Bull.Br.arachnol.Soc. (1976) 3 (8), 214-221

Changes in the ground-living spider fauna after heathland fires in Dorset

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Summary

Spiders were sampled continuously by pitfall trapping for five years on two adjacent areas of burnt heathland, together covering the first ten years after burning. The vegetation and bare ground were recorded annually. The spider fauna can be divided into groups of species which reach their peak numbers at different stages in the heathland succession.

Study Area and Methods

An accidental fire on Hartland Moor National Nature Reserve (Dorset) burnt about eight hectares of dry heathland on 30 April 1965. The whole of this area (Grid ref. SY(30)9585 approx.), and a large area of surrounding heathland, had been burnt previously by another accidental fire on 13 September 1959. The area is situated on the Tertiary Bagshot Beds, the soil consisting mainly of coarse sand, overlying clay. The habitat studied was mainly dry heathland dominated by *Calluna vulgaris* (L.), with considerable amounts of *Erica cinerea* L., *Ulex minor* Roth and *Agrostis setacea* Curt. *Molinia caerulea* (L.) and *Erica tetralix* L. were abundant in some damper patches.

On 7 May 1965, a transect of 18 pitfall traps was placed across the length of the area which had been burnt a week previously, and a similar transect of 18 traps was laid out parallel to it on the area burnt in 1959. The traps used were glass jam jars of 5.5 cm inner diameter, sunk into the ground so that the rim was slightly below the soil surface, a small quantity of a 0.1% solution of phenyl-mercury acetate being put in each as a preservative. The traps were emptied approximately once a fortnight, and operated continuously until 12 May 1970. As the rate of change in the catch had slowed down considerably, they were then taken up with the intention of replacing them in May 1971, but the occurrence of another larger fire over the whole area in April 1971 brought the investigation to an end. The trapping that was done therefore covered the periods 0-5 years after the 1965 fire, and 5½-10½ years after the 1959 fire (or 5-10 growing seasons for the vegetation).

The numbers of adult spiders of each species caught in the two transects have been summed to give yearly totals running from early May to early May. The phenology of most of the species was decribed in earlier papers, (Merrett, 1967, 1968, 1969).

With the exception of 1968, the vegetation was recorded each year in September, i.e. near the end of the growing season. Vegetation records are therefore available for 1-3, 5-8 and 10-11 growing seasons after burning. A 0.5m^2 quadrat, divided into 50 10 cm squares was used to record presence or absence in each square of all higher plant species, height of vegetation and percentage of bare ground in 1m^2 adjacent to each trap, the same quadrats being recorded every year. The percentage of bare ground proved to be the most useful factor when assessing changes in the vegetation in relation to changes in the spider fauna. It was measured by estimating the amount in each square to the nearest quarter of a square and summing for the 100 squares. Bare ground was counted if it was overhung by a *Calluna* branch well above ground level.

In many cases, the results shown in Table 1 are supported or enhanced by numerous collections made in other heathland areas in southern England.

Results

It is well known that the efficiency of pitfall traps can vary according to the type of vegetation, particularly in relation to the height of vegetation and presence or absence of bare ground, but there is little evidence of any marked difference in efficiency in dry Callunetum within the age range of 0-10 years. It is not until the *Calluna* canopy becomes closed and a distinct litter layer is formed that the activity of ground-living species is noticeably affected; this does not begin to occur on Dorset heathlands until about 10 years after burning. Pitfall traps also have the disadvantage that they measure only the activity of ground-living species and give no indication of population density, but in the habitat studied, which consisted of short vegetation and bare areas, ground-living species represent a large proportion of the total

