

ECOLOGICAL NICHES OF DECOMPOSER ORIBATID MITES

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SUMMARY

In the beech litter of the biological reserve of La Tillaie, Fontainebleau Forest, *Achipteria coleoptrata* (Linné), *Nothrus silvestris* Nicolet and *Nanhermannia elegantula* (Berlese sensu Willmann 1931) are among the most abundant panphytophage oribatid mites present simultaneously. As their populations overlap and as they were present in greater numbers in the same F-layer, it seemed important to look at the possibility of identifying some of their ecological niche characteristics from periodical census data. This study shows well marked differences between these species in the annual pattern of either their spatio-temporal distribution or their female potential fecundity and adult feeding potential.

KEY WORDS : Oribatid mites - ecological niches - beech litter.

INTRODUCTION

Achipteria coleoptrata (Linné), *Nothrus silvestris* Nicolet and *Nanhermannia elegantula* (Berlese sensu Willmann 1931) are three panphytophage oribatid mites amongst the most abundant species occurring together in beech (*Fagus sylvatica* Linné) litter of the biological reserve of La Tillaie, Fontainebleau Forest. Being panphytophages, these species play an important role in the decomposition of the beech litter, feeding on the leaf material as well as on bacteria and fungi (Schuster 1956, Luxton 1972). Thus, as they were present in greater numbers in the same F-layer, it seemed important to examine the possibility of identifying some of their ecological niche characteristics from periodical census data. This

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subject was also approached in our communication to the IX International Colloquium on Soil Zoology, Moscow 1985 (Cancela da Fonseca 1987).

The plot studied has no herbaceous cover and its soil is a leached soil with a mull-moder type of humus (Bouchon et al. 1973). Four layers were sampled from May 1971 to May 1972; litter of the year (L), litter-fermentation layer (F), humus-mineral layer, A 11-H 0-3cm, and mineral layer, A 11 : 3-6 cm (Athias-Henriot and Cancela da Fonseca 1976).

On this soil the annual mean density of oribatid mites is not very high, only about 16450/m² (Athias-Henriot and Cancela da Fonseca 1976), of which about one fourth (3750/m²) corresponds to the annual mean density of the three species : *A. coleoptrata*, 2250/m²; *N. silvestris*, 1050/m²; and *N. elegantula*, 450/m².

SPATIAL AND TEMPORAL NICHE COMPONENTS

Although *N. elegantula*, *N. silvestris* and *A. coleoptrata* coexist on a square meter area, coexistence is not necessarily observed on a smaller area, the sample-unit area (20 cm²), which is more related to the size and the average low rate of daily movement of this category of oribatid mites (Berthet 1964, Lebrun 1965). Thus, on only 14-19% of the sample-units with at least one of these species present (183 out of 416, i.e. 44%) two species were present simultaneously, and on only about 8%, three. The concurrence of two or three species was more frequent in the F and A11-H layers where the density of all the species but *A. coleoptrata* in A11-H is higher : for the doubles about 10% of the sample-units in F and 2-6% in A11-H and for the triples about 6% in F and 2% in A11-H. No species coexistence was observed in the mineral layer.

Analysis of the coexistence of the species by the two by two contingency table method (Annex 1; Fisher 1958, Dagnelie 1960, Cancela da Fonseca 1966), can show whether this association is statistically significant or not and if it is positive or negative : positive if the species have some niche affinities, negative if not (Table 1). In the litter fermentation layer (F), the association *N. elegantula*-*N. silvestris* is positive but not significant. It agrees with the highest spatial niche overlap estimated (Pianka's index), the more similar vertical distribution, and the identical feeding preferences. However, the associations *N. elegantula*-*A. coleoptrata* and *N. silvestris*-*A. coleoptrata* in the same layer (F) are significant but negative, the highest value being for *N. silvestris*-*A. coleoptrata*. Again, it agrees with the lowest Pianka's niche overlap index, and the

different patterns of vertical distribution and feeding preferences. In the humus-mineral layer A11-H, for the three associations, the type of association is not significant : almost null for *N. elegantula*-*N. silvestris* and negative for the two other associations.

