FOLIA PARASITOLOGICA 33: 251—264, 1986.

ANALYSIS OF INTERSPECIFIC RELATIONSHIPS IN MESOSTIGMATID MITES (ACARI: MESOSTIGMATA) IN THE NESTS OF THE BANK VOLE (CLETHRIONOMYS GLAREOLUS (SCHREBER, 1780))

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Dedicated to Dr. J. Prokopič, Corresponding Member of the CAS, on the occasion of his 60th birthday

Abstract. An analysis is presented of a community of mesostigmatid mites from the nests of *Clethrionomys glareolus* found in the forest biotopes of Vsetínské Beskydy Mts. (North Moravia) throughout all seasons of the year. Main attention was paid to the structure of the nest community, relationships of mites to their host and interspecific relationships in the mites themselves. Primarily cluster and factor analyses based on correlation matrix were used for mathematical assessment. The particular elements of correlation matrix were Spearman's non-parametric correlation coefficients computed from frequencies of species in the nests studied.

While starting a long-term and many-sided research of parasitic nidicolous arthropods and the influence of nest environment on the dynamics of their development, material from 251 nests of small terrestrial mammals belonging to 7 species was collected in the forest biotopes of Vsetínské Beskydy Mts. (North Moravia) throughout all seasons of the year. Mesostigmatid mites from these nests were treated in the paper written by Mrciak, Daniel and Rosický (1966). The assessment of their occurrence was made by standard methods used in work of this type at that time, i.e. by finding out the absolute frequencies, by calculation of mean values, or percentile representation and by empiric comparison of these indices.

The majority of nests found (3/5) belonged to the bank vole *Clethrionomys glareolus* (Schreber, 1780). This material was re-assessed at a time when new additional data and experience from the investigations of nest communities were gathered (Daniel, Holubičková 1972). The objective of that study was not only treatment of own actual material, but an attempt to create a method for the assessment of collected nidicoles as well, in order to make a detailed analysis of relationships operating in nest communities and to obtain their numerical and graphic documentation. (For this reason also discussed was the suitability of methos used by former authors; we are referring to this part of the paper cited.)

Daniel and Holubičková (1972) included in their assessment of nest communities some aspects modified and adopted from the field of plant ecology. Interspecific relationships in mesostigmatid mites from *C. glareolus* nests were solved by means of association analysis using affinity index as derived by Fager (1957). The results were expressed graphically by matrices and by means of empiric association graphs which can be relatively easily compared. On the basis of these results individual groups of associated mite species and the level of their mutual relationships indicating dissimilarity (or harmony) of ecologic requirements could be defined. The structure of the associations studied in this way was much richer and more diverse than the mere demonstration of species composition of mites. In later decade advances were made again not only in the research directed at long-term field experiments and in the relevant exact procedures worked out, but also in the assessment of results achieved. The cooperation with the workers of the Mathematical centre of the Physiological Institute, Czechoslovak Academy of Sciences, contributed a great deal to these advances. The availability of the computer IBM 370 and the BMDP-programme series (Dixon and Brown, 1979) considerably expanded the possibilities of finding new methods. Recently two latest publications have appeared in this respect: the treatise by Daniel and Albrecht (1983), dealing with microclimate of nests and the paper by the same authors (Daniel and Albrecht, 1985), concerned with the structure of mesostigmatid mite communities in nests of the European suslik (*Citellus citellus* L.), the relationships of mites to their host and to the nest environment and to interspecific relationships among the mites themselves. Apart from other mathematical methods, also the cluster analysis (using χ^2 and φ—statistics as measure of similarity), analysis of mutual correlations (on the basis of common and non-parametric Spearman's coefficients) and factor analysis were used.

The results obtained gave an impetus to verify by this method the justification of conclusions made in 1972 (Daniel, Holubičková) on the basis of association analysis, using Fager's affinity index and empiric association graphs. Such a comparison helped to verify the general validity of the expressed conclusions, because involved were groups of nests of different origin and two different hosts (i.e. nests of the European suslik *Citellus citellus* obtained during long-term field experiment and nests of the bank vole *Clethrionomys glareolus* obtained from free nature), in which, however, similar species of mesostigmatid mites occurred to a certain degree.

MATERIAL AND METHODS

The assessment was based on the data published by Mrciak, Daniel and Rosický (1966) on mesostigmatid mites found in 149 nests of *Clethrionomys glareolus* in forest biotopes of the Vsetínské Beskydy Mts. (the paper cited contains all basic ecological characteristics). In these nests a total of 5,609 mesostigmatid mites belonging to 42 species were found. In order to make the pertinent analyses, the material was first arranged as described in the paper by Daniel and Holubičková (1972), i.e. the findings with a low frequency of occurrence (occurrence in less than 5 nests) were eliminated, so that 25 species (cf. Table 1, on p. 70 in the publication of Daniel and Holubičková 1972) were available for analyses. For formal reasons the chosen level of occurrence frequency, however, proved to be too low for the newly chosen analyses; only 13 species indicated below in Table 1 met the set requirements. (This fact is commented upon in "Discussion"). On the other hand, sex and nymphal stages were distinguished, (in three species no males were detected in the nests), so that the basic group analysed contained a total of 36 variables.