Trapping period	7.5.65-5.5.66	5.5.66-5.5.67	5.5.67-3.5.68	3.5.68-9.5.69	9.5.69-12.5.70	7.5.65-5.5.66	5.5.66-5.5.67	5.5.67-3.5.68	3.5.68-9.5.69	9.5.69-12.5.70
Growing seasons after fire	0 – 1	1 – 2	2 – 3	3 – 4	4 – 5	5 – 6	6 – 7	7 – 8	8 – 9	9 – 10
Dysdera erythrina (Walck.)				1		1		1	5	3
Drassodes cupreus (Bl.)	7	15	19	20	15	23	32	33	27	27
Haplodrassus signifer (C.L.K.)	1	1		1		3	3	4	2	2
H. dalmatensis (L. Koch)	57	74	44	74	30	89	86	35	61	20
Zelotes latreillei (Simon)				1			1	1	2	3
Z. serotinus (L. Koch)	41	50	88	61	70	48	84	114	64	54
Gnaphosa lugubris (C.L.K.)	3	4	1	7		1	2	2		
G. leporina (L. Koch)	3	2	5	3	8	12	19	7	12	29
Micaria silesiaca L. Koch	5	13	1	3	1	2				
Clubiona trivialis C.L.K.	1		2	3	2	2	1	1	2	2
Cheiracanthium virescens (Sund.)		2		1	2	2	1			2
Agroeca proxima (O.P.-C.)	21	13	32	30	118	57	81	129	159	392
Scotina gracilipes (Bl.)	15	13	21	43	23	25	60	42	122	43
Xysticus cristatus (Cl.)	1	2	1	5	5	9	7	7	7	5
X. sabulosus (Hahn)	27	11	23	13	37	9	11	3	6	5
Oxyptila atomaria (Panzer)			1						1	7
Euophrys petrensis C.L.K.	11	5	4	1	4	17	6	6	6	8
Aelurillus v-insignitus (Clerck)	1	8	1	2	3	1	2	5		1
Pardosa palustris (Linn.)	37	98	85	89	81	111	86	105	72	31
P. pullata (Cl.)	1	2		18	15	23	22	50	65	48
P. nigriceps (Thorell)	4	5	8	25	24	55	42	93	112	76
Alopecosa accentuata (Latr.)	28	38	43	38	69	24	51	42	15	14
Trochosa terricola Thorell		14	6	11	11		9	3	25	24
Arctosa perita (Latr.)	23	32	13		1					
Agelena labyrinthica (Cl.)			1	9	3	3	5	8	12	9
Hahnia nava (Bl.)		2		14	2	8	12	13	47	12
Steatoda albomaculata (Degeer)	129	87	60	31	20	8				
Enoplognatha thoracica (Hahn)	1	1	2	4	13	22	21	15	16	12
Pachygnatha degeeri Sund.			1	14	3	2	5	4	26	8
Hypsosinga albovittata (Westr.)				2	1	2			2	1
Walckenaera acuminata Bl.		1	1	2	4		2	5	8	31
W. antica (Wider)	6	4	4	4	4	8	19	19	18	25
W. monoceros (Wider)	2	2	2	1	1	2	2	2		
Gonatium rubens (Bl.)	2	3	2	6	3	8	9	23	17	12
Peponocranium ludicrum (O.P.-C.)	3	1	1	2	1	2	1	1	1	
Mecopisthes peusi Wunderlich	216	330	489	517	497	299	269	402	575	165
Micrargus laudatus (O.P.-C.)				1			1		2	4
Typhochrestus digitatus (O.P.-C.)	1		13	5	9					1
Erigone dentipalpis (Wider)	35	8	10	9	10	11	2	1	1	1
E. atra (Bl.)	80	55	143	153	84	124	27	79	53	43
E. promiscua (O.P.-C.)	187	98	109	193	108	36	10	24	23	3
Phaulothrix hardyi (Bl.)	609	2868	1245	484	397	128	38	5	5	2
Meioneta rurestris (C.L.K.)	17	3	7	2	2	17	1	5	2	1
Centromerita bicolor (Bl.)	1	1	1	1			1	3		
C. concinna (Thorell)	40	114	237	175	106	197	272	511	303	170
Bathyphantes gracilis (Bl.)	1	1	9	10	3	3	1	10	10	4
Tapinopa longidens (Wider)			1	3	2	1	2	4	4	3
Stemonyphantes lineatus (Linn.)	36	127	129	96	143	28	42	33	33	51
Lepthyphantes tenuis (Bl.)	1	3	4	8	5	1	7	4	5	1
L. mengei Kulcz.		1	2	2	2	1		3	19	6
L. ericaeus (Bl.)				4	1	2		2	3	2

Table 1. Yearly totals of 51 species of which 8 or more specimens were trapped.

spider fauna and the catches over a number of years show clear trends in some cases.