Table 1. Significance of the sample-units with two species association :

Species association	Layers		Association	F 88 (sample-units) X ²	Significance
	C ₁₁	C ₁₁			
<i>N. elegantula</i>	17	13.4	C ₁₁ > C ₁₁	1.87	N.S.
<i>N. silvestris</i>			Positive		
<i>N. elegantula</i>	17	22.6	C ₁₁ < C ₁₁	6.01	*
<i>A. coleoptrata</i>			Negative		
<i>N. silvestris</i>	19	26.1	C ₁₁ < C ₁₁	9.66	* *
<i>A. coleoptrata</i>			Negative		

Both species present : C₁₁ - observed

C₁₁ - calculated

X² (P=0.05)=3.84 X² (P=0.01)=6.34 X² (P=0.001)=10.83

The vertical distribution pattern of the three species differs (Table 2) when synthesized by Usher's mean depth (Annex 2; Usher 1975) and by Lebrun's vertical distribution (DV) index (Annex 3; Lebrun 1971). Though *N. elegantula* and *N. silvestris* are both mainly present in the F and the All H layers, *N. elegantula* is more a litter species than *N. silvestris* which seems more indifferent to the depth-organic matter factor. On the contrary, *A. coleoptrata* is typically a litter species, being much more abundant in the L-layer than the other two species. The mean depths of *N. elegantula* and *N. silvestris* (layer 2.20 and 2.50) were significantly different from that of *A. coleoptrata* (layer 1.77) for the 13 months of observation, but for the same period the mean depth for *N. elegantula* was not significant, however, for the period between May 1971 and January 1972 (Table 2), which is indicated by the temporal variation of the mean depth (Table 3).

These different patterns in the vertical distribution of the species can be translated in terms of spatial niche overlap measured by the

Pianka's Oij index (Annex 4; Pianka 1973) or by some other index, such as those which take into account the measure of species diversity, and the total and average diversity by cenotic level (Annex 5; Colwell and Futuyma 1971, Pielou 1972, Cancela da Fonseca 1984).

Table 2. Vertical distribution of *N. elegantula*, *N. silvestris* and *A. coleoptrata*

Vertical layers	<i>N. elegantula</i> (NEL)	<i>N. silvestris</i> (NSI)	<i>A. coleoptrata</i> (ACO)
1 (L)	4.40%	1.88%	30.80%
2 (F)	72.52%	50.23%	62.28%
3 (A11-H)	21.98%	44.13%	6.25%
4 (A11)	1.10%	3.76%	0.67%
DV index	23.08%	47.89%	6.92%
Mean depth (13 months)	2.20	2.50	1.77
Mean depth (9 months)*	2.24	2.51	1.81

* May 1971 to January 1972

Analysis of the differences between mean depths by the Friedman test (Siegel 1956) :

13 Months

NEL versus NSI $X^2 = 3.77$ Not significant

NEL versus ACO $X^2 = 6.23$ Significant ($P < 0.05$)

NSI versus ACO $X^2 = 9.31$ Highly significant ($P < 0.01$)

9 Months

NEL versus NSI $X^2 = 7.11$ Highly significant ($P < 0.01$)

Table 3. Temporal variation of the mean depth of *N. elegantula*, *N. silvestris* and *A. coleoptrata* (May 1971 to May 1972)

Months	<i>N. elegantula</i>	<i>N. silvestris</i>	<i>A. coleoptrata</i>
1971 May	2.17	2.83	1.67
June	2.50	2.52	1.56
July	2.00	2.00	1.50
August	2.00	2.31	1.52
September	2.33	2.51	2.43
October	2.33	2.57	2.13
November	2.56	2.72	1.67
December	2.00	2.22	1.73
1971 January	2.67	2.95	2.95
February	2.67	2.00	1.94
March	2.00	2.00	2.16
April	2.10	1.83	1.67
May	1.83	2.08	1.63

In terms of Pianka's index, the highest average annual niche overlap over the four layers is that of the niches of *N. elegantula* and *N. silvestris* (about 60%) and the lowest that of the niches of *N. silvestris* and *A. coleoptrata* (about 40%) (Table 4). The temporal evolution of these niche overlaps shows a succession of peaks from July to October of the three pairs of species (*N. elegantula*-*N. silvestris*, *N. silvestris*-*A. coleoptrata*, *N. elegantula*-*A. coleoptrata*), and a dominance of the niche overlap of *N. elegantula*-*N. silvestris* from January to April (Table 5). But, if by the same index we take into account the global annual niche overlap over the four layers or over the totals (the four layers together) month by month, their values are much higher (Table 6) which indicates that the earlier monthly estimate over the four layers is the better one, i.e., a more realistic way of measuring the interspecific coexistence.

The overall estimate based on the diversity index shows that the niche overlap of the three species together is very high (about 84%). The overall niche width based on the average cenotic diversity index (86%) is similarly high. However, in terms of the measure of each species niche width through the measure of its cenotic diversity index (Levins 1968, Barbault 1981), *N. elegantula* is the species with the lowest niche width (0.531) while *N. silvestris* has the highest (0.619), *A. coleoptrata* being in between (0.594).

