Ecological survey and the arachnologist

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Introduction

In recent years there has been greater recognition by biologists of the importance of ecological survey. The widespread interest in wildlife conservation and the consequent demand for information has revealed an unsuspected ignorance of the distribution of animals and their ecological requirements, and yet less and less undisturbed land survives as a refuge for our native fauna. The emergence of a strong natural history movement, especially among Naturalists' Trusts, means that there are more students of wildlife than ever before and, in addition, the 500 private and 130 National Nature Reserves have focused attention on a wide range of habitats unknown to the pre-war collector. A reappraisal of our knowledge of the British invertebrate fauna is clearly overdue, not only of where species occur, but more especially, why they are found in certain habitats and not in others.

The British Arachnological Society is an example of the growing interest in natural history studies. Although it began as an informal meeting of a small group of people at the Flatford Mill Field Centre (Locket, 1969), it acquired its present title as recently as January 1969 and now has a membership of about 300. Field work is one of the main interests of its members and co-operative ecological surveys have been organised each year since 1964, first on sand-dunes and later on fens (Duffey, 1968; 1970a), while numerous meetings have been held at Field Centres and elsewhere. As membership grows additional ecological survey projects will be started and may promote interest among specialists in other invertebrate groups. The purpose of the following account is to describe briefly and in simple terms the methods, techniques and apparatus for ecological survey which are available to the amateur not normally having access to laboratory facilities. Most of the methods described are in use by specialists on other groups of invertebrates, and although much will be well-known to the experienced field worker it is important to be aware of the limitations of each, because catching devices differ in efficiency in relation to nature of habitat and the invertebrate groups being sought.

For many years the increase in knowledge of the British arachnid fauna depended mainly on casual collecting, the first object being to discover rarities or new species. Published information on distribution was ancillary to the accounts on morphology and taxonomy and inevitably biased to the personal experience of the few who were most prolific in publishing papers. Data on locality were often generalised and references to habitat absent or very brief.

Simple collecting and sampling methods

Elementary ecological survey usually sets out to find answers to three basic questions: (a) which species, and how many, are found in the habitat or site being studied? (b) how numerous are the individuals of each species and what is the seasonal variation? (c) what are the habitat preferences and ecological tolerances in relation to environmental factors? The first of these is easiest to study, requiring only regular collecting visits throughout the seasons and equal attention to the different habitat components of the site. The second is rather more difficult because quantitative sampling techniques will be necessary, while the third requires careful studies of individual species and is therefore much more time-consuming.

Complete answers cannot be obtained for any of these questions because in the ideal situation we would have to know the exact influence of all the factors controlling every stage in the life-history of a species. Ecological survey is, therefore, a compromise but nevertheless its limitations can often be assessed by the appropriate methodology. In the following account a distinction is made between "trapping and collecting" which, in general, produce numerical results which are not comparative, and "sampling" which is a quantitative attempt to assess the numbers of a species or population and produces results which are comparative between sites or collecting periods. Collecting can, of course, be comparative as, for instance, when assessing the number of species living on two or more sites. Applying precision to field measurements greatly increases the value of ecological information and also enables one to attach more significance to negative evidence. In the following account, survey methods are briefly described in relation to three major vegetation zones, GROUND LAYER, FIELD LAYER and CANOPY. Scrub is not distinguished separately because the field methods described for the Field Layer or Canopy usually apply. For more detailed information see Macfadyen (1963) and Southwood (1966).

Ground layer (up to about 15 cm in height)

This information is defined in the sense of Elton (1966) and includes all vegetation and ground structures not exceeding about 15 cm (6″) in height. The interpretation of the height limit is flexible because some areas are a mosaic of short and long vegetation and an approximate mean height must be taken. The ground layer is not only the most diverse in structure of the three formations mentioned, ranging from stony mountain top to saltmarsh, but is also far richer in species than field layer, scrub or canopy. It is also easier to sample because it is generally more accessible, so that methods for studying its fauna are probably better developed.

(i) ***Hand-collecting for unit period of time*** was adopted by British Arachnological Society members during a study of the spider and harvestman fauna of sand-dune formations, in S. Wales, E. England and E. Scotland (Duffey, 1968). The sampling unit found most convenient was 1 hour and, although the procedure is simple, self-discipline is required to maintain accurate time-keeping and to collect all specimens seen. In this way comparative data on different habitats can be accumulated on the number of species present, numbers of specimens of each and ratio of adults to immatures, for different times of the year.

The efficiency of hand-collecting depends on the type of plant cover or substrate. Open herbaceous vegetation is easier to examine than a tussocky growth. Moss and leaf litter is best examined over a plastic sheet using a sieve (Crocker, 1969a). Tough or dense vegetation may be cut near the ground with shears or knife so that the litter layer can be examined more easily. In other cases turfs may be cut out and pulled to pieces over a sheet.

The more open and short the vegetation, the more rapidly one can collect the "total" fauna. In Fig. 1 the relationship between the proportion of the "total" species collected, against time, is illustrated for habitats on a dune system. In a simple habitat such as the drift-line which is easily and quickly examined, collecting for 4 hours was sufficient to obtain virtually all the species present at that time, while in the more complex structure of dune meadow vegetation, 17 hours fieldwork was required before the 1 hour sampling period failed to produce a new species. The "total" fauna is, of course, not known with certainty but in this case it means all the species collected by 10 people who spent an average of 19 hours collecting in each dune habitat during the course of a week.

When specimens are very numerous in the sample being examined it is advisable to use a pooter for rapid collection. Two main types are in use (Fig. 2), the choice of which depends on whether one prefers to collect a large number in a pooter chamber before transferring to a preservative or whether it is easier to blow small numbers of specimens at a time from the pooter into the collecting tube (Cooke, 1966a). In wet weather a sample of vegetation or turf may be collected in a polythene bag and sorted under shelter for a unit period of time. A sorting tray with a corner hole is particularly useful (Locket pers. comm). It should measure about 120 cm x 70 cm (approx. 2′-3″ x 4″) with a hole 20 cm x 20 cm cut in the far left-hand corner. The hole overlaps the edge of the table so that vegetation after sorting may be pushed through to fall in a waste container beneath.