During the five years, 109 species of spiders were trapped in the study area, 29 being recorded from only one individual, and a further 29 from fewer than eight individuals. The yearly totals of the remaining 51 species of which eight or more individuals were caught are shown in Table 1.

Pioneer species which decline in numbers quickly

Perhaps the most interesting species are a small group which have their peak of abundance during the first few years after burning, and which virtually disappear by the end of ten years. The best examples are *Micaria silesiaca, Arctosa perita, Steatoda albomaculata, Walckenaera monoceros, Typhochrestus digitatus* and *Phaulothrix hardyi.* In Fig. 1 the numbers of *S. albomaculata* and *P. hardyi* are plotted against time and percentage of bare ground. This shows that these species have almost disappeared by the time that the amount of bare ground has fallen to 10%, i.e. after about 6-7 years. The relationship between bare ground and numbers of *P. hardyi* is illustrated in more detail in Fig. 2, where the numbers caught in each trap in the area burnt in 1965 are plotted on a log scale against percentage bare ground near the individual traps. Since *P. hardyi* is a winter-maturing species, the numbers of specimens trapped in the seasons 1966-67, 1967-68, and 1969-70 are plotted against the bare ground percentages obtained in the preceding September. *P. hardyi* has been found commonly on recently burnt heathland in other parts of southern England, from Devon to Sussex, but it also occurs in northern Britain and on mountains. Exposure in winter, when it is adult, may therefore possibly be the main factor which accounts for its success on burnt heathland. *S. albomaculata* has been found on recently burnt heathland elsewhere in Dorset, the New Forest and Surrey, but it appears to be less widespread than *P. hardyi.* It spins its webs mainly under the prostrate stems of *Ulex minor*, but