The nests collected in the field were classified according to biotopes, localization, season and material used for the nest bedding. However, all these parameters could not be traced in the assessment — as stated similarly in the paper by Daniel and Holubičková (1972) — because in this way groups with very low frequencies would be created. For this reason and in harmony with the experience mentioned in the paper cited, the material was first analysed as a whole. Further on similar methods were used for the separate analysis of the most numerous sub-group of nests, characterized by the following parameters:
Biotope—coherent forest;
Localization of nest — nests above the ground surface were eliminated;
Nest bedding — dry foliage.

The relationships in different mite species (differentiated also according to sex and developmental stage) were studied similarly as described in the paper by Daniel and Albrecht (1985) by means of cluster and factor analyses. In both cases we proceeded from the correlation matrix, whose particular elements were non-parametric Spearman's correlation coefficients computed from frequencies of species in the nests studied. Sperman's correlation coefficient showed (similarly as in the paper by Daniel and Albrecht, 1985) that it can be interpreted as a "measure of similarity" between numerical rows of frequencies of species occurrence. It became evident that unlike Pearson's correlation coefficient Sperman's coefficient very well distinguished the relationships within a species, i.e. in almost all cases the correlations between females and nymphs of the same species were of

higher value than the correlations between the females of one species and the nymphs of another species.

In cluster analysis we used average linkage rule for amalgamation of the clusters into new ones. In factor analysis we restricted our search to 3 or 4 factors which could be statistically dependent or they were ortogonal. This number of factors was not derived from the a priori idea of the arrangement of relationships in a mite community, but — as will be indicated in the "Results" — it is the number in question to which the data observed give a sufficiently convincing evidence.

Our own computation were made by means of the BMDP1M (cluster analysis) and the BMDP4M (factor analysis) programmes of the BMDP81 system (Dixon and Brown, 1981).

Table 1. Basic analysed group of mesostigmatid mites from *Clethrionomys glareolus* nests (n = 149)

Mite species		Number			
Symbol used*		♀ (F)	♂ (M)	N I + N II N	Total
EK	*Eugamasus kraepelini* (Berlese, 1904)	54	45	28	127
ER	*Eugamasus remberti* Oudemans, 1912	40	28	126	194
E	*Eugamasus sp.*	90	43	146	279
EE	*Euryparasitus emarginatus* (Koch, 1839)	199	93	503	795
CU	*Cyrtolaelaps mucronatus* (Canestrini, 1881)	37	35	315	387
CI	*Cyrtolaelaps minor* Willmann, 1952	19	22	242	283
VN	*Veigaia nemorensis* (Koch, 1839)	240	0	117	357
MP	*Macrocheles pauperior* (Berlese, 1918)	48	0	8	56
HH	*Hypoaspis heselhausi* Oudemans, 1912	48	0	4	52
ES	*Eulaelaps stabularis* (Koch, 1836)	506	19	28	553
HO	*Haemogamasus horridus* Michael, 1892	126	70	43	239
HN	*Haemogamasus nidi* Michael, 1892	880	193	119	1192
HR	*Haemogamasus hirsutus* Berlese, 1889	202	100	136	438
Total		2489	648	1815	4952

* These symbols of species are used in tables and graphs. Sex and developmental stage is expressed by letters F, M and N added to the species symbols.

RESULTS

The analysis proper was made by using 13 species, out of which 10 species comprised both sexes and nymphs, while in three species only the data on females and nymphs were available. Correlation matrix consisting of Spearman's correlation coefficients of 36 numerical rows was difficult to survey. Therefore, we used as a basis of analysis the dendrogram resulting from cluster analysis made on this matrix (Fig. 1).

At first sight, the dendrogram shows three basic clusters, which we interpreted in conjunction with the results of factor analysis. On the lowest level (first horizontal line connecting the clusters which had formed first) a total of 14 clusters formed: it should be stressed that 10 of them were clusters of species composed of either both sexes of the same species (*Eugamasus kraepelini, Cyrtolaelaps minor, Haemogamasus horridus, H. hirsutus*) or females and nymphs of the same species (*Veigaia nemorensis, Hypoaspis heselhausi, Euryparasitus emarginatus, Eugamasus* sp.), or males and nymphs of the same species (*Haemogamasus nidi, Eulaelaps stabularis*). On the other hand, in the next step the amalgamation of species was observed only twice (*Eugamasus kraepelini, Haemogamasus hirsutus*). There was no amalgamation of species in the next step either, but the clustering process kept its basic tendency, because it resulted in three basic clusters, which were always formed by complete species (as regards sex and stage) with one exception (*Cyrtolaelaps mucronatus*).

The character of these three basic clusters can be interpreted by the biology of the mite species forming them. From this aspect they can be designated as clusters of saprophagous species (dendrogram, left), predators (dendrogram, centre) and hematophagous or schisophagous species as well (dendrogram, right). This arrangement illustrates not only the structure of the nest community, but the relationship of individual members to the animal host and interspecific relationships as well. The gradual formation of these relationships is verbally characterized on the vertical axis of dendrogram.

