

Notes on spiders from tree trunks of different bark texture; with indices of diversity and overlap

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Summary

The numbers of individuals of spiders trapped on tree trunks appear to show a correlation with the degree of cracking of the bark for the same species of tree, but vary from one kind of tree to another.

Two relatively simple measures of diversity are illustrated which yield a quantitative estimation of the dispersion of a species between different habitats.

A simple measure of overlap is illustrated which gives a quantitative impression of the extent to which two species share their habitat ranges.

Introduction

The crevices of tree bark, depending on size and complexity, provide a sheltered habitat for spiders and other invertebrates. The cracks may act as micro-habitats where the animals are not subjected to exposure to adverse conditions of temperature and humidity, as well as possible protection from predators. A study of the arachnid fauna of tree trunks carried out in the winter months of 1971-72 has given some indication of a correlation between the number of spiders and the amount of cracking of the bark. Some simple indices of diversity and overlap are applied to the data; these indices are easy to calculate and may be some use to other collectors in comparing species distributions or habitat faunas.

The work described here was carried out in woodland on the island of Inchcailloch in the Loch Lomond National Nature Reserve. This island is located about 500m off Balmaha Bay and is approximately 1400m long with a maximum width of 600m. Because of the absence of grazing stock since the end of the last century, the island bears some of the best natural deciduous woodland remaining in Scotland today, consisting predominantly of oak. The traps used to sample the tree trunk populations were of the corrugated paper type which Duffey (1969) used to investigate seasonal movements of clubionids.

Nine trees were sampled — 3 mature and 1 young oak (*Quercus* sp.), 3 birch (*Betula pubescens*), 2 Scots pine (*Pinus sylvestris*) — located at five sites on the island. On each tree a strip of brown corrugated paper approximately 22cm wide was wrapped twice around the trunk about 1.5m above the ground. Each trap was held in place by string and two nails upon which it rested to prevent it slipping down the trunk. In addition, 10cm wide grease bands coated with adhesive resin were wrapped around the outside of the traps. The corrugations in the paper provided refuges for many small invertebrate animals and presumably function as extra "cracks and crevices in the bark". Each tunnel formed by the corrugations measured about 3 x 3 mm across; this imposes a maximum size limit on spiders taking shelter in the paper.

At weekly or fortnightly intervals, the corrugated paper traps and grease bands were removed and replaced by fresh ones. Each old trap was returned to the laboratory along with any disturbed specimens. Removal of invertebrates followed anaesthetization with chloroform and the careful stripping of the backing paper to expose the tunnels. Those arachnids evident on the grease bands were extracted and cleaned with acetone. The spiders were identified using the keys of Locket and Millidge (1951, 1953) and nomenclature follows theirs. The phalangids and pseudoscorpions were determined with the aid of Savory (1948) and Evans and Browning (1954) respectively.

Observations on tree trunk spiders

The captures from the traps are listed in Table 1. A total of 22 species of spiders were taken, as well as some specimens rendered unidentifiable by immaturity or damage. Two species of phalangids and one pseudoscorpion species were also taken. Nineteen araneid species were found in the corrugated paper; of these species, six were also taken on the grease bands. The grease band captures included nine spider species. There was a marked difference in the sex ratios of the adult spiders caught in the corrugated paper traps (sex ratio 0.6♂: 1♀) and those from the grease bands (5.5♂: 1♀). Possibly this reflects a greater tendency on the part of the males to move about more on the exposed surfaces of the bark and for the females to remain sheltered in the cracks.