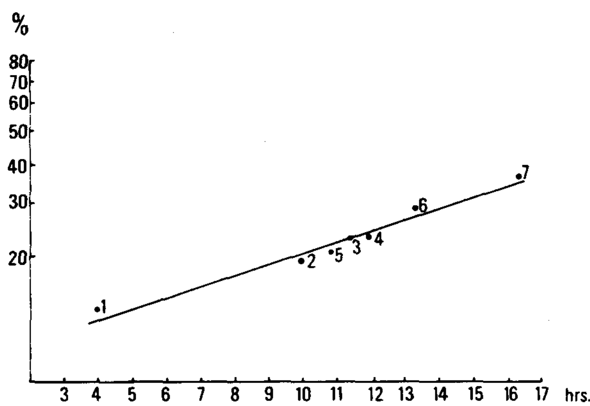

Fig. 1: The relationship between the time spent collecting and the proportion taken of the 'total' species on a sand dune system. **1.** Drift Line; **2.** Fore Dunes; **3.** Yellow Dunes; **4.** Marram transition; **5.** Dune Heath; **6.** Dune Slack; **7.** Dune Meadow.

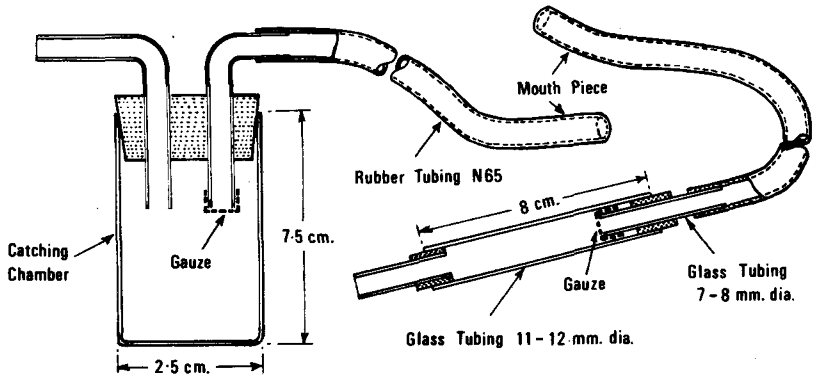

Fig. 2: Two types of Pooter.

(ii) ***Collecting by hand*** over a unit area may be used for comparative assessments of population density of species in relation to type of vegetation cover. Here again accuracy and duration of counts will depend on habitat structure; dense tussocks, rock fissures, a stony substrate such as a shingle bank or waterlogged ground, all add to the difficulties of collecting. In 1965 a 2 x 2 m plot on a dry sandy heath was divided into 100 squares, each measuring 20 x 20 cm. The vegetation, for the most part, was short and open and the soil loose and sandy, so that hand-sorting presented no difficulties. Each square was cut out, placed in a polythene bag and sorted in the laboratory. The few tussocks were fairly small and the only woody vegetation, a heather plant, was removed by secateurs. In Fig. 3 a clear relationship is demonstrated between the occurrence of *T. cito* and the open lichen heath and between *D. prona* and *S. gracilipes* and the tall vegetation of the grass tussocks and *Calluna*.

(iii) ***Heat-extracting apparatus*** is often essential for the type of study described in (ii), either because of lack of time or because the vegetation is too tough and dense for accurate hand-sorting. The two methods described, which are most appropriate for macro-arthropods, need no special knowledge for. construction and the material required is easily obtained. More detailed information can be obtained

	2	2	2	2					
3	4	2	6		2				1
5	4	3	6	2	3				
3	2	6	3	4	4	1	1	1	
1	3	5	7	3	3	4	2		
5	1	2	3	5	1	6	1	1	2
14	7	4	2	1	7	2	1	2	
2	5	3	3	3	7	1	3	3	
6	9	5	5	1	3	6	2	1	
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Trichopterna cito

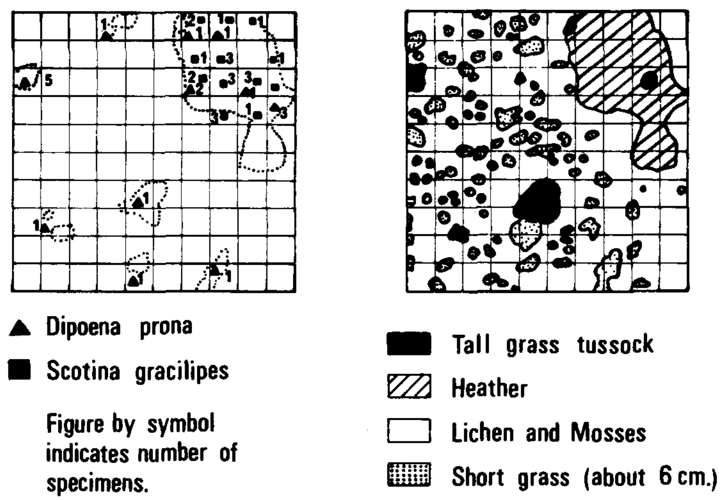

Fig. 3: The distribution of three species of spider in relation to vegetation.

from Duffey (1962a), Macfadyen (1963) and Southwood (1966).

(a) *Tullgren Funnel* (Macfadyen version). The unit is a closed system so that a temperature gradient is imposed on an internal environment which has a fairly high humidity for the first part of the extraction. Therefore the animals leave the sample in response to the temperature gradient rather than to increasing desiccation. They fall down the funnel and are caught in a collecting jar containing a non-volatile preservative such as phenyl-mercuric acetate – but 50% alcohol sol. with 5% glycerin may be used. Grass turfs should be placed upside-down on the tray, otherwise escape routes will be blocked by roots and soil. Extraction usually lasts 4 to 7 days depending on thickness and amount of moisture in the sample.

A simple extraction funnel can be built from "Sisalkraft" Building Paper which is fairly rigid and resistant to tearing. Cut out a section to form a steep-sided funnel which can be supported in a wire frame. The turf or litter is held in a garden sieve and an electric light bulb used as a heat source. I am indebted to Dr. N. Webb for this information.

When the turf is cut out in the field a metal frame the size of the tray may be used. The frame should be rigid, having a cutting edge which is forced into the vegetation or, if a wire ring is used, a stout knife is required to cut round it. The horizontal cut beneath the sample should be done carefully so that the minimum amount of soil is removed from the site, as with lawn turf.

(b) *Platform Extractor.* This apparatus works on the same principle as the Tullgren Funnel but the design has advantages in certain circumstances (Duffey, 1962a). For active invertebrates its efficiency appears to be the same as the funnel but it is not suitable for small slow-moving species. The platform type has two main practical advantages – 4 extractors occupy little more space than a unit with 2 funnels, and loose, fragmented material (e.g. leaf litter, vegetation on a sandy soil) can be treated without debris falling into the collecting gutter.