We further studied the structure of correlation matrix by means of factor analysis considering the possibility of three or four factors. However, the preceding result of cluster analysis would indicate that three factors would suffice for the explanation of the structure. If we consider quite formally the statistical significance of factors, i.e. what

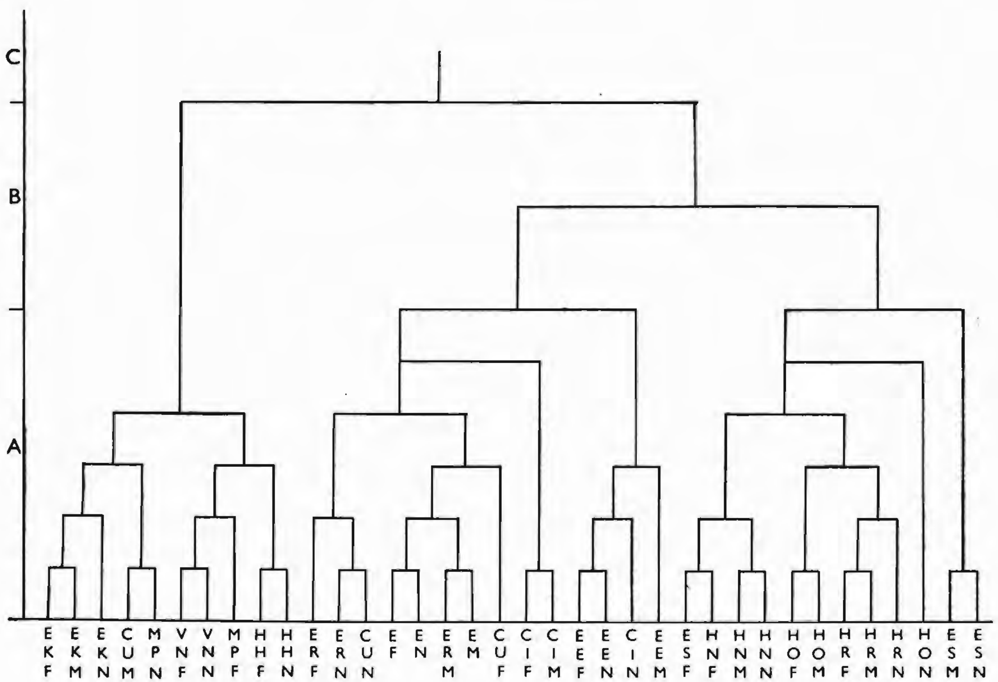

Fig. 1. Structure of the community of mesostigmatid mites in *C. glareolus* nests collected in free nature (Western Carpathians), depicted in dendrogram based on cluster analysis of interspecific relationships. Respective clustering phases of nest community are verbally given on vertical axis left. (Symbols used: see Table 1). A — Internal structure of mite groups, B — Relationships among groups, C — Mite community.

Table 2. Matrix of factor loadings

Species (sex, stage)	Factor 1	Factor 2	Factor 3	Species (sex, stage)	Factor 1	Factor 2	Factor 3	Factor 4
HRF*	0.817	0.0	0.0	HRF	0.830	0.0	0.0	0.0
HRM	0.769	0.0	0.0	HRM	0.773	0.0	0.0	0.0
HNN	0.756	0.0	0.0	HRN	0.761	0.0	0.0	0.0
HRN	0.742	0.0	0.0	HNN	0.745	0.0	0.0	0.0
HOM	0.710	0.0	0.0	HOM	0.732	0.0	0.0	0.291
HNF	0.683	0.0	0.0	HNM	0.665	0.0	0.0	—0.289
HNM	0.681	0.0	0.0	HNF	0.648	0.0	0.0	—0.441
HOF	0.628	0.0	0.0	HOF	0.640	0.0	0.0	0.0
ESF	0.578	0.370	0.0	ESF	0.577	0.386	0.0	0.0
HON	0.519	0.0	0.0	HON	0.552	0.0	0.0	0.389
EN	0.0	0.677	0.0	ERN	0.0	0.682	0.0	0.0
ERN	0.0	0.665	0.0	EN	0.0	0.665	0.0	0.0
EEN	0.0	0.634	0.0	CUN	0.0	0.599	0.0	0.0
EM	0.0	0.608	0.0	EM	0.0	0.584	0.0	0.0
CIN	—0.375	0.593	0.0	EEN	0.0	0.556	0.0	0.539
CUN	0.0	0.584	0.0	CIN	—0.345	0.551	0.0	0.309
ERM	0.0	0.526	0.0	ERM	0.0	0.524	0.0	0.0
EKF	0.0	0.0	0.733	CIM	0.0	0.519	0.0	—0.250
EKM	0.290	0.0	0.721	EKF	0.0	0.0	0.791	0.0
EKN	0.279	0.0	0.648	EKM	0.0	0.0	0.738	0.0
VNF	0.0	0.0	0.575	EKN	0.0	0.0	0.658	0.0
VNN	—0.325	0.0	0.530	VNF	0.0	0.0	0.513	0.275
ERF	0.0	0.493	0.0	EEM	0.309	0.0	0.0	0.546
ESM	0.310	0.0	0.0	CUF	0.0	0.499	0.0	—0.281
CIF	0.0	0.452	0.0	MPF	—0.266	0.0	0.0	0.0
MPF	—0.259	0.0	0.0	CIF	0.0	0.465	0.0	0.0
CUM	0.0	0.368	0.0	ERF	0.0	0.489	0.0	0.0
CIM	0.0	0.482	0.0	CUM	0.0	0.413	0.0	—0.293
EEM	0.258	0.0	0.0	ESM	0.317	0.0	0.0	0.0
CUF	0.0	0.457	0.0	VNN	—0.331	0.0	0.466	0.256
MPN	0.0	0.0	0.344	MPN	0.0	0.0	0.385	0.0
HHN	0.0	0.293	0.0	HHN	0.0	0.279	0.0	0.0
ESN	0.0	0.0	—0.254	ESN	0.0	0.255	0.0	—0.352
HHF	0.0	0.461	0.0	HHF	0.0	0.434	0.0	0.0
EF	0.0	0.472	0.0	EEF	0.0	0.386	0.0	0.342
EEF	0.0	0.433	0.0	EF	0.0	0.480	0.0	0.0