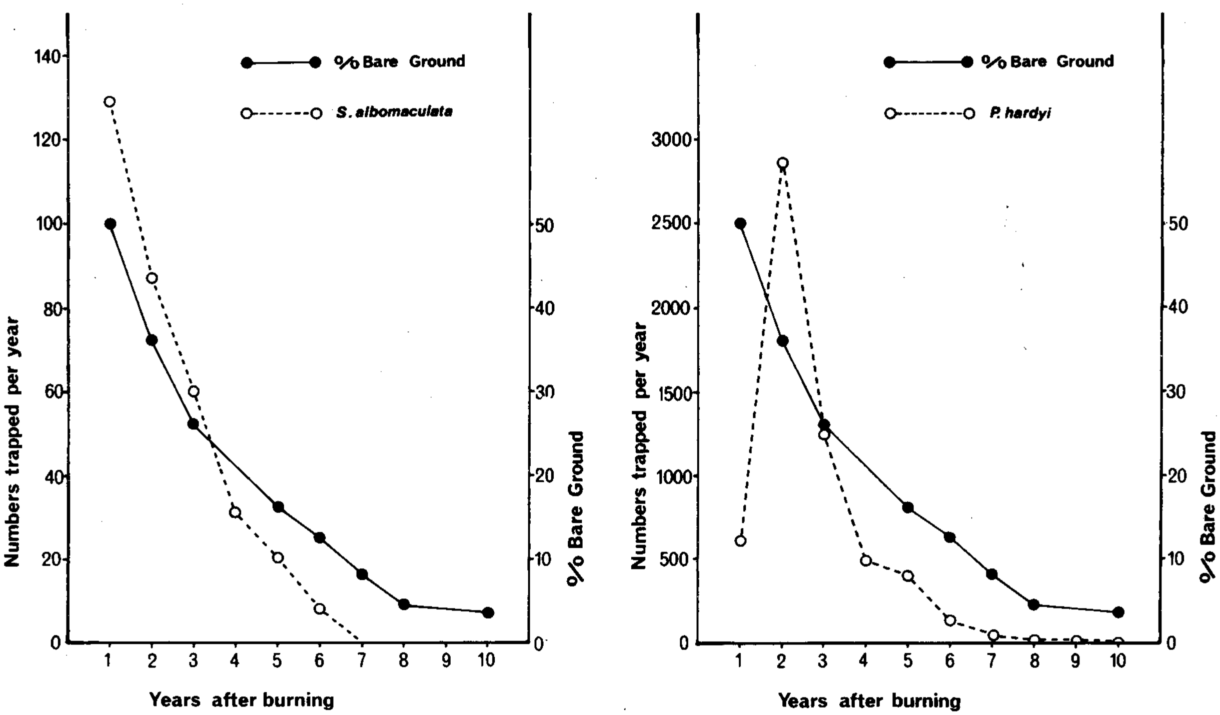

Fig. 1: Numbers of adult *Steatoda albomaculata* and *Phaulothrix hardyi* trapped per year, and average percentage of bare ground for whole transect.

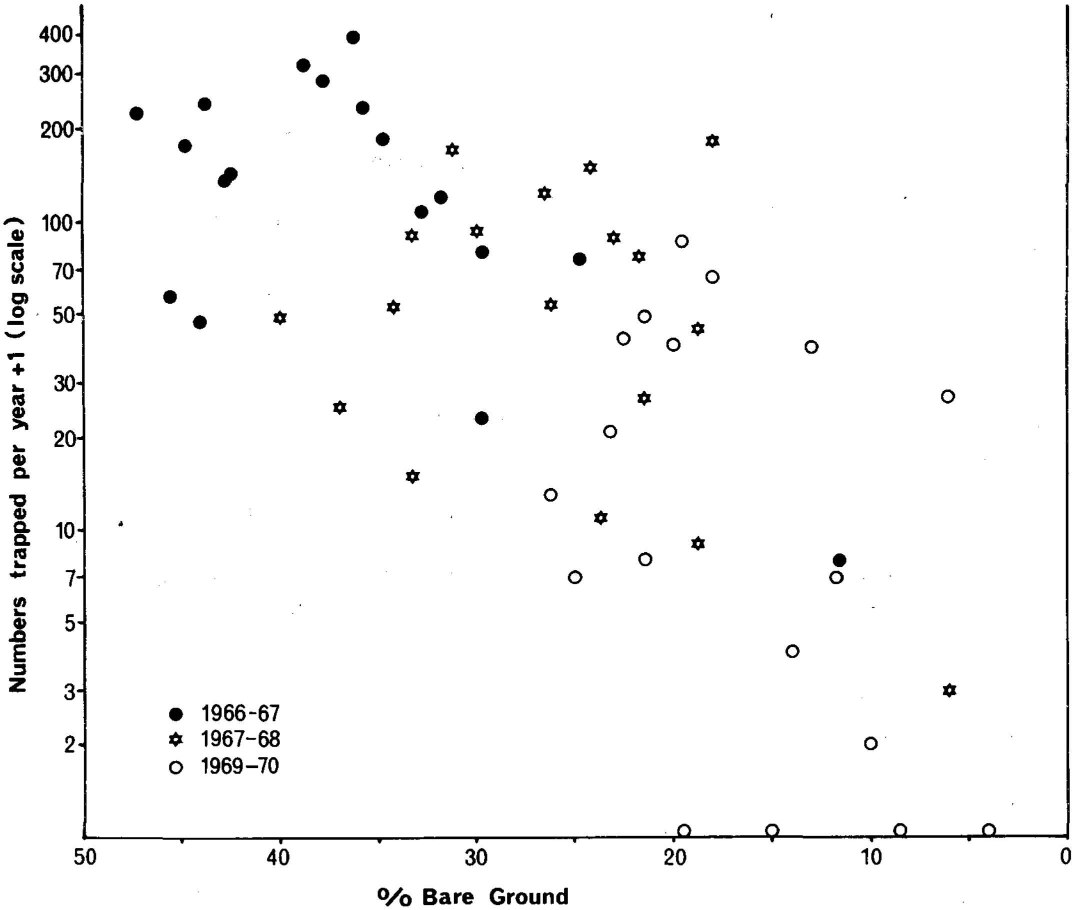

Fig. 2: Numbers of *Phaulothrix hardyi* (+ 1) trapped in 1966-67, 1967-68, and 1969-70, plotted on log scale against percentage bare ground near individual traps.