The sample material is placed in a wire tray which rests between the gutter and heating element on an asbestos-cement floor. When switched on the metal tube enclosing the element becomes hot, and draws a current of air through the mesh-covered holes of the hinged cover and over the trough containing an aqueous solution of phenyl-mercuric acetate. The moist air passes through the sample and out through

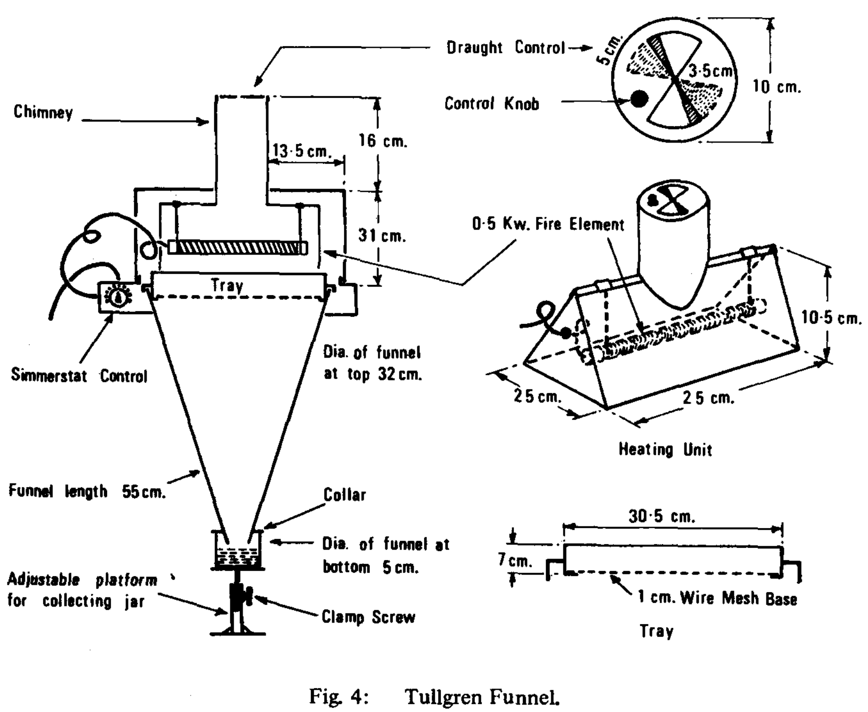

Fig. 4: Tullgren Funnel.

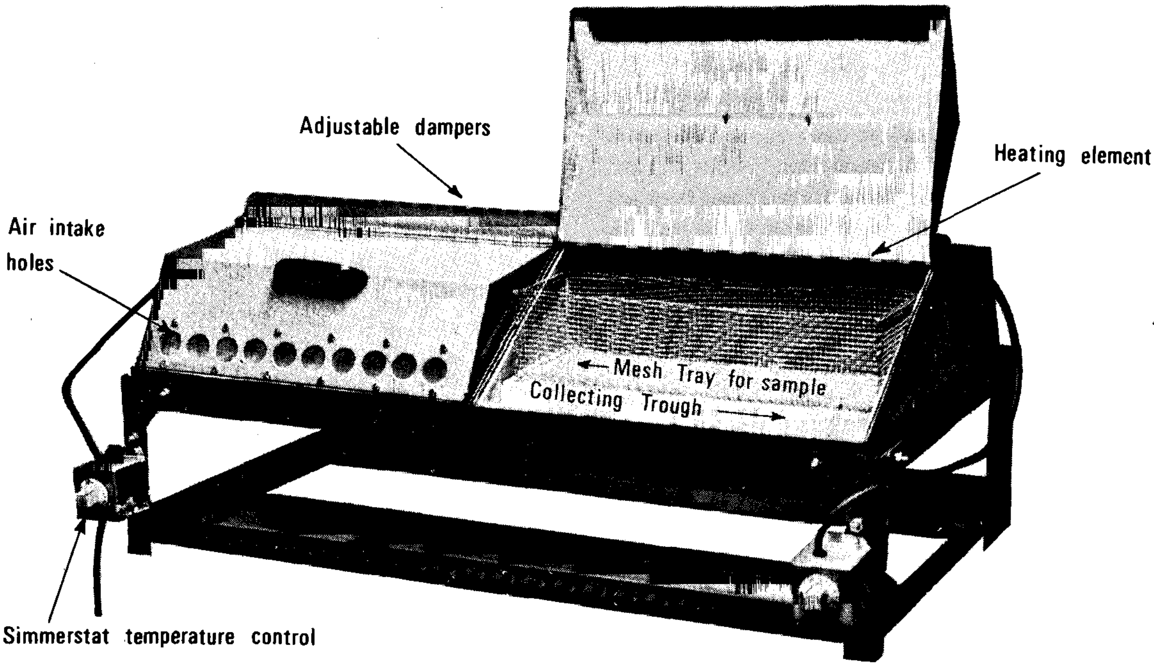

Fig. 5: Platform Temperature-gradient apparatus.

ventilation holes in the ridge. Sharp temperature and humidity gradients are formed and the mobile species move out to fall in the collecting gutter. Each tray rests on two pieces of stout wire to raise it a few millimetres above the apparatus floor so that animals moving through the sample to the bottom of the tray have a ready escape route to the gutter (Fig. 5).

A few drops of wetting agent (detergent) should be added to the preservative solution to ensure that the animals sink. At the end of the extraction period (usually from 2-4 days) the solution is drained off into a sorting dish.

Both these methods require care with use. It is recommended that the damper is left fully open for the first 24 hrs unless the sample is already very dry (in which case the damper should be three quarters closed). Wet vegetation will cause considerable condensation on the inside metal surfaces unless excess moisture is evaporated by maximum draught. On the second day the dampers should be half closed and left in this position until the last day, when they are almost closed. A rough test for measuring the normal working temperature, which has been found to be generally satisfactory, can be made by placing the palm of one's hand on the flat top of each apparatus, midway between the edge and the chimney (damper). The metal should be hot but just bearable to the hand.

In the platform type the constant movement of air across the aqueous preservative solution increases the rate of evaporation, so that it is necessary to top up the levels from time to time by adding water.

(iv) ***Pit-fall traps*** (sometimes called Barber traps) of different types are widely used for ecological survey, especially to catch cursorial species of spiders, harvestmen, beetles and some other active invertebrate groups. The most common type of trap used in Britain is the 1 lb jam jar, although plastic and metal containers of various sizes are sometimes preferred (Fig. 6). The narrowed neck of the jam jar and the smooth surface of the glass are, nevertheless, the best combination for preventing escape after an animal has fallen in.

The trap is set in position by digging a hole with a knife, trowel or borer, which is slightly smaller than its diameter. The tight fit ensures close contact between the surface of the ground and the rim of the trap. If animals are to be kept alive it is best to place some leaf litter or a piece of moss in the bottom of the trap so that they can hide from predators. In any case frequent visits will be necessary. More often the collector will wish to leave the traps out for several days unattended and, in this case, a preservative is required. Chemicals which prevent bacterial and fungal growth are useful although sometimes they are slow to penetrate larger invertebrates. Other widely used preservatives are 2% formalin or undiluted ethylene glycol. These are particularly effective in warm weather. Both can be filtered and used more than once. If phenyl-mercuric acetate is used it should be made up the day before by mixing half a flat teaspoonful with 1 gallon (4.5 litres) of hot water and shaking vigorously.