The above factor loadings matrix has been rearranged so that the columns appear in decreasing order of variance explained by factors. The rows have been rearranged so that for each successive factor, loadings greater than 0.5000 appear first. Loadings less than 0.2500 have been replaced by zero (according to BMDP4M program used).

* Explanation of abbreviations see page 253.

percentage of variability of the mite group the factor explains, then the number of three factors can appear as insufficient. Three factors explain 37 % of total variability of the group, four factors—43 %, five factors—47 %. Fig. 2 illustrates the diminished increase of the explained variability of the mite group coming to the gradual inclusion of subsequent factor. The curve clearly consists of two parts. The first steep part indicates that the diminished increase of the explained variability caused by inclusion of fourth factor is still quite considerable. The second part of the curve testifies that the inclusion of 6th, 7th etc. up to 37th factor does not make any difference, as demonstrated by the gradually and regularly falling line of this part.

For this reason we investigated both possibilities, i.e. the computation of three or four factors, while considering the statistically dependent or ortogonal factors. The difference between the cases of dependent and independent factors was quite negligible or the two members of factors considered. Therefore we present factor loadings for only three or four dependent factors (Table 2). It should be noted here that the factors are mutually very little correlated (see below).

Table 2, containing those factor loadings whose value is over 0.2500 (i.e. lesser values are substituted by zeroes for a better survey) shows that the first, second and third factors are loaded with always similar mite species irrespective of the number of factors (three or four). The first factor is loaded with hematophagous (schizophagous) species: essentially *Haemogamasus hirsutus*, *H. nidi*, *H. horridus* and *Eulaelaps stabularis* are involved. The second factor is loaded with predators (i.e. *Eugamasus sp.*, *E. remberti*, *Euryparasitus emarginatus*, *Cyrtolaelaps minor*, as well as *E. stabularis* again). The third factor is loaded with saprophagous species, primarily *Veigaia nemorensis* and *E. kraepelini*. The difference between the results of factor analysis with three or four factors consists in the fact that factor four begins to indicate a substructure in the group of predators: this factor is markedly loaded with the species *Euryparasitus marginatus* which joins the other five predators in both sexes and stages only after its amalgamation in the final phase of the formation of basic cluster (dendrogram Fig. 1).

We emphasize again that we are dealing with dependent factors. Table 3 gives correlations between the factors of three- or four-factor analyses. It is evident that in both cases only correlations between the factor of hematophagous mites and that of predators comes near to the value 0.2; the factor of hematophags tolerates the factor of saprophags somewhat less as indicated by the negative value of correlation of these factors, the rest of correlations not reaching the value of 0.1.

Anyway, the low level of correlations between factors shows that the relationships among hematophags, predators and saprophags are not very close. Low values of correlations also show why the results of factor analysis with independent and dependent factors have been almost the same. A relatively low percentage of variability of the mite group explained by four factors may suggest that it is caused by the heterogeneity of nest parameters of the material analysed (especially in comparison with the previous

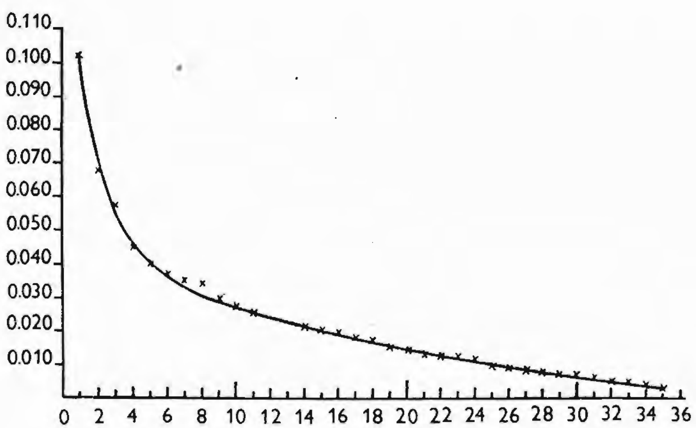

Fig. 2. Factor analysis of Spearman's correlation matrix — diminished increases of the explained variability of the mite group with gradual involvement of further factors (*C. glareolus* nests — Western Carpathians). Horizontal axis — number of factors. Vertical axis — difference in increases of the explained variability.

paper by Daniel and Albrecht, 1985—see "Discussion"). Our efforts to verify (or eliminate) this assumption gave impetus to carry out a separate analysis of selected groups of underground nests with dry foliage bedding (n = 99 nests), collected in the