Table 4. Annual mean of the spatial niche overlap (four layers) of *N. elegantula*, *N. silvestris* and *A. coleoptrata*, two by two (Pianka's index, Oij)

Pairs of species	Annual mean \pm Standard deviation
<i>N. elegantula</i> — <i>N. silvestris</i>	0.583 \pm 0.224
<i>N. elegantula</i> — <i>A. coleoptrata</i>	0.489 \pm 0.177
<i>N. silvestris</i> — <i>A. coleoptrata</i>	0.428 \pm 0.212

Table 5. Temporal variation of the spatial niche overlap (four layers) of *N. elegantula*, *N. silvestris* and *A. coleoptrata*, two by two (Pianka's index Oij)

Months	Pairs of species		
	<i>N. elegantula</i> <i>N. silvestris</i>	<i>N. elegantula</i> <i>A. coleoptrata</i>	<i>N. silvestris</i> <i>A. coleoptrata</i>
1971 May	0.576	0.588	0.215
June	0.139	0.251	0.149
July	0.883	0.377	0.304
August	0.460	0.467	0.572
September	0.503	0.633	0.938
October	0.599	0.803	0.547
November	0.685	0.554	0.220
December	0.430	0.307	0.474
1972 January	0.762	0.545	0.289
February	0.619	0.363	0.459
March	0.958	0.448	0.473
April	0.667	0.266	0.597
May	0.299	0.751	0.331
Mean	0.583	0.489	0.428

Table 6. Spatial niche overlap of *N. elegantula*, *N. silvestris* and *A. coleoptrata* : annual mean (four layers), annual (13 months) and global (annual totals, four layers) (Pianka's index O_{ij})

Pairs of species	Annual mean	Annual	Global
<i>N. elegantula</i> — <i>N. silvestris</i>	0.583	0.641	0.759
<i>N. elegantula</i> — <i>A. coleoptrata</i>	0.489	0.826	0.740
<i>N. silvestris</i> — <i>A. coleoptrata</i>	0.428	0.662	0.436

Another interesting way to compare the two closest species, *N. elegantula* (NEL) and *N. silvestris* (NSI), and to reduce their different annual behaviour to a common basis, is by means of the diversity index, taking into account that the community formed by the two species is constituted by ten instars, five for each species : larva, protonymph, deutonymph, tritonymph and adult. In this way, and with the Shannon-information diversity index, $H(S)$ distinct differences can be seen (Figure 1), even if for some two months the overall diversity index is similar : June and July 1971, $H(S) = 2.76$ and $H(S) = 2.74$. Nevertheless, the individual values for each species separates them : June - $H(S) \text{ NEL} = 0.79$ and $H(S) \text{ NEL} = 1.97$; and $H(S) \text{ NSI} = 1.71$; and July - $H(S) \text{ NES} = 1.71$ and $H(S) \text{ NSI} = 1.03$ (Cancela da Fonseca 1980 a).

The temporal component of the ecological niches of the three species was made evident by a multivariate analysis method : correspondence analysis (Figure 2; Cancela da Fonseca 1980 b). Thus, in early autumn the juveniles of *N. elegantula* were absent, from late autumn to late spring an absolute dominance of the juveniles of *A. coleoptrata* was observed, and in summer some of the stages of *N. silvestris* were present in significant numbers (deutonymphs and tritonymphs) or absent (larvae and adults).

FEMALE POTENTIAL FECUNDITY NICHE COMPONENT

The maximum number of eggs a gravid female can carry depends on the size of the female (Webb and Elmes 1979). Thus, the maximum observed inside *N. elegantula* was three, compared with four inside *N. silvestris* and *A. coleoptrata*. As not all the females had eggs, the average number of eggs per female is lower than the mean number of eggs per gravid female : *N. elegantula*, 0.7 versus 1.3; *N. silvestris* versus 2.1; and, *A. coleoptrata*, 2.1 versus 2.5.