Species	Corrugated paper		Grease bands	
	Nos.	Sites	Nos.	Sites
<i>Ciniflo fenestralis</i> (Stroem)	3♂ 19♀ 50imm(4)	1,2,3	1imm	2
<i>Harpactea hombergi</i> (Scopoli)	2♂ 3♀	1,2		
<i>Segestria senoculata</i> (Linn.)	1♀	2		
<i>Clubiona compta</i> C.L.Koch	1♂ 2 imm	2	1♂	2
<i>Anyphaena accentuata</i> (Walckenaer)	3♂ 4♀ 2 imm(1)	1,3,4,5		
<i>Xysticus (lanio?)</i> C.L.Koch	1 imm	1		
thomisid (damaged)	1♀	5		
<i>Cryphoea silvicola</i> (C.L.Koch)	37♂ 46♀ 18imm	1,2,4	12♂ 5imm	1,4
<i>Robertus lividus</i> (Blackwall)	1imm	4		
<i>Tetragnatha montana</i> Simon	2♀	1,4	1imm	2
<i>Tetragnatha (obtusa?)</i> C.L.Koch			2imm	2
immature argiopid			1	1
<i>Araneus umbraticus</i> Clerck	2♀	1,2		
<i>Ceratinella brevipes</i> (Westring)	1♂	4		
<i>Gonatium rubellum</i> (Blackwall)	1♀	4		
<i>Lophocarenum nemorale</i> (Blackwall)	1♀	1		
<i>Thyreosthenius parasiticus</i> (Westring)	1♂ 2♀	3,4		
<i>Monocephalus fuscipes</i> (Blackwall)	1♂ 2♀	4		
<i>Savignia frontata</i> (Blackwall)			2♂	2
<i>Diplocephalus cristatus</i> (Blackwall)			6♂ 1♀	4
<i>Caledonia evansi</i> O.P.-Cambridge	2♀	4		
<i>Drapetisca socialis</i> (Sundevall)	1♂ 3♀	1,2	1♀	2
<i>Lepthyphantes alacris</i> (Blackwall)	1♀	2	1♀	1
<i>Linyphia peltata</i> Wider	2♂ 1♀ 5imm	1,4		
immature linyphiids	3	1	6	1,2,3
unidentifiable (damaged or imm.)	4	1,2,4	21	1,2,3,4
<i>Megabunus diadema</i> (Fabricius)	9	1,2,5		
<i>Oligolophus hansenii</i> (Kraepelin)			1	2
<i>Chthonius (tetrachelatus?)</i> (Preyssler)	3	3		

Table 1: List of captures from corrugated paper traps and grease bands.

Numbers of arachnids captured in corrugated paper traps and on grease bands on trees at the five different sites. Numbers in brackets refer to individuals displaced from traps on removal, counted but not caught.

Site 1 – in open woodland; some bracken and bramble; altitude 40m; soil: brown podzol on serpentine rock.

Site 2 – on North Hill amongst Scots pine; some bracken, heather and blaeberry; altitude 61m; soil: peaty ranker on sandstone.

Site 3 – exposed on burnt heather and tufted grass on Tom Na Nigheann summit; altitude 85m; soil: as site 2.

Site 4 – in South Central Valley in deciduous woodland with oak, hazel, bramble, bracken; altitude 27m; soil: brown podzol on sandstone and conglomerates.

Site 5 – near north coast of island, 8m from lochside in open oak woodland with bramble; altitude 9m; soil: gleys on mixed colluvium and drift.

Species No.	Species	% of total	B_i	B_i'
1	<i>Cliniflo fenestralis</i>	29.56	4.26	0.64
2	<i>Segestria senoculata</i>	0.44	1.00	0
3	<i>Anyphaena accentuata</i>	8.21	6.36	0.81
4	<i>Cryphoea silvicola</i>	39.86	3.01	0.55
5	<i>Drapetisca socialis</i>	1.68	2.03	0.30
6	<i>Lepthyphantes alacris</i>	0.22	1.00	0

Table 2: Relative proportions and diversity indices for some spiders taken in corrugated paper traps. Percentage of total catch, Levins index of diversity (B_i) and Shannon index (B_i'). Based on figures adjusted to unit area of trap per week.

Of the 19 species of spiders taken in the corrugated paper traps, two were very abundant. The relative proportions of six of the species are given in Table 2. *Cliniflo fenestralis* (29.56% of total) and *Cryphoea silvicola* (39.86%) together constitute nearly 70% of the total catch. The next most plentiful species was *Anyphaena accentuata* which formed about 8% of the catch; the remaining species were taken only relatively rarely, their proportional representations being only of the order of 0.5-1.5%. These percentages are based on figures adjusted to a unit area of trap per week; a procedure made necessary by the different girths of the trees sampled.