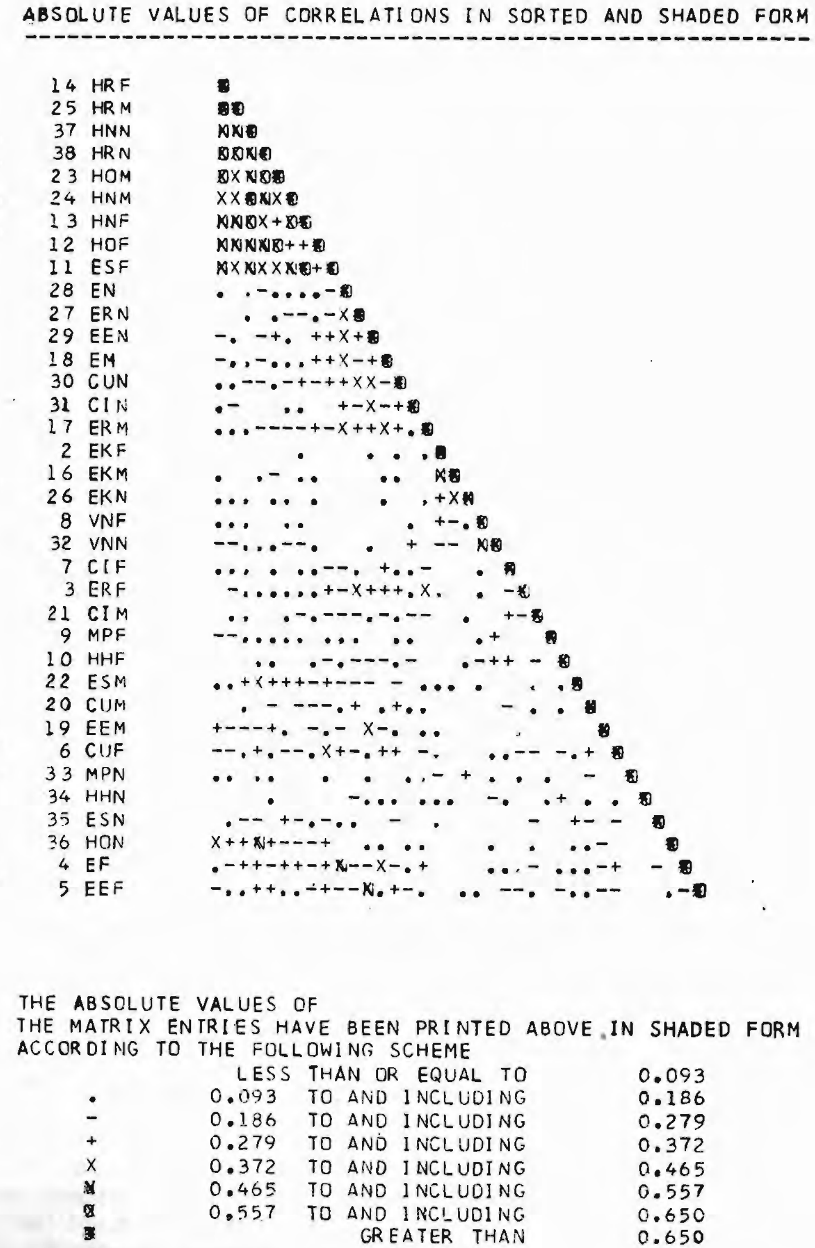

Fig. 3. Factor analysis of Spearman's correlation matrix. Absolute values of correlations in sorted and shaded form (according to programme BMDP 83).

biotope of coherent forest. Contrary to the assumption, this sub-group homogenized as far as important ecological parameters are concerned, showed that 43 % of variability of frequencies of the mite community studied are explained by four factors again. Consequently, the material obtained gives no support to the mentioned assumption. It should be noted, however, that factor analysis carried out on this homogenized group practically yielded the same results as did the analysis of the whole material.

Profuse graphic possibilities of the BMDP system offer yet another objective method to detect interspecific relationships in the community studied: Fig. 3 illustrates absolute values of correlations of occurrence frequencies in sorted and shaded form. The figure demonstrates well the high degree of correlations among hematophags (HRF—HON). On the average the correlations among predators (ERN—CIM) are lower than those among hematophags, and the correlations of the other species surpass the absolute value of 0.4 only sporadically.

DISCUSSION

The character of the present paper requires to discuss the results obtained from three aspects: 1. from the aspect of commentary to the results obtained by a new method of assessment; 2. their comparison with the results described in the previous paper (Daniel and Holubičková, 1972) in which a similar material was treated by different methods; 3. comparison with the paper by Daniel and Albrecht (1985), in which a different material (from nests of the European suslik *Citellus citellus*) was treated by the same methods.

1. Commentary to the results obtained

The dendrogram (Fig. 1), based on the results obtained by cluster analysis and illustrating the structure of the nest community of mesostigmatid mites, is described in the "Results". In the basic cluster, composed of species characterized by predominating hematophagia (or schisophagia), an interesting substructure, formed due to reaction of respective sexes and stages of *Eulaelaps stabularis*, can be observed: females react as hematophags of the genus *Haemogamasus*, but males and nymphs join the structure of the whole cluster as last. This fully agrees with the food characteristics of the species *E. stabularis* which represents a transition between hematophags and predators. A certain deviation from the reaction of adult mites *Haemogamasus horridus* is indicated in its nymphs but in view of their low frequencies we do not consider this deviation to be important.