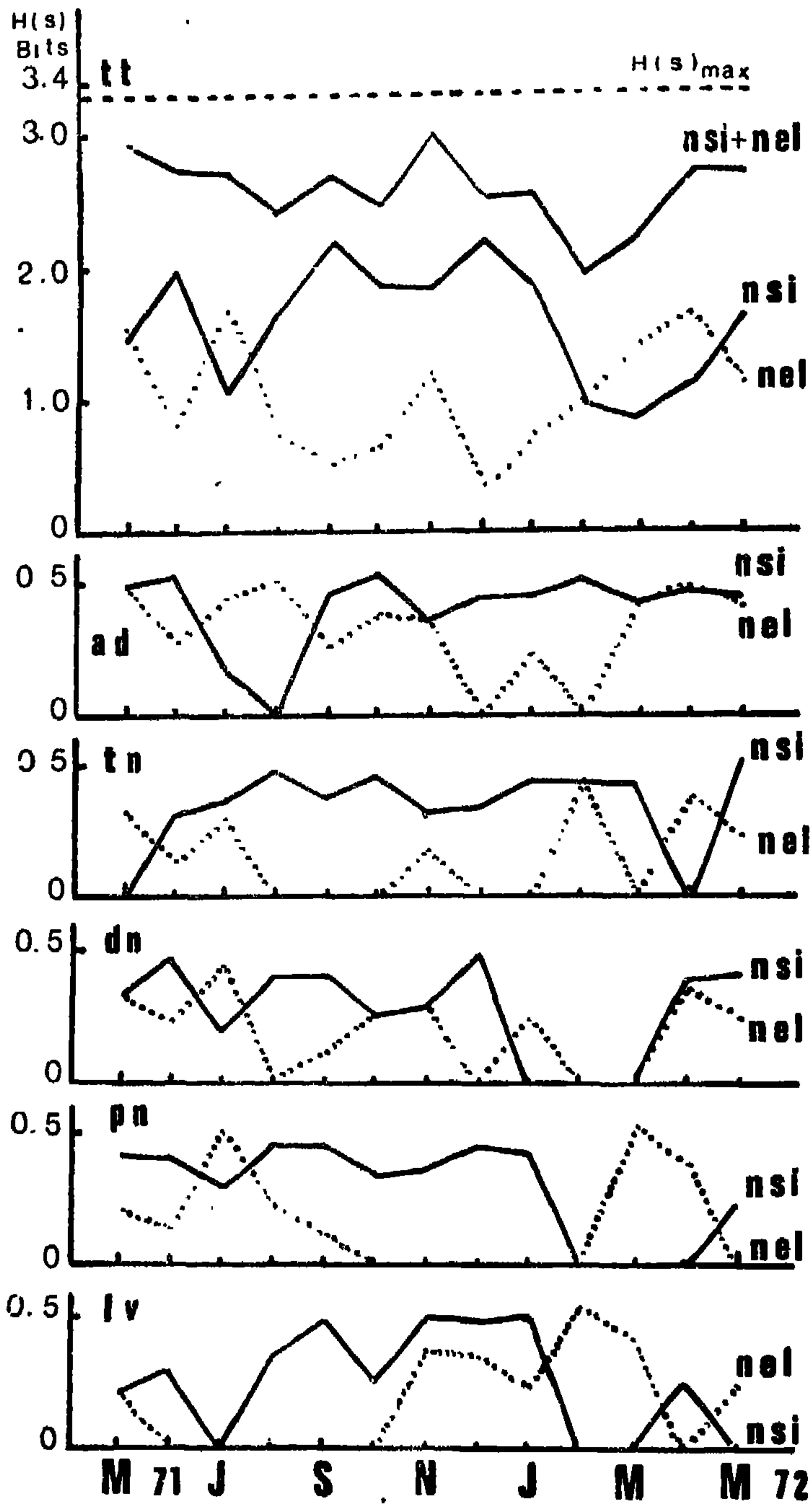


Figure 1. Temporal variation of the intraspecific diversity of the community *N. elegantula*-*N. silvestris* (NEL-NSI) (From Cancela da Fonseca 1980 a). - TT : total of the instars; AD : adults; TN : trity nymphs; DN : deutonymphs; PN : protonymphs; LV : larvae.

