treatments, the quantitative raw data was transformed to presence-absence data (signum transformation). To reveal possible *quantitative* alterations of the vegetation the BRAUN-BLANQUET and the LONDO scale were replaced by numerical values approximating reasonably well to the original cover percentages (Table 3). In both cases, the pathway of the analysis was the same as that indicated for the relevés by the construction of the frequency table yielding scatter diagrams of the relevés. For each surface, the points representing the relevés taken in subsequent years were connected by arrows. This method proposed by VAN DER MAAREL (1969) aims at revealing developmental trends in a data set as a whole. In order to make the diagrams easy to survey, the arrows were presented for each treatment in a separate graph.

3.4. *Phenological records*

Phenological observations were carried out weekly from March to early November. They were assigned to three categories:

a) quantitative observations of all phases in the four study areas leading to complete-quantitative-analytical-total diagrams (for terminology see DIERSCHKE 1972, 1977);
b) especially detailed records of the flowering phase in all 1 m^2 plots and of the number of species in blossom per 1 m^2 and per 50 m^2, respectively, throughout the year;
c) estimation of the percentage of surface covered by the flowers of different colours in the 50 m^2 plots, presented in the form of synthetic colour diagrams.

a) *Quantitative-analytical-total diagrams.* Various phenological phases were recorded of all species within the four study areas (Table 4). Observations refer to the whole study areas and were carried out in 1977, 1978 and 1979 and comprised vegetative as well as generative phases. The percentage of individuals of a given species at a particular phase was estimated according to a six-degree-scale (Table 5). In the diagrams,each species is represented

Table 4. Key to phenological records

Vegetative phases:	Generative phases:
ground leaves	flower buds
shoots	bloom
yellowing	fading
	fruit
	seed dispersal

Table 5. Scale for the estimation of the percentage of individuals at a given phenological phase

Code	Percentage of individuals at a given phenological phase
+	0% < and < 5%
1	5% < and < 20%
2	20% < and < 40%
3	40% < and < 60%
4	60% < and < 80%
5	80% < and < 100%

Table 6. Scale for the estimation of the surface covered by flowers of a given colour

Code	Mean cover (%) of the flowers of a given colour
+	< 0.1%
0.1	0.1%
0.2	0.2%
0.4	0.4%
0.4-1	0.7%
1	1.0%
1-2	1.5%
2	2.0%
2-3	2.5%
3	3.0%
4	4.0%
5	5.0%
6	6.0%
:	:

by two horizontal stripes, the upper one corresponding to generative phases and the lower one representing the vegetative development. Developmental phases and their percentage are differently marked (Table 4). The width of all stripes is equal. The significance of a species within the study areas is indicated by the species value.

b) *Flowering intensity and number of species in blossom per 1* m^2 *and per 50* m^2. In each 1 m^2 plot studied, the flowering units depending on the morphology of different species (e.g. 1 flower, 1 flower head, 1 inflorescence, 1 umbel and so on) were counted every week for all species in blossom within the plot. If a given species did not flower in the 1 m^2 surface but only in the adjacent 50 m^2 plot, a note was taken but the flowering intensity was not specified. The flowering units of some species (e.g. *Primula veris, Orchis pallens, Ranunculus bulbosus, Buphthalmum salicifolium, Aster amellus*) were also counted in the 50 m^2 surfaces. As far as grasses were concerned, further information was gathered: in addition to the above mentioned observations, the total number of inflorescences was recorded for the different grasses within the 1 m^2 plot cut in mid June just before cutting whilst those in the other 1 m^2 plots were recorded in early July.

For the presentation of the response of the flowering intensity to the different treatments, the highest recorded values or the total number of inflorescences (*Gramineae*) were taken into consideration. Most of the diagrams are based upon three replicas of 50 m^2 each, otherwise the number of samples and the plot size is specified in the explanation of figures in the text.

In some cases the data gathered was incomplete. For instance, cutting in June almost completely prevented the flowering of *Buphthalmum salicifolium* and *Aster amellus* within study area 4 from the very beginning of the experimental management in 1977. 1976 values being unknown, the flowering intensity on surfaces subject to this treatment prior to the beginning of experiment had to be inferred from the corresponding values of the surrounding, otherwise treated plots. Connections between the supposed starting points and the first recorded values are indicated by dashed lines.

c) *Synthetic colour diagrams.* The percentage of surface covered by flowers grouped according to the flower colours (i) yellow, (ii) white, (iii) blue and violet and (iv) red was estimated weekly in all 50 m^2 plots studied (Table 6). These estimates were verified from time to time by counting the flowering units of species most contributing to the effect of a given colour within some 50 m^2 surfaces; it was thus possible to compute quite reliably the real cover. The cover percentages of the four flower colours throughout the year are presented in synthetic colour diagrams one above the other, all values being the average of three replicas.

3.5. *Profile diagrams (photographs)*

In 1980, six cuttings of 0.5 x 0.5 m were taken for each of the differently treated surfaces within the study area 1. For those plots cut in mid June samples were taken on June 19th just before cutting, for plots under other treatments samples were taken on July 1st. Prior to photographing, each sample was aligned at a distance of 0.5 m.

4. Results

4.1. *Phenological responses of individual species to environmental changes*

4.1.1. *Short-term observations*

Under certain circumstances, phenological records collected during a single vegetation season have some predictive value. Using analytical total diagrams (for terminology see DIERSCHKE 1972, 1977) it should be possible to predict the effect of a given treatment upon the sexual reproduction of plants (WELLS 1971) as well as the reproductive success of animals; in particular, insects frequently depend for part of their life-cycle on flowers or fruits (BONESS 1953, MORRIS 1967, 1969, 1973a, b, 1978, 1979, MORRIS and LAKHANI 1979). For this reason, short-term phenological observations were carried out in the course of the present study. After comparing the expected and the actual effects, the obtained results were assigned to one of the two categories