Also the species *Haemogamasus hirsutosimilis* should fit in this cluster, but due to its low frequencies detected in the nests it did not meet the demands made on it by mathematical procedures used (see methodical part). Its conclusion in this place of the nest community structure belongs to the category of "intuitive conclusions" as discussed in detail in the paper by Daniel and Albrecht (1985).

The next basic cluster of predatory species has an interesting substructure. There are three sub-groups clustering not gradually, but only at a higher level. The first group is dominated by the species *Euryparasitus emarginatus*, which we can rightly consider to be the actual dominant species of the whole cluster of predators. (Evans et al. (1961) record it as "most important mesostigmatid predator in the subterranean nests of small mammals" and cite detailed direct observations of Michael (1886) who concluded: "For its size, this species is one of the most ferocious creatures I ever had to deal with".) It is of interest that this group, separately formed by both sexes and stages of *E. emarginatus*, was joined by the nymphs of *Cyrtolaelaps minor*, because it is the adults of this species which form the second separate little group. Their separation can be explained by the fact that due to their food specialization representatives of this genus of mesostigmatid mites have an intermediate position between predators and saprophags. This is testified by the position of the second representative of the same genus, *Cyrtolaelaps mucronatus*, which —as a single one—passes from one basic cluster to another.

The third basic cluster (dendrogram, left) includes saprophagous species feeding on decomposing organic matter of diverse origin. From this aspect their function in the nest is very well expressed by the designation "scavengers", in this connection used by Evans (1961).

The substructure of cluster of predators, depicted in dendrogram (Fig. 1), is also clearly seen from the results of factor analysis (Table 2), if the results obtained in observations of three and four factors are compared. In the first case the factors 1—3 correspond with basic clusters of dendrogram (from right to left). In the second case factor 2 (i.e. factor loaded by the group of predators) becomes divided and factor 4 in the first place is loaded by individual sexes and stages of the species *Euryparasitus emarginatus*. *Cyrtolaelaps minor*-nymphs has also a high value of loading, while *C. minor*-females have a null value and *C. minor*-males a negative one.

The increase of explained variability of the mite group analysed, relevant to the gradual involvement of further factors, is shown in the results in the respective part of the paper. A relatively low percentage of the explained variability of frequencies of the group, when 3—4 factors are considered, indicates that the relationships in the nest community of mesostigmatid mites are influenced by an additional number of other factors (in our case 35 formally, however, Fig. 2 shows their diminishing importance). The analysis of factor loadings for three or four factors in both cases revealed the significance of nutritional specialization of mites. It may be therefore concluded that it is this nutritional habitus of individual species which plays the main role in their relationship to host, its nest as well as interspecific relationships among the members of the nest community themselves. Other factors are involved in their whole complexity while a considerable percentage of variability of frequencies of the mite group investigated is explained, but for an isolated estimation of other factors and their influence even the numerous material collected in free nature, such as 150 nests of *C. glareolus* treated, is insufficient. The analysis of the subgroup, as mentioned in the "Results", is evidence of this. The ecologic parameters traced during one-time collecting of nests in the field, do not offer a sufficient basis for the explanation of the entire variability of frequencies. It was revealed that homogenization of conditions statically found at the moment of collecting do not appear to be effective. The arrangement of the long-term field experiment makes it possible to homogenize even the dynamically changing parameters (e.g. migration of nidicoles between nests, exchange of parasites during the host's contact, distinct peculiarities of microbiotope etc.), as indicated by the results of the assessment of mesostigmatid mites from experimental nests of *C. citellus*, in which three factors were enough to explain 64 % of the total variability of frequencies.

It is generally confirmed that the nutritional specialization plays a main role in the formation of the relationships in the nest community. We assume that particularly from the practical aspect of utilization of the results obtained in the studies on nest communities in epidemiology and epizootology of diseases characterized by natural foci, these relationships (i.e. of mites to host, mites to mites and to environment and other components of nest biocenosis) formed by nutritional specialization, are most important.

The low values of correlations between factors (Table 3) show that nutritional specialization does not constitute a basis for the association between these groups. This means that predators are not dependent on other mesostigmatid mites and feed at the expense

Table 3. Factor correlations for 3—4 factor analysis

	Factor 1	Factor 2	Factor 3		Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.000			Factor 1	1.000			
Factor 2	0.198	1.000		Factor 2	0.178	1.000		
Factor 3	—0.129	0.060	1.000	Factor 3	—0.116	0.070	1.000	
				Factor 4	—0.037	0.027	0.061	1.000

of other components of the nest community. This agrees with the observations of Ryba et al. (1986), who recorded the influence exerted by mesostigmatid mites on the ecology of fleas in the nests of susliks.

2. Comparison with the results obtained in the analysis of the same material by other methods

As explained in the introduction, the purpose of our studies to compare the results obtained with corresponding conclusions in the paper by Daniel and Holubičková (1972), was an impulse for a new re-assessment of the material from the nests investigated. Before starting such a comparison, it is necessary to pay attention to the arrangement of the material which was analysed in both cases.