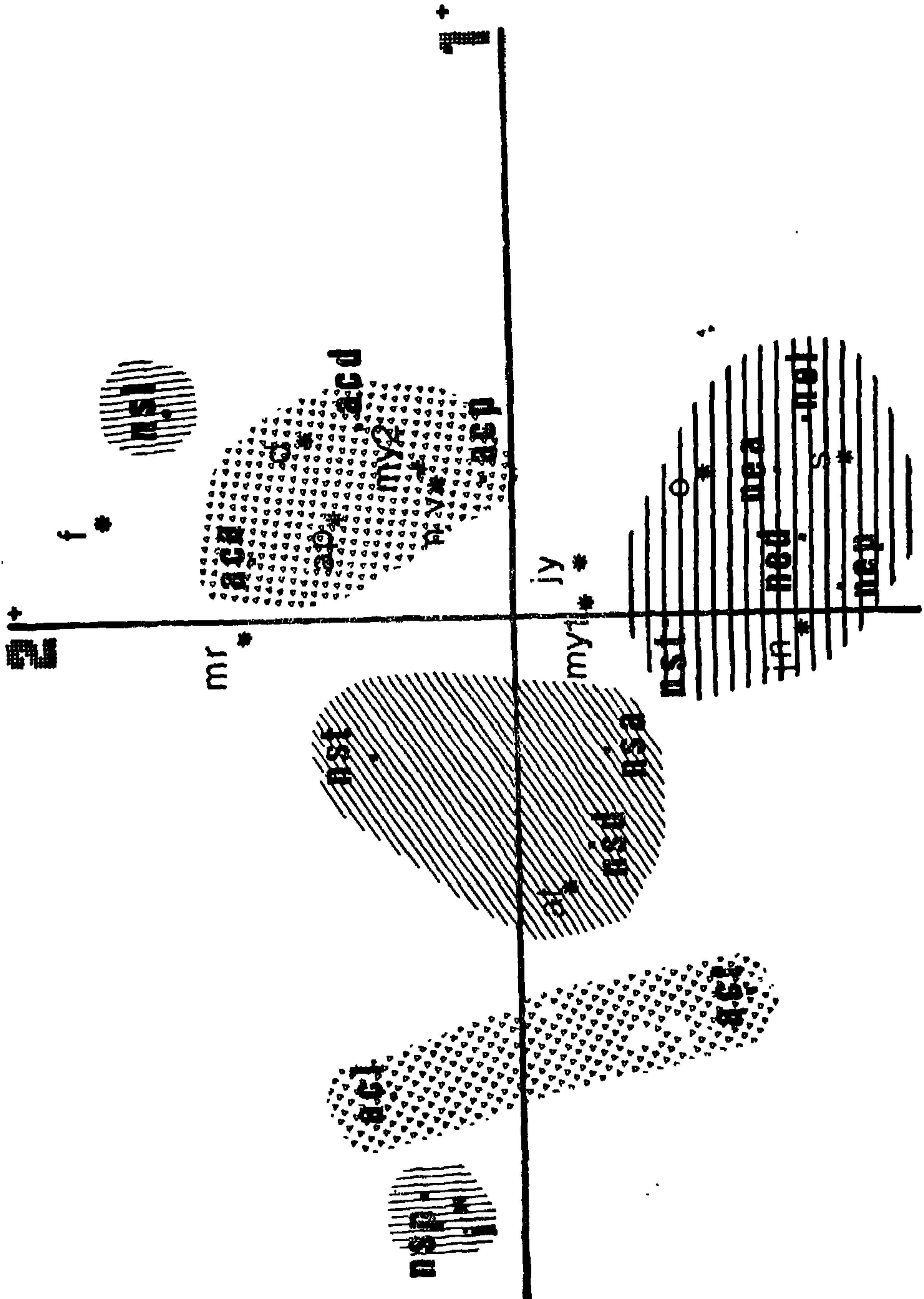


Figure 2. Temporal component of the spatial (ecological) niches of the species *N. elegantula* (NE), *N. silvestris* (NS) and *A. coleoprata* (AC) put in evidence by the correspondence analysis (From Cancela da Fonseca 1980 b). - . . A : adults; . . T : tritonymphs; . . D : deutonymphs; . . P : protonymphs; . . L : larvae.

The mean number of eggs per female (with or without eggs) varies throughout the year and permits a rough estimate of the number of eggs laid per month and per square meter (Table 7). The mean number of eggs per female was highest for *N. elegantula* and *N. silvestris* in spring and early summer and for *A. coleoptrata* in winter and spring. This agrees with observations made in a Danish beech woodland (Luxton 1981 a). The density of females is also at a maximum at the same periods, so that the potential number of eggs laid attains the maximum values, i.e., about 400 in May 1971 for *N. elegantula* (annual mean, 121/m²), about 3000 in June 1971 for *N. silvestris* (annual mean, 393/m²), and about 2000 in February 1972 for *A. coleoptrata* (annual mean 637/m²).

We must point out that *N. elegantula* and *N. silvestris* are «inferior» oribatids, not very far from one another from systematic point of view, and are parthenogenetic, with only females present. But *A. coleoptrata* is a «superior» oribatid and is bisexual, an important biological difference from the other two species. Thus, although the number of females of *A. coleoptrata* varies from month to month as for the other two species, the number of males also varies, which implies a wide range of mating probabilities. The sex ratio went from zero (only males) in October 1971 to 0.83 (females more abundant) in September 1971; at other times, the sex ratio was about 0.40-0.50 (Table 8).