also under stones and occasionally under young *Calluna* plants. It feeds mainly on ants and small beetles, especially weevils. It is also common on dry stony heaths in the Breckland of Suffolk and Norfolk and in Denmark, and it has been found on consolidated shingle just above high water mark on Scolt Head Island, Norfolk (Duffey, 1965). It would appear, therefore, that open sandy or stony ground is essential for its survival.

The distribution of *M. silesiaca* is similar to that of *S. albomaculata,* but it is less abundant.

A. perita is well known as a species of sand dunes, where it is often seen running on bare sand, and it is therefore not unexpected that it should occur in open sandy areas on recently burnt heathland. It is also common on ploughed firebreaks on heathland, and it is the first species of this group to disappear as the amount of bare ground decreases. It is worth noting that the specimens found on the dark heathland sand are usually much darker than those on coastal sand dunes. Similarly, very dark specimens have been taken on colliery spoil heaps in the Midlands (Arnold and Crocker, 1967).

The results for *W. monoceros* and *T. digitatus* are slightly inconclusive in that the numbers are small and one specimen of *digitatus* was taken in the tenth year, but collections made elsewhere on southern heathlands support the evidence shown here that these species are most frequent in the first five years or so after burning.

Xysticus kochi Thorell, of which only three specimens were taken at Hartland, and *Milleriana inerrans* (O.P.-C.), of which five specimens were taken, can also probably be included in this group.

Pioneer species which persist for ten years or more

Species which are also most abundant in the early years after burning, but which decline in numbers less rapidly than those in the first group, include *Erigone promiscua, E. dentipalpis, E. atra, Meioneta rurestris, Stemonyphantes lineatus, Xysticus sabulosus, Gnaphosa lugubris, Alopecosa accentuata, Aelurillus v-insignitus, Haplodrassus dalmatensis* and *Pardosa palustris.* The results presented here for some of these species, notably the last two, do not show a conclusive decline by the end of ten years, but suggest a downward trend which is supported by collections made elsewhere on southern heathlands of a greater age range. Most of these species may persist in small numbers among mature heather over 20 years old, but are always most numerous during the first ten years and build up to high numbers during the first 2-3 years. As with some of the previous group, *G. lugubris* and *H. dalmatensis* have both been recorded from dry stony coastal habitats.

Species which reach maximum numbers between 5-10 years

There are a number of species which do not build up to high numbers as rapidly as those in the first two groups, but which are usually more abundant in short burnt heathland than in mature heathland. These include *Zelotes serotinus, Euophrys petrensis, Enoplognatha thoracica, Mecopisthes peusi, Micrargus laudatus* and *Centromerita concinna.* None of these species shows a significant decline in numbers by the end of the ten years of this study, but data derived from other sites indicate that numbers could be expected to fall sharply between 10 and 15 years after burning. *E. thoracica* is another species typical of dry stony coastal habitats.

Species which reach peak numbers after ten years

A number of species included in Table 1 show a slow build-up reaching their highest numbers in the ninth or tenth year after burning, suggesting that numbers are likely to increase still further after the ten-year period. Examples are *Dysdera erythrina, Zelotes latreillei, Gnaphosa leporina, Agroeca proxima, Scotina gracilipes, Oxyptila atomaria, Pardosa pullata, P. nigriceps, Trochosa terricola, Agelena labyrinthica, Walckenaera acuminata, W. antica, Gonatium rubens* and *Lepthyphantes mengei.* In Fig. 3 the numbers of *A. proxima* and *P. nigriceps* are plotted against time and percentage of bare ground. Although there is some fluctuation, possibly related at least in part to differences in climatic conditions at the time of peak abundance, the overall trend is clearly an exponential increase throughout the ten years. Several of these species, e.g. *Z. latreillei, G. leporina* and *P. pullata,* are possibly more typical of wet heath or bog than of dry heath; it seems likely, therefore, that they can only survive on drier heath when the vegetation cover has grown up to provide a certain level of humidity. Since *W. acuminata* also occurs commonly in woodland litter, the establishment of a litter layer is probably important before it can attain high numbers on heathland.