Again using figures adjusted to unit area of trap per week, the catch from the different trees varies widely. The crack areas of the sampled trees were estimated by measuring the area of cracks in a quadrat 20cm x 20cm square at the position of the corrugated paper trap. There appears to be some correlation between the amount of cracking of the bark of oaks and the number of spiders. The mature oak trees, with well cracked bark, provided most of the spider captures. The pine trees, although with a much more broken surface texture than the oaks, yielded fewer spiders. The birch trees with their relatively smooth surface gave very few spiders in the traps. These results are illustrated in Figure 1, in which the oaks show an increase in the number of spiders caught with increasing cracking of the bark.

The small number of trees sampled during this brief project do not make the results amenable to statistical treatment, but the results nevertheless indicate a possible interesting relationship worth further study.

Indices of diversity

Whether carrying out an organised ecological research programme or relatively casual collecting, an arachnologist usually wishes to recognise some association between the animals caught and the habitat sampled. One would like to appreciate the spread of a species over several habitats, i.e. the habitat diversity of the species; or the number and relative proportions of the species in a particular habitat, i.e. the species diversity of the habitat. If the data are derived from a number of discrete habitats then the resulting habitat diversity for each species could be interpreted as indicating the "dispersion" of that species between the different habitats. In an ecological sense, the habitat diversity could be regarded as an indication of the relative extents to which the species exploits different habitats, or different aspects of a single habitat, i.e. its niche breadth.

Niche breadth, or versatility, is defined (Colwell & Futuyma, 1971) in spatial model terms as the "distance through" a niche along some particular line in niche space. Essentially, niche breadth may be regarded as the inverse of ecological specialisation. A spider, for example with very specialised eating habits will have a narrower niche breadth than a more general eater. Much has been written on diversity as an ecological concept, for example Pielou (1966, 1969, 1972), Levins (1968), McIntosh (1967), Hurlbert (1971), Margalef (1958), and Simpson (1949).

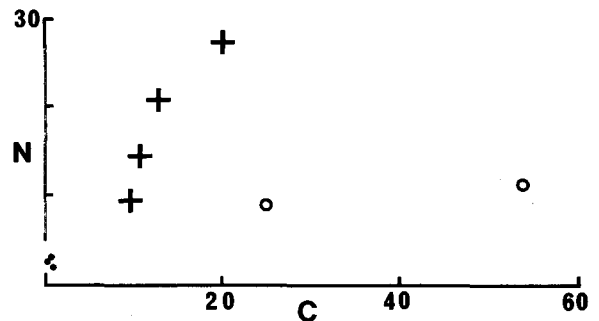


Fig. 1: Relationships between relative number of spiders caught - N, expressed as percentage of total catch, and crack area - C, cm² per 400cm² quadrat.

Symbols: ● - birch trees; + - oak trees; ○ - pine trees.

A Tribute to our Retiring Editor

With the appearance of part 9, vol. 3 of the Bulletin John Crocker's editorship came to an end. A glance at that number, as well as at the first part of vol. 1 (1969), will show what the Society owes him and something of what he has achieved in that time, during which seventeen issues have appeared. Our President paid a worthy tribute to him at the Annual General Meeting but to many Members who were not able to attend, the Council would like to say a word on behalf of those who had the privilege of working closely with him during that time.

He was assigned the very difficult task of producing the Society's main publication within a prescribed framework, going forward from the extremely strong position established by David Mackie for the British Spider Study Group Bulletin. It is likely that no-one could have been found

anywhere who could have combined the ability to do this with his technical know-how, on which the Society has been extremely lucky to be able to draw. The result is clear for all to see. But there is also a human side to work of this kind, and to have to make critical decisions among friends is often an unwelcome and trying experience. Let it simply be said that his integrity and singleness of purpose has been of inestimable importance to the Society in this most critical stage of its development and we shall always have cause to be grateful for his sound judgements and for his firm good sense in dealing with the many difficult problems that have come his way while carrying out the Society's most important function. What he has given us has been at the expense of many hours of leave left over from the demands of an increasingly exacting profession, and we now wish him some well earned leisure in which to exercise his great ability as an arachnologist.