A total of 42 species of mesostigmatid mites was identified. After eliminating species with low frequency of occurrence (see "Methods"), only a group of 25 species was available for mathematical analysis in the paper by Daniel and Holubičková (1972). Out of them only 13 species were associated to a different degree (namely, *Eugamasus remberti*, *Eugamasus sp.*, *Euryparasitus emarginatus*, *Cyrtolaelaps mucronatus*, *C. minor*, *Veigaia nemorensis*, *Androlaelaps sardous*, *Hypoaspis heselhausi*, *Eulaelaps stabularis*, *Haemogamasus horridus*, *H. nidi*, *H. hirsutus* and *H. hirsutosimilis*), which were characterized as follows: "If we understand nidocenosis as a group of directly or indirectly associated species, in which mutual causal relationships exist, the nest community of mesostigmatid mites under conditions studied is composed of only these 13 species. The other species occurring in the nest are actually a part of other communities".

Mathematical methods used in the present paper required somewhat stricter criteria, and after their application only 13 species met the formal requirements out of the total number of species found (i.e. 42). The harmony in the number of species in both cases is astonishing and requires a comparison, to what extent also the species spectrum of the two groups is alike: 11 species are members of both groups compared (namely, *Eugamasus remberti*, *Eugamasus sp.*, *Euryparasitus emarginatus*, *Cyrtolaelaps mucronatus*, *C. minor*, *Veigaia nemorensis*, *Hypoaspis heselhausi*, *Eulaelaps stabularis*, *Haemogamasus horridus*, *H. nidi* and *H. hirsutus*). The species *Androlaelaps sardous* and *H. hirsutosimilis*, which appeared to be associated to a certain extent after Fager's index of affinity had been applied, did not qualify to become members of the group analyzed in this paper due to a low frequency of occurrence. On the other hand, the species *Eugamasus kraepelini* and *Macrocheles pauperior*, which did not appear to be associated in the first case, became members of the group analysed in the second case.

For the comparison with dendrogram (Fig. 1), belonging to results obtained in this study, best suited is Fig. 13 (p. 80) in the publication by Daniel and Holubičková (1972) which illustrates the association diagram based on the analysis of pairs of species of the entire group studied by means of Fager's index of affinity. Quite distinctly two identical conclusions stand out: the cluster of hematophags (schizophags) in the dendrogram corresponds with the group of similar species in association diagram. The same

may be stated for the cluster of predators. In the first case (cluster of hematophags) a special position is held by the species *E. stabularis*, in the second case (predators) by *E. emarginatus*. The cause must be seen in the predatory character of their nutritional habitus which partly separates them from the closely related species on one hand and mutually associates them, on the other.

The third basic cluster clearly seen in the dendrogram (scavengers) has no suitable counterpart in the association diagram, despite the association diagram based on analysis of pairs of species by means of contingency tables (Fig. 14, p. 81), which is somewhat richer as far as the number of included species is concerned.

This brief comparison reveals a general agreement in the results obtained by both methods on the one hand, and on the other, an enhanced accuracy and differentiation ability of the cluster analysis made by the method described in this paper (on the basis of Spearman's correlation matrix). Also the objectivity of the last mentioned method must be emphasized, because the erection of association diagram may be influenced subjectively (e.g. by the mode in which the two groups are graphically connected etc.).

In the paper by Daniel and Holubičková (1972) statistically significant associations between species are used for the assessment of mutual relationships among mesostigmatid mites. They are depicted graphically as edges (connecting lines) connecting vertices of the graph (i.e. individual species). In **Fig. 4** (p. 76) of the paper cited three marked groups of positive associations (edges) are seen at the highest level of 0.001. The first group mutually connects the species *Eugamasus remberti*, *Eugamasus sp.*, *Euryparasitus emarginatus* and *Cyrtolaelaps mucronatus*. The second group contains the species *Eulaelaps stabularis*, *Haemogamasus horridus*, *H. nidi* and *H. hirsutus*. The third group of associations connects the first and second groups, namely through the species *E. emarginatus* and *Eugamasus sp.* on the one hand, and *E. stabularis* on the other. Despite the fact that the results were obtained by different methods, a certain common agreement with the groupings of species can be stated not only in cluster analysis, but also in the determination of loadings (i.e. species of mites) loading individual factors in factor analysis (Table 2).

3. Comparison with results obtained in the analysis of other nest material by the same methods

This comparison was based on the results obtained in the analysis of the community of mesostigmatid mites from nests of the European suslik (*Citellus citellus*), published in the paper by Daniel and Albrecht (1985). The present comparison primarily aims to verify the degree of agreement in the results obtained, of their universality (nests of considerably different hosts are involved) and finally, to confront the conclusions made in free nature (in the case of *C. glareolus*) and in the long-term field experiment (*C. citellus*).

The two groups of mesostigmatid mites which have met the criteria for mathematical analaysis, include only two identical species (*Haemogamasus nidi*, *Eulaelaps stabularis*), both belonging to the subgroup of hematophags (schizophags). The other species are different, but closely related as far as their genus is concerned and their ecological characteristics are also very similar, dividing them into the subgroups of predators and scavenger. It is evident from the comparison of the results of cluster analysis: in both cases a distinct basic cluster of mites with direct relationship to host (conditioned by at least partial hematophagia) and separate clusters of mites of other nutrional character are formed in dendrograms. The species *E. stabularis* has a special position, oscillating between hematophags and predators. In *C. glareolus* nests providing a much more numerous material, a further subdivision of these mites into predators and scavengers, or further substructure of both these clusters is seen. On the contrary, in the dendrogram of mites coming from the suslik nests the gradual clustering of both sexes and developmental stages of respective species is better represented, illustrating thus their uniform reaction to environment. This can be regarded as a reflection of the fact that the mite group from the long-term field experiment with *C. citellus* nests is characterized by highly homogenous external conditions (biotope, localization of the nest, its size and bedding etc.), in contrast to the nest material of *C. glareolus* from free nature.