Species typical of mature heathland

A final group of species which are not represented in Table 1 are those which do not appear in appreciable numbers until after 10 years, and which increase to peak densities in mature heathland of 20 years or more in age. These fall into two main categories; (a) web-spinners living in the *Calluna* canopy and on bushes of *Ulex europaeus,* mostly belonging to the families Dictynidae, Theridiidae, Araneidae and Linyphiidae, and (b) litter-living species, mostly small members of the family Linyphiidae, including some which spin webs near ground level. Although none of these species was recorded from more than a few individuals in the study area at Hartland, it is worth listing some of the common species of mature heathland in Dorset which may be included in these categories (* denotes recorded from study area from few individuals).

All of the species listed in category (b) may also be found, most of them commonly, in woodland litter.

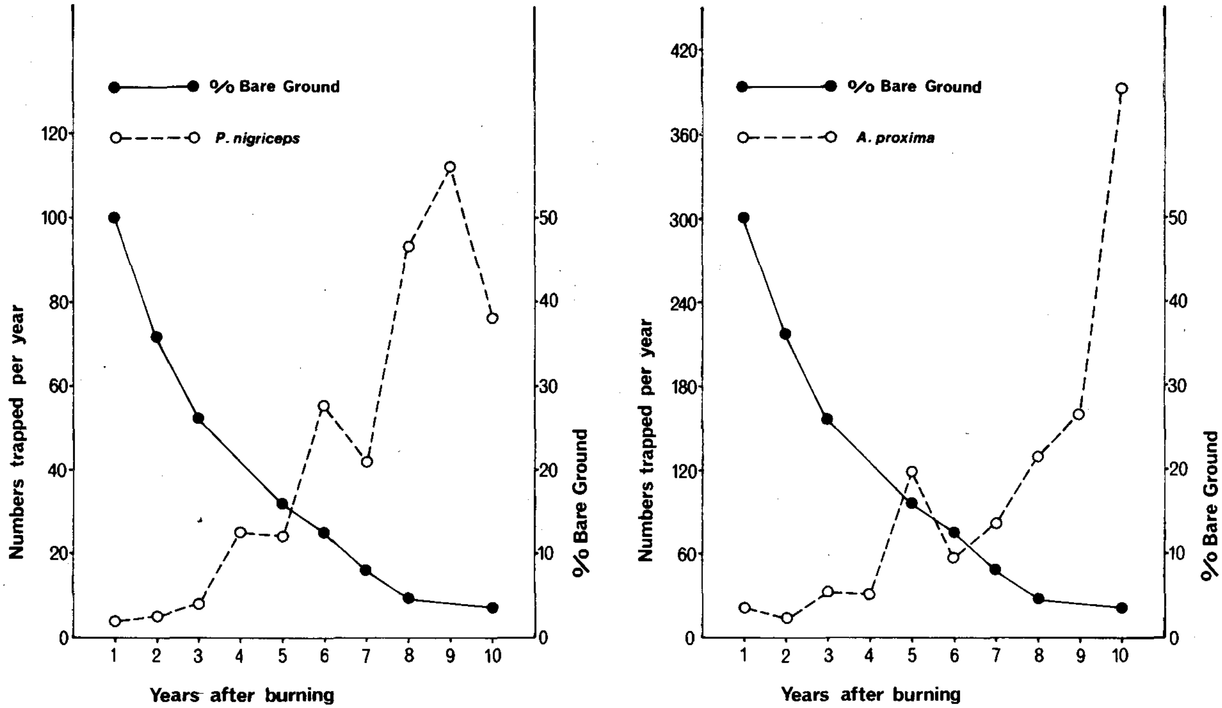

Fig. 3: Numbers of adult *Pardosa nigriceps* and *Agroeca proxima* trapped per year, and average percentage of bare ground for whole transect.