Errata – Vol. 2

- p. 1 '*Lyniphia*' to read '*Linyphia*'
- p. 27 Caption to drawing 'D', '*L. audax*' to read '*L. umbraticola*'
- p. 41 'Cook (1965)' to read 'Cooke (1965)'
- p. 103 In Appendix, '*C. prudens*' to read '*Centromerus prudens*'
- p. 167 '*Cliniflo*' to read '*Ciniflo*'
'Ciniflonidae' to read 'Ciniflonidae'
- p. 184 '*Asamonea*' to read '*Asemonea*'
- p. 190 '*Sintula corniger*' to read '*Sintula cornigera*'
- p. 177 'Fig. 1' to read 'Fig. 20'
- p. 183 'Fig. 20' to read 'Fig. 1'

As examples of such indices, two are applied to the data obtained from the corrugated paper traps. The figures from traps on the different trees can be used to determine the dispersion of each species amongst these different habitats. A table, the resource matrix in the terminology of Colwell & Futuyma (1971) is drawn up with species as rows and traps ("resource states") as columns. The number of individuals per unit area (500cm²) of trap per week was calculated and set down in the resource matrix. For species *i* associated with resource state *j*, this number is designated N_{ij} . The total number of individuals of species *i* (the row total = $\sum_j N_{ij}$) is called Y_i . The

dispersion of a species in the resource matrix can be estimated by measuring the uniformity of the distribution of individuals of that species among the resource states of the matrix (i.e. among the traps).

Two simple measures of uniformity are Levin's (1968) formula:

$$B_i = Y_i^2 / \sum_j N_{ij}^2$$

and the Shannon-Weaver (1963) formula for information content:

$$B_i' = - \sum_j p_{ij} \log p_{ij} = \sum_j \frac{N_{ij}}{Y_i} \log \frac{Y_i}{N_{ij}}$$

$p_{ij} = N_{ij}/Y_i$ is the proportion of individuals of species *i* associated with resource state *j*.

\sum_j — means sum over all values of *j*.

B_i and B_i' are a maximum when an equal number of individuals of species *i* are associated with each resource state. This would imply that species *i* does not discriminate between the resource states and therefore has the broadest possible "niche" with respect to those states and the greatest dispersion over them. The measures are at a minimum when all individuals of species *i* are associated with one resource state (minimum niche breadth or dispersion; maximum specialisation). In the present context a minimum value of B indicates that the species was restricted to, or was only found at, one of the trap sites.

For each of the six selected species, the two different indices are listed in Table 2. According to these results the greatest dispersion is shown by *Anyphaena accentuata* ($B = 6.36$, $B' = 0.81$).

Members of this species were found on seven of the nine trees sampled, on all three types of tree (oak, pine and birch), and at all five sites. *Ciniflo fenestralis* ($B = 4.26$; $B' = 0.64$) and *Cryphoea silvicola* ($B = 3.01$, $B' = 0.55$) showed the next highest dispersions, even though these species were far more numerous than *A. accentuata*. There is good agreement between the order of values for both indices, although their actual ranges differ.

An index of overlap

Comparison of the distribution of species can be a rather subjective process, but can be rendered objective by the utilisation of a quantitative measure of overlap (or similarity). Some such measures are discussed by Horn (1966) and they can be quite difficult to calculate without the aid of a computer, e.g. that of Morisita (1959) which is based on Simpson's (1949) index of diversity. One discussed by Colwell and Futuyma (1971), and elaborated by them, is relatively simple to calculate and is applied to the corrugated paper trap data here.

The index of overlap used here to compare species is given as:

$$C_{ih} = 1 - \frac{1}{2} \sum_j |p_{ij} - p_{hj}|$$

where p_{ij} and p_{hj} refer to the proportions of species *i* and *h* respectively in habitat *j*. $|p_{ij} - p_{hj}|$ is the absolute difference between these, irrespective of sign. The values of C , corrected to two decimal places and multiplied by 100 to give percentage overlap, are given in Table 3.

Values range from zero for no overlap to 100 for complete overlap in distribution of the species. Such a measure is more useful in the case of species pairs where C lies away from the extreme values. In the present case, for species which were taken on only one and the same tree, they obviously completely overlap and the calculated value of C is in fact 100, e.g. species numbers 2 and 6. Similarly those species taken rarely but from different trees have an overlap of zero, e.g. species pairs of 2 and 3, 2 and 4. The three most abundant species — 1 (*C. fenestralis*), 3 (*A. accentuata*) and 4 (*C. silvicola*) — show rather lower overlap than one might have expected on a subjective estimation:—

$$C_{1,3} = 38; \quad C_{1,4} = 36; \quad C_{3,4} = 48.$$

Species Nos.	1	2	3	4	5	6
6	29	100	0	0	53	
5	60	53	6	21		
4	36	0	48			
3	38	0				
2	29					
1						

Table 3: Indices of overlap for some spiders.