ADULT FEEDING POTENTIAL NICHE COMPONENT

The number of food boli present in the gut gives an indication of the feeding activity of the species (Mitchell and Parkinson 1976).

For *N. silvestris* the highest mean numbers of food boli were observed during winter and spring (January-May 1972 : 2.25-3.00 boli per female) and the lowest values in autumn (October-November 1971 : 0.57 and 0.33 boli per female). For *N. elegantula* and *A. coleoptrata* females the lowest values were observed first in September 1971 (0.25 and 0.40 respectively) and afterwards in January 1972 (1.00 and 0.50) with a peak (1.67 and 1.14) in November 1971 when the lowest value (0.33) for *N. silvestris* was observed. The striking difference between *N. elegantula* and *A. coleoptrata* was that the mean number of food boli was greater in *A. coleoptrata* during the spring and the summer (May to September 1971) and in *N. elegantula* from autumn to early spring (October 1971 to April 1972) (Table 9).

Table 7. Temporal variation of the potential number of eggs laid per square meter by *N. elegantula*, *N. silvestris* and *A. coleoptrata*

Months	<i>N. elegantula</i>		<i>N. silvestris</i>		<i>A. coleoptrata</i>	
	Mean number of eggs/ ♀ laid	number of eggs laid	Mean number of eggs/ ♀ laid	number of eggs laid	Mean Number of ♀	Number of eggs/ laid
1971 May	1.20	378	2.20	693	2.25	563
June	0.67	127	2.47	2939	2.50	625
July	1.00	315	2.00	130	1.80	567
August	0.80	252	—	—	0.25	63
September	0.50	125	0.25	188	1.00	315
October	0	0	0.29	128		
November	0.67	127	0	0	1.86	818
December	—	—	0	0	2.00	1000
1972 January	0	0	0	0	3.00	375
February	—	—	2.00	250	2.07	1811
March	1.00	65	1.00	65	3.00	375
April	0.25	63	1.67	317	2.57	1131
May	0.33	63	1.75	438	3.83	1436

0 : females present without eggs

— : no females present

Table 8. Sex ratio (females/total adults) of *A. coleoptrata*

Months	Sex ratio
1971 May	0.80
June	0.57
July	0.56
August	0.44
September	0.83
October	0
November	0.41
December	0.50
1972 January	0.50
February	0.61
March	0.40
April	0.47
May	0.46

Table 9. Temporal variation of the mean number of food boli present per adult of *N. elegantula*, *N. silvestris* and *A. coleoptrata*

Months	<i>N. elegantula</i>	<i>N. silvestris</i>	<i>A. coleoptrata</i>	
	Females	Females	Females	Males
1971 May	2.00	2.20	2.25	1.00
June	1.67	1.79	2.25	1.67
July	1.40	2.00	1.40	1.50
August	1.40	--	2.00	1.20
September	0.25	1.92	0.40	3.00
October	1.00	0.57	--	0
November	1.67	0.33	1.14	1.60
December	--	1.50	0.88	1.38
1972 January	1.00	2.25	0.50	1.00
February	--	2.50	0.71	1.56
March	2.00	3.00	1.00	1.33
April	1.75	2.67	0.71	1.00
May	0.67	2.25	1.33	1.43

0 : Adults present without food boli -- : No adults present

DISCUSSION AND CONCLUSIONS

Although *N. elegantula*, *N. silvestris* and *A. coleoptrata* occur together and are most abundant in the F layer, some significant differences are evident in their vertical distribution. *A. coleoptrata* is more attracted by the litter of the year (litter-dwelling species) than the other two species, while *N. elegantula* is attracted primarily by the fermentation layer and secondly by the humus-mineral layer (sub-litter-dwelling species), and *N. silvestris* is present in almost the same proportions in the F and the A11-H layers (indifferent-dwelling species). This agrees with the observations made by other authors (Van Der Drift 1951, Anderson 1971, Luxton 1981 b, and some others).

Tough *N. elegantula* is smaller (590 x 255 μ) than *N. silvestris* (760 x 405 μ) their vertical colonization of the substrate seems not to be directly correlated with the lower porosity of the humus-mineral layer. (It is interesting to note that the length of *A. coleoptrata* - 600 μ - is close to that of *N. elegantula* and that its width - 395 μ - is closer to that of *N. silvestris*).