Whichever preservative is selected, it is advisable to visit the traps at least once a week because catching efficiency can be reduced in a number of ways. Stems and leaves may be blown in to form escape bridges, small rodents may be caught and drowned so that carrion beetles are attracted, the ground surface adjacent to the trap may be disturbed by burrowing (moles) or scratching (rabbits), or the trap may become full after heavy rain. The pit-fall trap is most effective when positioned in a firm substrate but if used in sandy soil, such as a coastal dune, it should be sited where there is a good vegetation cover otherwise wind-blow will soon fill it with sand.

When ready for emptying lift the trap carefully from its hole and empty the contents into a tray for sorting. If preferred the contents may be transferred to a screw-top jar so that sorting may be done later in the laboratory. Some collectors use screw-top jars as traps so that at the end of each trapping period a lid can be screwed on and a fresh jar with preservative placed in the hole. Dr. Merrett tells me that plastic cups with drainage holes and used with a detergent, to ensure that the animals sink, are easier to use in light heathland soils than jam-jars.

A round piece of metal sheet (12 cm dia.) standing on 3 legs will serve as a protection during heavy rain but above-ground structures attract attention and hence disturbance. The advantage of plastic or metal traps is that drainage holes can easily be made at the mid-point so that during heavy rain the trap never becomes full. The soil must, of course, be porous. The pitfall trap is often effective in capturing winter-mature species which move about under snow-cover (Duffey & Millidge, 1954; Kronestedt, 1968).

Many other types of container (made of glass, metal or plastic, large or small, with or without preservative) can be used as pit-fall traps. Ingenious mechanical devices have been constructed to enable catches to be divided into shorter time-periods, for example to separate the day catch from the night or even one hour from the next. Further information on pit-fall trapping can be obtained from Heydemann (1960), Greenslade (1964), Merrett (1967).

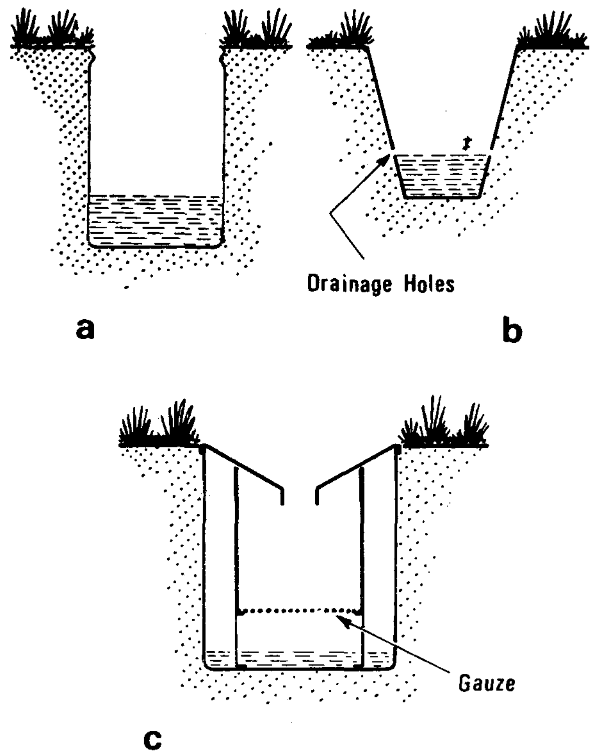

Fig. 6: Pitfall Traps: a) Jam-jar trap; b) Plastic-cup trap with drainage holes; c) Live trap with gauze floor for drainage, and funnel entrance to prevent predation by birds and small mammals.

The pit-fall trap is such a convenient catching method that collectors sometimes forget its limitations. Three main points should be kept in mind. (1) Some species of ground-moving arthropods, due to differences of behaviour and biology, are caught much more readily than others. For instance in a study of limestone grassland spiders (Duffey, 1962a) one of the most abundant species, *Hahnia nava,* was seldom taken in the pit-fall traps. (2) The depth and structure of the ground vegetation greatly influence the number of specimens and the species caught. Deep vegetation slows down horizontal movement and reduces the chance of cursorial invertebrates reaching the trap, whereas a very short grass turf or a moss cover provides few obstacles to movement over the ground. For this reason more speciments of a particular species may be caught in traps in short vegetation than in long, although the population density is higher in the latter. (3) The catch number is influenced by the weather conditions prevailing at the time of trapping.

For these reasons records of species taken in pit-fall traps should include a detailed account of the plant cover and vegetation structure in the catching area, and the greatest caution should be applied in the interpretation of the results, particularly the conclusions made on the relative numbers of species taken and comparisons between different sites.

(v) ***Litter heaps*** of cut vegetation, especially on grassland or in fens, have long attracted both arachnologist and entomologist because of the large numbers of animals which are often found in them. Tough, rigid plant material such as reed, sedges and some grasses provide a structure with many open spaces which attract small web-spinning species and through which cursorial species can move easily. The relative humidity and temperature are usually higher than in surrounding natural litter, making a favourable environment for many detritus and fungal feeders which in turn provide food for predators. Soft herbaceous material is unsuitable for litter heaps because it soon rots down to a compost. The greater volume of material in a litter heap provides much more "living space" for surface animals, simulating a natural situation such as a deep accumulation of beech leaf litter in a hollow, the large quantity of leaves and wood debris which collects between the stems of a hazel coppice stool, or a large tussock such as those of *Carex paniculata* L, *Juncus acutus* L. or *Deschampsia caespitosa* (L) Beauv.

Deep natural accumulations of litter occur on the shores of lakes, seashores and saltmarshes. Some may be extremely rich in animals although most of the specimens are usually found to belong to one or two species which have been able to exploit the newly created habitat more rapidly than others (Duffey, 1970b). The species found in a litter heap situated well within a particular vegetation formation are usually the same as those in the surrounding natural litter but they are "concentrated". However, in boundary zones such as sand-dune/saltmarsh, woodland/grassland, fenland/heathland, litter heaps often seem to attract many species from both adjacent formations.

For certain specific purposes it may be necessary to compare the numbers of animals or species in measured quantities of litter, or else natural litter may be so scarce that collecting is tedious and time-consuming. In such instances nylon net (1 cm mesh) bags filled with litter may be placed out and left for several weeks or months to allow natural colonisation. A fairly large size is needed for macro-arthropods, e.g. 25 x 25 cm and 5 cm deep.