(a) Web-spinners

**Dictyna arundinacea* (Linn.)
D. latens (Fabr.)
Anelosimus aulicus (C. L. Koch)
Theridion sisyphium (Cl.)
T. impressum L. Koch
T. simile C. L. Koch
Meta segmentata (Cl.)
M. mengei (Bl.)
Araneus diadematus Cl.
**A. quadratus* Cl.
**A. adiantus* (Walck.)
Zygiella atrica (C. L. Koch)
**Linyphia triangularis* (Cl.)
L. furtiva O.P.-C.

(b) Litter-living species

Agroeca brunnea (Bl.)
**Scotina celans* (Bl.)
**Zora spinimana* (Sund.)
Hahnia helveola Simon
Robertus lividus (Bl.)
**Pholcomma gibbum* (Westr.)
**Ceratinella brevipes* (Westr.)
Minyriolus pusillus (Wider)
**Tapinocyba mitis* (O.P.-C.)
**Monocephalus fuscipes* (Bl.)
**Gongylidiellum vivum* (O.P.-C.)
**Agyneta subtilis* (O.P.-C.)
Centromerus dilutus (O.P.-C.)
Lepthyphantes zimmermanni Bertk.

Species whose period of peak abundance is uncertain

There are many other species, which although common on Dorset heathlands, including Hartland, have not been sampled adequately enough to give a clear indication of the period in the heathland succession at which they reach their greatest abundance. Some of them, however, have been recorded in sufficient numbers to suggest whether they are likely to be most numerous in young or old heather in a general sense. Examples of species which may tend to be most abundant in younger heather are *Drassodes cupreus, Cheiracanthium virescens, Hahnia nava, Pachygnatha degeeri, Hypsosinga albovittata, Tiso vagans* and *Lepthyphantes tenuis,* whereas species which may be more in evidence later include *Haplodrassus signifer, Clubiona trivialis, Pisaura mirabilis, Hypsosinga sanguinea, Peponocranium ludicrum, Cnephalocotes obscurus* and *Tapinopa longidens.*

Changes in total numbers and biomass

The total relative biomass for each year was calculated by taking the cube of the average body length of each species as given by Locket and Millidge (1951-53), and multiplying by the number of individuals caught. This estimate of relative biomass, along with the total number of species and individuals for each year, is shown in Fig. 4.

The apparent peak in both numbers of individuals and biomass in year 2 is accounted for by the extreme abundance of *P. hardyi* at that time. From year 3 onwards there is no significant change in the relative biomass caught, but there is a trend showing the biomass per individual to be greater in years 5-10 than in years 1-4. This can be related to a fall in the numbers of some small linyphiids, especially *P. hardyi,* and an increase in numbers of some larger species, e.g. *A. proxima, P. nigriceps.* There is no clear change in the number of species per year, but a suggestion of a slight overall upward trend. It might be expected that the number of species would increase as the heather gets older, since the complex structure of mature heather should provide a wider range of niches than young heather.

Discussion

As stated earlier, the comparison of pitfall trap results may be considered suspect because of possible