In terms of vertical distribution, *N. elegantula* and *N. silvestris* are closer to each other than to *A. coleoptrata*, their niche overlap index being the highest observed and their type of association positive though not significant. In terms of mean number of eggs per gravid female, *N. silvestris* and *A. coleoptrata* are closer to each other (2.10 versus 2.50) than to *N. elegantula* (1.26). However, the fecundity tendency and the potential number of eggs to be laid are at a maximum for *N. elegantula* and for *N. silvestris* at the same season (spring and early summer) while for *A. coleoptrata* they are later in the year, and are more evenly spread during the winter and the spring. The three species are clearly differentiated by their patterns of fecundity.

Trophic differences also characterise the ecological niches of these species, although the census data do not clearly reflect these differences. However, counts of food boli present in the gut at different times of the year illustrate differences that suggest the season when suitable food is available. The best feeding months seem to be those of winter and spring for *N. silvestris*, and those of spring and summer for *N. elegantula* and *A. coleoptrata* females. For *A. coleoptrata* males no dominant season was detected.

Anderson (1975) found some evidence that the trophic separation of oribatid mites was related to their mean body size, as is the case for the panphytophage species *N. elegantula* and *N. silvestris*. Nevertheless, other trophic differences between these two species that conform with differences in their vertical distribution were found experimentally in the laboratory (Kiffer and Cancela da Fonseca 1971).

In the presence of pure cellulose attacked by cellulolytic fungi, and of the soil underneath, *N. elegantula* was 2.5 times more numerous on the cellulose than in the soil and 1.3 times more numerous on this substrate (cellulose) than *N. silvestris*. On the other hand, in the soil, *N. silvestris* was about 4 times more numerous than on the cellulose and about 7 times more numerous than *N. elegantula*. Although the preferred cellulolytic fungus for both species seemed to be the fungus *Oidiodendron chinulatum* Barron, *N. elegantula* was secondarily more attracted by *Chrysosporium pannorum* (Link) Hughes, and *N. silvestris* by *Cordana pauciseptata* Preuss (Cancela da Fonseca et al. 1979).

According to Luxton (1972), *N. silvestris* feeds preferentially on beech leaves, black sterile mycelium and *Cryptococcus albidus* (Saito) Skinner and is not attracted by *Phoma* sp. and *Aureobasidium pullulans* (de Bary) Arnaud, common on the surface litter (L layer). On the other hand, *A. coleoptrata* strongly prefers the last two fungi, together with the black

sterile mycelium and *C. albidus*. It follows that the localization of *A. coleoptrata* in the L layer and that of *N. silvestris* in the fermentation zone (F layer) can be predicted by these feeding preferences (Luxton 1981 b).

The type of microhabitats, with their spatial and food characteristics, is certainly one of the most important factors in the separation of the ecological niches of soil oribated mites. These microhabitats are normally distributed in a mosaic (Anderson 1977), so that *A. coleoptrata*, *N. silvestris* and *N. elegantula* can easily coexist.

Annexe 1. Measure of the degree of species association by the contingency table method (Fisher 1958, Dagnelle 1960, Cancela da Fonseca 1966)

		SPECIES A		
		PRESENCE	ABSENCE	TOTAL
S P E C I E S	PRE			
	SEN	c11	c12	t10
B	CE			
	AB			
	SEN	c21	c22	t20
	TO			
	TAL	t01	t02	n

Where n is the number total of samples (observed) :

$$n = c11 + c12 + c21 + c22$$

The statistics is

$$X^2 = \frac{n (c11 \cdot c22 - c12 \cdot c21 - n/2)^2}{t10 \cdot t01 \cdot t20 \cdot t02}$$

To measure the association we must compare the c11 observed with a calculated C11 :

$$C11 = t10 \cdot t01/n$$

Then, for

$c11 > C11$ the association is positive

$c11 = C11$ the association is null

$c11 < C11$ the association is negative

Annexe 2. Vertical distribution of the soil species : mean depth parameter (Usher 1975).

$$\text{Mean depth} = M = \frac{\sum_{i=1}^k di \cdot ni}{N}$$

Where :

k is the number of layers

di is the (relative) depth of the i th layer (the depth of the centre of the i th layer)

ni is the number of individuals of the species in the i th layer

N is the total number of individuals of the species in the k layers of the sample

Annexe 3. Soil species vertical distribution index (Lebrun 1971)

$$DV\% = \frac{D.CI}{D.CI + D.CS} \times 100$$

Where :

D. CI is the species density in the lower layer

D. CS is the species density in the upper layer

$0 \leq DV \leq 20\%$ Litter species

$20 < DV \leq 40\%$ Sublitter species

$40 < DV \leq 60\%$ Inriferent species

$60 < DV \leq 80\%$ Humus species

$80 < DV \leq 100\%$ Subhumus species

Annexe 4. Pianka's niche overlap index (Pianka 1973)

$$O_{ij} = \frac{\sum_{h=1}^k p_{ih} \cdot p_{jh}}{\sqrt{\sum_{h=1}^k p_{ih}^2 \cdot \sum_{h=1}^k p_{jh}^2}}$$