(vi) Artefacts such as ***tiles, shells and pieces of wood*** or the construction of ***shallow holes to simulate rabbit scrapes*** may be useful in certain situations, Fig. 7. Open grassy heaths with very short turf, such as chalk down or heathland, are often very difficult to collect in because there are few surface structures and only a thin layer of vegetation to examine. Roof tiles as artificial stones provide a micro-habitat for shelter, egg-laying, moulting or web-spinning in the same way as do large shells in coastal situations or pieces of wood in a forest with little fallen timber. The surface topography of a site can also be made more varied by

Natural rabbit scrape

A roof tile as artificial cover

Fig. 7: Artefacts.

making small excavations in the surface. Depressions, about 10 x 10 cm, often made by rabbits but less numerous since myxomatosis, attract many web-spinning linyphiid and theridiid spiders and some species of thomisids which like to position themselves just under the rim of scrapes or holes.

(vii) ***Sticky traps*** cannot normally be used successfully on the ground because they are soon smothered by wind-blown debris. There is, however, some evidence that they are more effective than pit-fall traps in catching certain species of salticids. The type described was used on short turf in the Suffolk Breckland with a parallel series of pit-fall traps and took many more of *Attulus saltator* (Simon) during the main period of male activity. A glass petri dish was placed on the ground with base uppermost. Fruit-tree banding gum was then spread thinly over the glass surface. It was necessary to inspect the traps every 2 days because sand and dead vegetation were soon blown over the sticky surface. Mice were also attracted to the trapped insects and left remains of fur on the trap. For solvents of this type of gum see 2(iii). A similar type of trap is described by Mellanby (1962).

(viii) ***The Dietrick vacuum sampler*** should be mentioned here because it has been used successfully by arachnologists, although the cost (£250) puts it beyond the means of most amateur zoologists. A small portable petrol engine attached to a frame is carried on the back of the operator. The engine works a fan which draws air through a concertina tube attached to a glass fibre cylinder. The cylinder is placed over the ground and small invertebrates, caught by the draught of air, are held against the fine mesh of a nylon net bag. The bag with the catch is removed and sorted live or placed in a screw-top jar with a killing agent. The apparatus is bulky and noisy but is probably one of the best methods for rapid quantitative sampling. The vacuum sampler is particularly useful for sampling grassland insects, although its efficiency is progressively reduced as the vegetation becomes taller and denser. Above about 30 cm vegetation height a vacuum sampler with a detached funnel is sometimes used. The engine driving the fan is carried on a two-wheeled hand trolley and the open end of the tube has a diameter of only 10-20 cm. The large detached cylinder is placed over the vegetation and the animals are caught by moving the mouth of the inlet tube over the sampling area within it, as in domestic vacuum cleaning. Further details of these methods can be obtained from Southwood (1966) and Morris (1969).

Field layer (up to about 1 m in height)

(i) ***The sweep-net*** is the only widely used method for collecting from fieldlayer plants of about 20 cm or more in height. The net frame has a straight side for more effective contact with the vegetation and a relatively short handle is attached to the curved side. The sweep-net has been used extensively in research although not very much is known about its efficiency on different types of field layer vegetation. Heikinheimo & Raatikainen (1962) compared sweep-net sampling with vacuum-sampling (detached cylinder type) in a timothy grass ley and a spring cereal crop. The results showed that the catching efficiency of these two methods varied considerably according to type of vegetation especially in the representation of invertebrate groups and numbers of specimens. Lowrie (1971) has also compared the effects of time of day and weather on sweep-net catches.

(ii) ***Hand-collecting*** is a useful method in open types of field-layer vegetation. It has a high degree of accuracy because each individual plant can be examined and it provides the maximum ecological information about the site, activity and numbers of the animal species recorded. For example, the numbers and distribution of the spiders in an open field-layer vegetation of *Hypericum* sp., *Pastinaca* and *Cynoglossum* in a limestone grassland may be assessed by marking out a fairly large sampling area, about 10 x 10 m, and subdividing into 1 x 1 m squares (Duffey, 1962b). A cane should be placed at each grid-line intersection if this can be done without disturbance, otherwise a string should be thrown over at metre intervals to mark out the grid. Each square should be numbered in relation to a grid drawn on paper and the plants examined square by square, plotting the position of each identified spider. The remainder are collected and those from each square kept separately. The identity of the "host" plant should be recorded, also the position of the spider on the plant, the presence of web, eggs, prey and activity. Much can be learned from such studies about preference for certain plant structures, over-wintering sites and other biological characteristics.

In the summer when plants are in leaf the plots selected should not have more than about 40-50 plants per m^2, otherwise the census will be very time-consuming. During the winter months higher plant densities may be selected because dead plants are easier to examine.

(iii) The dispersal activity of spiders from field-layer plants is best studied by the use of ***sticky traps***. They are easy to construct and the materials cheap but the collection of specimens is tedious and some of the recommended gum solvents make spiders brittle and difficult to handle for determination. The gum material may be exposed for catching in a number of different ways. The most usual methods make use of canes or stakes, glass plates and cylinders. The gum is spread over the upper 30 cm of a 2 m cane but not on the top 3 cm because it is used as a perch by wild birds. About 20 canes are usually required to obtain a large enough sample. Ballooning spiders are caught directly or when their parachute thread makes contact with the gum. There is a small but unavoidable error with this method. Certain species which normally live in field layer vegetation crawl up the canes and are caught when they reach the edge of the gum. However, other species which are preparing to disperse aerially may also climb canes and are caught in the same way. There is likely to be some difficulty in separating these two components of the catch because knowledge of dispersal behaviour is still very inadequate (Duffey, 1956).

The problem can be overcome by using suspended glass plates or cylinders. The plates are gummed on each side and hooked on to wire supports from a wooden T frame 2 m in height. At the end of the trapping period the plates are unhooked and placed in a wire carrier with slots of appropriate size (as with a magazine or record rack) for transport to the sorting room. Cylinders which are suspended in the same way take a plastic cover or sleeve on which the gum has been spread. This method has the advantage of a larger catching area but glass plates are more conveneient and easier to put out and collect in large numbers.

The most effective adhesive material is resin gum, as used for banding fruit trees, because it is less likely to become fluid in warm weather. However the recommended solvents, trichlorethylene, ether, hot paraffin or a half and half mixture of glacial-acetic acid and ethyl acetate, are unpleasant to use and some workers prefer a stiff grease which can be dissolved in a mixture of benzene and isopropyl alcohol.