Spiders taken in corrugated paper traps. Index of overlap expressed as percentage. Species numbers as in table 2.

Such a measure of overlap is thus a useful tool for application to any set of results for distribution of species between different habitats. It can also be utilised in an analogous manner to compare the species compositions of faunas at different sites.

An alternative to the calculation of overlap of the species' distributions is the computation of a distance measure such as $D_{ih} = \sqrt{\sum_j (n_{ij} - n_{hj})^2}$, where n_{ij} and

n_{hj} are the numbers of individuals of species i and h at site j (McIntosh, 1967). This is related to the diversity index proposed by McIntosh (1967) which is given by $\sqrt{\sum_i n_i^2}$, where n_i is the number of

individuals of each species i at the site. These latter indices are computed on the basis of the actual numbers of individuals taken, rather than the relative proportions of the species and are thus sensitive to the abundances of the species at the different sites. The relationships between various indices have been studied by DeBenedictis (1973). The distribution of values of diversity indices with communities of different numbers of individuals and of species is a complex problem and the interested reader is referred to the work of Bowman *et al.* (1971) for a detailed mathematical treatment.

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References

- BOWMAN, K. O., HUTCHESON, K., ODUM, E. P. & SHENTON, L. R. 1971: Comments on the distribution of indices of diversity. *Statistical Ecology* vol. 3. *Many species populations, ecosystems and systems analysis*. (ed. Patil, G. P., Pielou, E. C. & Waters, W. E.)
- COLWELL, R. K. & FUTUYMA, D. J. 1971: On the measurement of niche breadth and overlap. *Ecology* **52**: 567-576
- DeBENEDICTIS, P. A. 1973: On the correlation between certain diversity indices. *Am.Nat.* **107**: 295-302
- DUFFEY, E. 1969: The seasonal movements of *Clubiona brevipes* Blackwall and *Clubiona compta* C.L.Koch on oak trees in Monks Wood, Huntingdonshire. *Bull.Br.Arach.Soc.* **1**: 29-32
- EVANS, G. O. & BROWNING, E. 1954: *Pseudoscorpiones. Synopses of the British fauna No. 10*. London, Linnean Society of London
- HORN, H. S. 1966: Measurement of "overlap" in comparative ecological studies. *Am.Nat.* **100**: 419-424
- HURLBERT, S. H. 1971: The nonconcept of species diversity: a critique and alternative parameters. *Ecology* **52**: 577-586
- LEVINS, R. 1968: *Evolution in changing environments*. Princeton, Princeton University Press
- LOCKET, G. H. & MILLIDGE, A. F. 1951: *British Spiders*. Vol. 1. London, Ray Society
- LOCKET, G. H. & MILLIDGE, A. F. 1953: *British Spiders*. Vol. 2. London, Ray Society
- MARGALEF, D. R. 1958: Information theory in ecology. *Gen.Syst.* **3**: 36-71
- McINTOSH, R. P. 1967: An index of diversity and the relation of certain concepts to diversity. *Ecology* **48**: 392-404
- MORISITA, M. 1959: Measuring of interspecific association and similarity between communities. *Mem.Fac.Sci., Kyushu Univ.Ser.E.(Biology)* **3**: 65-80
- PIELOU, E. C. 1966: The measurement of diversity in different types of biological collections. *J.theoret.Biol.* **13**: 131-144
- PIELOU, E. C. 1969: *An introduction to mathematical ecology*. New York, Wiley Interscience
- PIELOU, E. C. 1972: Niche width and niche overlap: a method for measuring them. *Ecology* **53**: 687-692
- SAVORY, T. H. 1948: *Opiliones. Synopses of the British fauna No. 1*. London, Linnean Society of London
- SHANNON, C. E. & WEAVER, W. 1963: *The mathematical theory of communication*. Urbana, University of Illinois Press.
- SIMPSON, E. H. 1949: Measurement of diversity. *Nature, Lond.* **163**: 688