Where :

$$p_{ih} = \left(\frac{N_i}{N_i + N_j} \right)_h \quad p_{jh} = \left(\frac{N_j}{N_i + N_j} \right)_h$$

are the probabilities of occurrence of the species i and j on the resource h

N_i is the number of individuals of the species i

N_j is the number of individuals of the species j

$h = 1, 2, \dots, k$ are the resources

Annexe 5. Measure of the niche overlap and the niche width by the Shannon - information diversity index (Levins 1968, Colwell and Futuyma 1971, Pielou 1972, Barbault 1981, Cancela da Fonseca 1984).

1. Overall niche overlap :

$$L = \frac{HT(S)}{H(S)} \quad 0 \leq L \leq 1$$

2. Overall niche width :

$$W = \frac{HS(T)}{H(T)} \quad 0 \leq W \leq 1$$

3. Species niche width :

$$A'_s = \frac{e^{H(T)} i}{h} \quad (\text{Levins 1968, Barbault 1981})$$

4. Species diversity (i species) :

$$H(S) = - \sum_i P_i \ln P_i$$

5. Cenotic diversity (j cenotic levels) :

$$H(T) = - \sum_j Q_j \ln Q_j$$

$H(T)_i$ is the cenotic diversity of each species i , separately

6. Average species diversity by level :

$$HT(S) = - \sum_j Q_j \sum_i q_{ij} \ln q_{ij}$$

7. Average cenotic diversity by species :

$$HS(T) = - \sum_i P_i \sum_j p_{ij} \ln p_{ij}$$

8. Where :

$P_i = N_i/N$ is the marginal probability of occurrence of each species i

$Q_j = N_{.j}/N$ is the marginal probability of the species occurrence in each level j

$p_{ij} = N_{ij}/N_i$ is the conditional probability of occurrence of the same species i in all levels j

$q_{ij} = N_{ij}/N_{.j}$ is the conditional probability of occurrence of all species i in the same level j

N_i is the total number of individuals of the species i

$N_{.j}$ is the total number of individuals of all species i in the same level j

N_{ij} is the number of individuals of the species i present in the level j

N is the total number of individuals in the ecological system, all species together

h is the number of levels (=resources)

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الخانات البيئية لأنواع اللحم الأوريباتيدية المفككة للنثار

اعداد

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جامعة باريس (V)

يختص هذا البحث بدراسة تواجد ٣ أنواع من اللحم الأوريباتيدية المفككة في طبقات النثار والدبال والتربة المعدنية السفلية . وتتواجد هذه الأنواع مع بعضها في كل من هذه الطبقات الثلاث بنسب تختلف من شهر الى آخر على مدار العام . ولذا كان من الضروري دراسة امكانية التعرف على خصائص خاناتها البيئية وكيفية اختلافها انطلاقا من المعطيات الاحصائية التي توفرت من جمع العينات . وقد أظهرت الدراسة اختلافات واضحة بين الأنواع الثلاثة في أنماط التوزيع المكاني والزمني وفي خصوبة الاناث وفي المواسم المناسبة للاغتذاء كذلك في أنواع الفطر المفضلة كغذاء .

لذلك يعتبر نوع البيئة الموضعية على المستوى الجهري ، بما ينطوى عليه من اختلافات في الفجوات المتاحة للحركة وفي توزيع الغذاء العضوي، عاملا هاما في الفصل بين الخانات البيئية لأنواع اللحم الأوريباتيدية المفككة للنثار في طتقات التربة المختلفة . وحيث أن هذه البيئات الموضعية المجهرية موزعة في طبقات التربة بشكل متداخل ، فمن الممكن لهذه الأنواع الثلاثة من اللحم أن تتواجد معا بسهولة في المساحات التي تقرب من المتر المربع ، ولكنها قلما تتواجد معا في مساحات العينات المأخوذة بمساحة ٢٠ سم ٢ .

ويبين هذا البحث أهمية استخدام الأساليب الاحصائية المتقدمة لمعالجة المعطيات ، مثل أسلوب التحليل التوافقي ، في استشفاف العلاقات بين الأنواع الحيوانية وبيئاتها على المستوى الجهري ، انطلاقا من جداول بيانات غير واضحة من حيث العلاقات البيئية المتداخلة ، والتي لا يمكن استقراؤها من مجرد قراءة أرقام هذه الجداول .