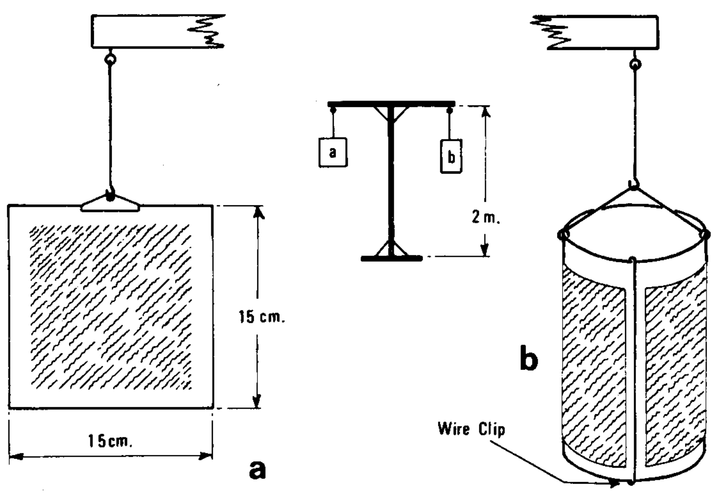

Fig. 8: Sticky Traps: a) Suspended glass plate; b) Suspended plastic or metal cylinder with gummed paper.

Canopy, trunk and branch (scrub and trees)

(i) ***An umbrella or beating tray*** (cloth-covered folding frame) are the most usual items of equipment for the arachnologist collecting from tree or shrub foliage. The tray is held under a section of canopy which is then tapped with a stick to dislodge the animals from the leaves and twigs. Two sharp taps are usually sufficient, care being taken not to damage the tree. Many of the spiders inhabiting tree foliage are too large to be collected by use of a pooter and it is advisable to have a supply of 5 x 1 cm (or 2" x ½") tubes available.

This method has been used quantitatively (a fixed number of taps per unit of canopy) to compare the insect fauna of different species of trees and the same species in different woods (Sachell & Southwood, 1963). Other methods of sampling the fauna of tree foliage, particularly small insects, are described in Southwood (1966) and Murphy (1962) but they are not likely to be of value to the arachnologist.

(ii) Sampling from ***whole trees*** for predatory invertebrates is only possible when the tree is of small size. The simplest method is to spread a plastic sheet over the ground around a small tree or bush which should then be given a sharp knock or knocks with a rubber or wooden mallet. A companion is needed to help collect the fast-moving species which fall on the sheet, as otherwise some of the catch may be lost.

It is worth noting that research workers studying tree pests sometimes estimate the population density of insects by shrouding the whole tree in a polythene sheet and then pumping an insecticide dust or spray inside. The dead insects fall onto a ground sheet.

(iii) The ***trunk and branches*** of trees have a distinctive fauna which is often difficult to sample. Three methods are described here which are easy and cheap to use, (a) brushing, (b) gum bands and (c) corrugated paper traps. If the tree bark is covered with mosses and lichens, as in high rainfall areas, the epiphytes should be pulled or scraped off into a tray or net and then hand-sorted in the usual way.

Brushing is a quick and convenient method of sampling large numbers of tree trunks or branches. A small, soft, hand-brush is used, lightly brushing the bark surface and crevices so that the specimens are dislodged into a net or tray held beneath. Deeply-fissured bark may be best treated with a smaller brush capable of penetrating the crevices.

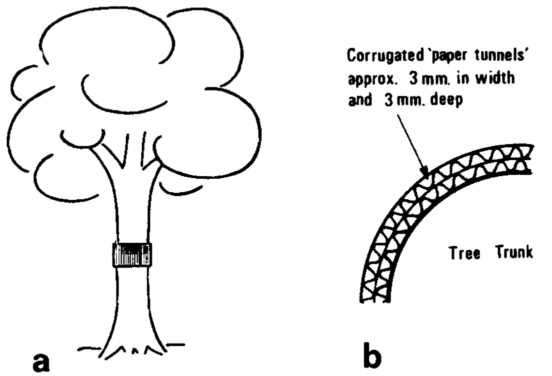

Fig. 9: Trunk Traps: a) Corrugated paper band applied to trunk of tree; b) Section through paper on tree.

Gum-bands, applied as on fruit trees, are useful in that they need only be visited every few days. Spiders which hunt over the bark or make diurnal or seasonal movements up and down trees are readily caught. Gums, greases and solvents are described in 'Field layer' above.

Corrugated brown paper is a preferable trapping method, however, because it is cleaner, the specimens do not suffer damage and it can also be adapted for quantitative studies (Duffey, 1969). The corrugated paper is cut into strips about 20 cm wide and long enough to be wound twice round the tree. The paper is held in place by string and a small nail knocked into the trunk, by the lower edge, to prevent it slipping down. Spiders and other bark-living invertebrates lodge in the "tunnels" of the corrugated paper (Fig. 9). This type of trap can be left out for several weeks at a time and survives frequent rain. The only hazard recorded (once in over a year) was from a bird, probably a woodpecker, which tore holes in the paper. At the end of the trapping period the paper is gently unwound and placed in a polythene bag. A drop of ether on cotton wool anaesthetises the animals in a few minutes. The two sheets making up the corrugated paper can easily be pulled apart (they are soon softened by the moist outside atmosphere) to reveal the animals caught. This method is particularly suitable for smooth-barked trees as it is really an artificial method of providing the crevices normally present on rough-barked trees.

In a final comment to this section one should reiterate that many of the field collecting methods described were originally used to obtain specimens for collections and only later adapted for ecological survey. In other cases they were developed for studies on soil animals and later modified for larger surface-living invertebrates. None is perfect and each varies in its catching efficiency in relation to the site characteristics, particularly vegetation structure, behaviour differences and numbers of the animals being collected and the weather conditions. Although quantitative data are often the main object of some projects, it is well to remember that the *maximum* ecological information about a species can still only be obtained by accurate recording and study of the individual specimens. For this reason an ideal scheme for ecological survey should be partly intensive (detailed studies of the biology of a species) and partly extensive (the study of distribution, numbers and habitat preferences). The technology of ecological survey – for example, the standard of equipment available and the efficiency of methods commonly employed – is probably in an early stage of development because so little survey has yet been done in any country and many improvements are likely in the future. One important aspect of this concerns the length of time which is normally required to record the greater part of the fauna on a particular site. Many groups still have very few specialists able to name the specimens taken, but even with popular groups such as Coleoptera and Lepidoptera, many hours collecting during different seasons may be necessary to obtain most of the breeding species. Short cuts in making faunal assessments are necessary. One example which can be quoted arose out of work on the spider fauna of an open sandy heathland with sparse vegetation. Pit-fall traps and turf samples were used throughout a 12 month period and it was found that when the number of species recorded each month was plotted, there were two peaks, one in early summer and the second in October. Assuming that the two sampling methods recorded all species living on this heath, it would have been possible to obtain about 70% of them by using 20 pit-fall traps from mid-May to mid-June and again during the month of October. This level of assessment would probably be adequate for a rapid comparative survey of a series of similar sites. However, it should be emphasised that in a thicker and taller vegetation this method would almost certainly record a much lower proportion of the total species and a different technique would be required. Nevertheless rapid survey is an important new field which, with further careful study and analysis, may prove to have considerable potential for technical advance in the future.