This difference also became manifest in the results of factor analysis. While four factors explain only 43 % of variability of frequencies of the group (as discussed above) in the *C. glareolus* nests, already three factors explain 64 % of total variability of the respective group in experimental *C. citellus* nests.

With all reservations to the comparison of the results obtained by such different methods it can be stated that the mites in both groups revealed many similar features of behaviour. Thus a general conclusion may be supported that in the total structure of nest community of mesostigmatid mites a whole complex of relationships is involved in which the nutritional specialization of mites plays a main role. Other factors affecting the community of mesostigmatid mites externally are of secondary importance.

At the same time it was demonstrated that the structure of the community of mesostigmatid mites detected in experimental *C. citellus* nests and analysed in the paper by Daniel and Albrecht (1985) was not a consequence of the arrangement of the experiment, but corresponded with natural conditions.

Conclusions

1. The dendrogram (Fig. 1), expressing the results of cluster analysis of 36 variables (i.e. 10 species with separately analysed females, males and nymphs and 3 species in which only data on females and nymphs were available) clearly shows three basic clusters formed by always complete species (as far as both sexes and developmental stages are concerned), with the exception of the species *Cyrtolaelaps mucronatus*.

2. Basic cluster can be interpreted by biology, primarily by the nutritional requirements of mites forming them: the cluster of hematophags (or schisophags as well), the cluster of predators and the cluster of saprophags (scavengers).

3. This arrangement illustrates the structure of nest community of mesostigmatid mites, the relationship of their members to host and interrelationships of the mites themselves.

4. The study of the structure of correlation matrix by means of factor analysis has indicated the importance of the first four factors for the explanation of variability of frequencies in the group studied. The difference between the four and five factors considered increases the explanation by 4 %, but the inclusion of the sixth and subsequent factors (up to 35) does not result in any substantial changes.

5. The study of factor loadings for three and four dependent factors has shown that factor 1, 2 and 3 is loaded by always identical species irrespective of the number of factors being three or four. The first factor is loaded by hematophagous (schisophagous) species, the second factor—by predators and the third factor—by saprophags (scavengers), confirming the results apparent in dendrogram (Fig. 1). The difference between the results of factor analysis with three and four factors begins to indicate a substructure of the group of predators, clearly seen in dendrogram.

6. Low values of correlations between 3 and 4 factors show that the nutritional specialization does not form a basis for the association between entire particular groups of mesostigmatid mites. This means that predators are not nutritionally dependent

on other mesostigmatid mites and that they feed on other components of the invertebrate fauna of nest community (e.g. larvae of fleas). This further explains why the results of factor analysis with independent and dependent factors have been almost the same.

7. The comparison with the results obtained by Fager's index of affinity (Daniel and Holubičková 1972) shows a common agreement on the one hand, but an increased accuracy and differentiating ability of cluster analysis based on Spearman's correlation matrix, on the other. It is further necessary to stress the complete objectivity of the last named method.

8. The comparison between the results obtained in the analysis of mite community from *C. glareolus* nests collected in free nature and the results obtained by analysing experimental *C. citellus* nests revealed a common harmony, but at the same time also some interesting discrepancies in details (Daniel and Albrecht 1985).

9. In the dendrogram of the group of mesostigmatid mites from the suslik nests the clustering of both sexes and developmental stages of respective species is better seen, manifesting their uniform reaction to the influence of environment. In the factor analysis in the *C. glareolus* nests four factors explain only 43% of variability of frequencies in the group studied, while in experimental nests of *C. citellus* as few as three factors explain 64 % of variability of frequencies of the relevant group. The two mentioned facts can be regarded as a reflexion of the situation in the group of mesostigmatid mites from experimental nests, characterised by highly homogenous external conditions, in contrast to the nests collected in free nature.

10. The comparison of the two groups supports the general conclusion that in the formation of the structure of nest community of mesostigmatid mites a whole complex of relationships is involved, in which the nutritional specialization of mites plays the main role. Other factors affecting the mite community externally are of secondary importance.

АНАЛИЗ МЕЖВИДОВЫХ ОТНОШЕНИЙ У МЕЗОСТИГМАТИЧЕСКИХ КЛЕЩЕЙ (ACARI: MESOSTIGMATA) В ГНЕЗДАХ РЫЖЕЙ ПОЛЕВКИ (*CLETHRIONOMYS GLAREOLUS* (SCHREBER, 1780))

М. Даниел и В. Альбрехт

Резюме. В работе дан анализ сообщества мезостигматических клещей из гнёзд рыжей полёвки, собранных в лесных биотопах гор Всетинске Бескиды (северная Моравия) в течение всех времён года. Главное внимание уделено структуре сообщества в гнёздах, отношениям клещей к их хозяину и межвидовым отношениям самых клещей. Для математической оценки использованы прежде всего кластерный и факторный анализы, исходящие из корреляционной матрицы. Отдельными элементами корреляционной матрицы были коэффициенты ранговых корреляций Спермана, вычисленные из частот видов в исследуемых гнёздах.

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Received 18 December 1984

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