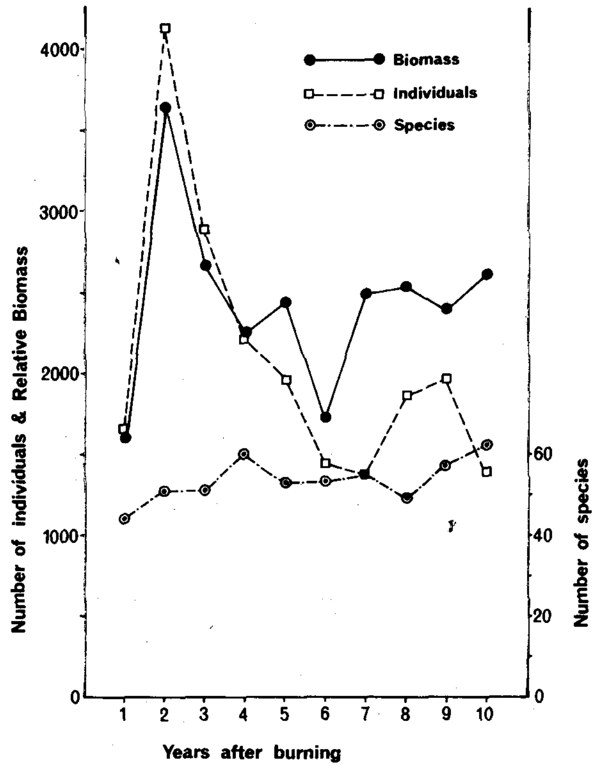

Fig. 4: Numbers of species, individuals, and relative total biomass in each year.

changes in efficiency related to changes in the vegetation, but the trends shown in Figs. 1 and 3 and described above probably represent genuine changes in abundance as well as of activity. Evidence for this is provided here by related species, which probably have similar general behaviour patterns, showing trends in opposite directions, e.g. *Gnaphosa lugubris* and *G. leporina, Pardosa palustris* and *P. pullata, Steatoda albomaculata* and *Enoplognatha thoracica, Walckenaera acuminata* and *W. monoceros.* It has also been noted that many of the pioneer species on heathland are also associated with other sandy or stony open-ground habitats, and that many of the species which appear later are also found in woodland litter, thus indicating that the habitat preferences shown on heathland are in accordance with what might be expected from a knowledge of spiders in other habitats. Because of normal fluctuations in numbers from year to year, too much importance must not be attached to the results for any one year, but in most cases there is either a clear underlying trend or at least a sign of greater abundance either near the beginning or at the end of the ten year period.

It is evident that the pioneer species must be capable of efficient dispersal in order to take advantage of recently burnt areas. Small populations of species such as *S. albomaculata* and *P. hardyi* frequently occur on persistent areas of bare stony ground on hill-tops and *A. perita* may occur in some numbers on ploughed firebreaks, from which they can easily spread to neighbouring heathland when the opportunity arises. Along with other invertebrates, small numbers of spiders and their eggs can survive heathland fires either under stones or buried deep in litter, but those species which are not adapted to the exposed conditions may die later due to lack of food or other unfavourable environmental factors. It is worth noting that some of the species described here as occurring mainly on burnt heathland have also been described by Duffey (1975) as being among the most abundant colonisers of experimental grass swards, e.g. *E. atra, E. dentipalpis, M. inerrans, M. rurestris,* and *L. tenuis.* It seems likely that these species, which are all well known aeronauts, are adapted to colonising a variety of newly created habitats.

It was noted above, as evidence in support of the reliability of pitfall trap results, that some related species show different trends. This is also of interest as a means of reducing competition between related species, the various stages in the heathland succession greatly increasing the number of available niches for different species. Perhaps the clearest examples occur in the families Lycosidae and Gnaphosidae. Of the three common large species of lycosids, *A. perita* is restricted to the early stages after burning, *T. terricola* occurs mainly among mature heather and in damper situations, while *A. accentuata* occupies an intermediate position. The three common *Pardosa* species are split up in a slightly different way, *palustris* occurring mainly on burnt dry heathland, while *pullata* and *nigriceps* both increase later in the succession, with *nigriceps* living largely in the higher strata of the vegetation and *pullata* tending to live more at ground level and in damper situations. Among the gnaphosids, *G. lugubris* and *Z. serotinus* both occur mainly on open dry heathland, while *G. leporina* and *Z. latreillei* are associated more with mature heathland and extend also into wet heath and bog, as do *P. pullata* and *T. terricola.*

The diversity of periods at which different species reach maximum abundance shows the importance of maintaining a mixture of different aged stands of heather by rotational burning in order to conserve the maximum number of species on any heathland site. It also illustrates the potential dangers of fragmentation of heathland into small sites, which may not be large enough to carry a sufficient range of different aged stands of heather, or which may be totally destroyed by an accidental fire without there being a neighbouring reservoir of species for recolonisation.

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