What to record

The simplest form of report is a list of names of species taken on a site. For many collectors this is sufficient, but it is perhaps not realised that a little extra effort can make the information very much more valuable. In addition to specific names the minimum data which should be recorded are: date, name of locality, 6-figure National Grid Reference and a brief description of the habitat. This is the type of information normally required for a Record Card designed to map the distribution of a species throughout the country.

(i) ***Distribution Record Card*** was first used on a large scale for the British flora but has now been extended to many invertebrate groups by the Biological Records Centre of the Nature Conservancy at Monks Wood Experimental Station. In 1964 a list of British spiders was published by the BRC. on a 5" x 8" card (12.7 x 20.3 cm). Each specific name, arranged in alphabetical order, is abbreviated and has a code number which is used for mechanical data storage and retrieval. The head of the card has space for the name of the locality, NGR, habitat, date, vice-county name and number, and altitude. Although the main purpose of this card is to map geographical distribution, it can also be used for a series of collections from a specific vegetation type, for example, chalk grassland, *sphagnum* bog, heather moor or saltmarsh. However if the card is used to record species on a particular site or nature reserve where there is a wide range of different habitats, then ecological data cannot be recorded – a card per habitat would be needed. In addition, as already mentioned, ecological survey asks three basic questions which demand a good deal more information than can normally be entered on a distribution record card.

(ii) The ***Ecological Record Card*** poses many problems because of the infinite variety of wildlife habitats. The main difficulty has been to devise a system which is simple enough for general use and realistic enough to reflect the range of situations found in nature. An ecological survey card in this country, which has been tested over a long period (17 years), was designed in 1954 by Charles Elton at the University of Oxford for the Wytham Ecological Survey. This work attempted to record systematically on a 6" x 4" punch-card (approx. 15 x 10 cm) comprehensive data on the ecology, activity, numbers, developmental stage and habitat of the fauna occurring in Wytham Woods, Berks, 1000 acres (approx. 417 ha) of woodland, grassland, stream and marsh (Elton, 1966). The card (Fig. 10) has 92 holes for "punching" information in relation to different habitat systems, while further notes can be added in the blank space in the centre. It can be used for abstracting published data but is best adapted for recording an ecological event in the field, when maximum use can be made of the card's potential for documentation. The accumulated records are then grouped in relation to a habitat classification system also designed by Elton.

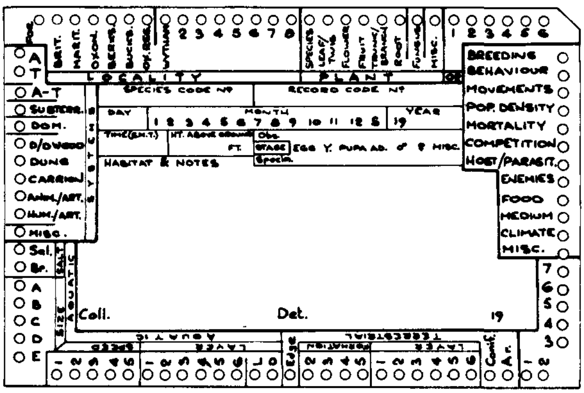

Fig. 10: The Eltonian ecological recording card, used for the Wytham Survey.

The Wytham Card was developed for a specific research problem and is probably too detailed for most collectors, particularly those arachnologists who are primarily concerned with processing their own data. Recently another type of Ecological Record Card has been designed for British isopods and myriapods, but because it is closely adapted to the ecological characteristics of this group it is not suitable for other invertebrates. A rather different card is in use at Monks Wood Experimental Station to record ecological information about the fauna of Juniper, and the Society for the Promotion of Nature Reserves has designed a Habitat Card "for recording all the significant information" about a site together with details of habitats and their acreages.

It is clear that there is no system which the average collector, interested in recording ecological information, can adopt without modification. Punch cards are still of value to the individual but for a national scheme rapid mechanical methods of data storage and retrieval are necessary. It is obviously desirable that all collectors use a common system because information from other sources can then be incorporated. A simplified form of the Wytham card could probably be devised for use by arachnologists, but the easiest method for the individual is to use a card index or loose-leaf folder in which additional cards or pages are added for each species as more information becomes available. Records of occurrences are entered in chronological order noting date, sex, number of individuals, activity, name of locality, grid reference and a full account of the habitat. The last item often presents most difficulty. The important thing to remember is to note not only the exact situation, e.g. "under stone" or "in leaf litter", but also the *ecological setting,* as follows, "under stone on open, short, grass heath on sandy soil", "in beech leaf litter 20 cm deep in densely shaded mature beech wood on chalk", "in moss on water-logged ground in sedge fen", or "beaten from canopy (at 2 m) of oak tree about 20 m high on edge of oak/ash woodland". These descriptions are very brief and it is a good rule to expand the habitat description to include all the ecological data the individual is capable of recording. Activities such as "web-spinning", "hunting", "with young", "carrying eggs", "courting" and "mating" should be noted as well as precise position in the habitat. Arachnologists able to name plants should make full use of this knowledge. A pocket notebook is an essential item of equipment if one is to record ecological information. If collections are made in several different localities during the course of a day, it is important to write up the habitat and activity details whilst on the site rather than rely on one's memory at the end of the day. Similarly, collections which are put straight into preservative should be labelled in the field and not left to the end of the day when they might become mixed up with other unlabelled tubes.

(iii) ***Voucher Specimens.*** Many collectors no longer keep specimens, irrespective of their origin, once they possess several examples of both sexes of a species. This may be justified for certain types of collections or well studied taxa but it has certain dangers for ecological studies. A record of a local species from an unusual habitat may, later on, be suspected as a mistake but cannot be checked in the absence of the specimen. For such reasons it is good practice to retain in separate labelled tubes specimens of a species recorded from a new locality, even if it has been taken frequently elsewhere. Two examples will illustrate this point. The rare *Pirata uliginosus* (Thor.) was first recorded in Britain in 1951 (Duffey, 1953). Subsequently, it was found in long-established collections preserved with the common and closely related *P. hygrophilus* Thor. but without date, locality or habitat. Similarly *Clubiona similis* L. Koch was first recognised in Britiain in 1956 (Peake, 1958) but was later found in older collections having been confused with the common and closely related *C. neglecta* O.P.-Camb.

The storage and preservation of specimens need no comment here, having been described fully in several publications, notably Locket and Millidge (1951), Cooke (1966b; 1969), Crocker (1967; 1969b) and Spalding (1967).

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References

COOKE, J.A.L. 1966a; A convenient design of Pooter for the capture of small carnivorous arthropods. *Ent.Mon.Mag.* **102**: p. 87

COOKE, J.A.L. 1966b: Spider collections and their organisation. *Bull.Brit.Spid.Study Group.* No. 32: 1–3

CROCKER, J. 1967: Hints, Tips and Gadgets for Spider Collections: The Collecting Bag. *Bull.Brit.Spid.Study Gr.* No. 35

CROCKER, J. 1969a: Hints, Tips and Gadgets – The collapsible sieve. *Bull.Brit.Arach.Soc.* **1**(1):p. 11

CROCKER, J. 1969b: Storing a Spider Reference Collection. *Bull.Brit.Arach.Soc.* **1**(3): 44-47

DUFFEY, E. 1953: On a lycosid spider new to Britain and two rare spiders taken near Oxford. *Ann.Mag.Nat.Hist.* **6**: 149-157

DUFFEY, E. 1956: Aerial Dispersal in a known Spider Population. *J.anim.Ecol.* **25**: 85-111

DUFFEY, E. 1962a: A Population Study of Spiders in Limestone Grassland. *J.anim.Ecol.* **31**: 571-599

DUFFEY, E. 1962b: A Population Study in Spiders in Limestone Grassland. The Field-Layer Fauna. *Oikos* **13**: 15-34

DUFFEY, E. 1968: An Ecological Analysis of the Spider Fauna of Sand-dunes. *J.anim.Ecol.* **37**: 641-674

DUFFEY, E. 1969: The seasonal movements of *Clubiona brevipes* Blackwall and *Clubiona compta* C.L. Koch on oak trees in Monks Wood, Huntingdonshire. *Bull.Brit.Arach.Soc.* **1**: 29-32

DUFFEY, E. 1970a: *The Spiders of Wicken Fen.* Guides to Wicken Fen No. 7. The National Trust.

DUFFEY, E. 1970b: Habitat Selection by Spiders on a Saltmarsh in Gower. *Nature in Wales* **12**: 15-23

DUFFEY, E. & MILLIDGE, A.F. 1954: *Centromerus incilium* (L. Koch), a Linyphiid spider taken near Oxford, with notes on related species. *J.Soc.Brit.Ent.* **4**: 218-23

ELTON, C.E. 1966: *The Pattern of Animal Communities.* Methuen, London.

GREENSLADE, P.J.M. 1964: Pitfall trapping as a method for studying populations of Carabidae (Coleoptera). *J.anim.Ecol.* **33**: 301-10

HEIKINHEIMO, O., & RAATIKAINEN, M. 1962: Comparison of suction and netting methods in population investigations concerning the fauna of grass leys and cereal fields, particularly in those concerning the leafhopper, *Calligypora pellucida* (F.). *Valt.Maatalousk.Julk.Helsingfors.* **191**: 31 pp.

HEYDEMANN, B. 1960: Die bizönotische Entwicklung vom Vorland zum Koog. I. Tiel: Spinnen (Araneae). *Akad.Wissen.Lit.* No. 11: 747-913

KRONESTEDT, T. 1968: Notes on the Swedish species of the genus Centromerus F. Dahl. (Araneae, Linyphiidae). *Entomol.Ts.Arg.* **89**: 111-127

LOCKET, G.H. 1969: A Short History of Our Society. *Bull.Brit.Arach.Soc.* **1**: 1-3

LOCKET, G.H. & MILLIDGE, A.F. 1951: *British Spiders.* Vol I. Ray Soc. London.

LOWRIE, D. 1971: Effects of time of day and weather on spider catches with a sweep net. *Ecology.* **52**: 348-351

MACFADYEN, A. 1963: *Animal Ecology:* Aims and Methods. 2nd Edit. Pitman, London.

MELLANBY, K. 1962: Sticky traps for the Study of Animals inhabiting the Soil Surface, in MURPHY P.W.(Ed.) *Progress in Soil Zoology.* Butterworth, London: 226-227

MERRETT, P. 1967: The Phenology of spiders on heathland in Dorset 1. Families Atypidae, Dysderidae, Gnaphosidae, Clubionidae, Thomisidae and Salticidae. *J.anim.Ecol.* **36**: 363-374

MURPHY, P. (Ed.) 1962: *Progress in Soil Zoology*, Butterworth, London

PEAKE, J.F. 1958: *Clubiona similis* L.Koch. A spider new to Britain. *Trans.Nor.Norw.Nat.Soc.* **18**: 32-33

SATCHELL, J.E. & SOUTHWOOD T.R.E. 1963: The Heteroptera of some Woodlands in the English Lake District. *Trans.Soc.Brit.Ent.* **15**: *117-134*

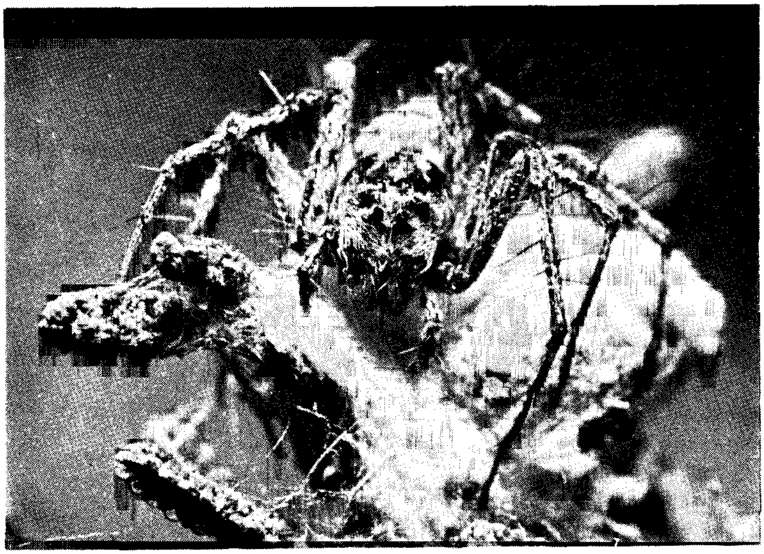
SOUTHWOOD, T.R.E. 1966: *Ecological Methods.* Methuen, London

SPALDING, D.A.E. 1967: A useful storage unit for spiders in tubes. *Bull.Brit.Spid.Study Gr.* No. 33

Oxyopes heterophthalmus Latr.

P. C. Jerrard

Two females of the above species were collected by the late Mr.D.J. Clark on a heath near Guildford, Surrey on 9 August 1970. Both were guarding their egg cases on spun-together *Calluna* twigs at the top of the plants.



Figs. 1 - 2. Female *Oxyopes heterophthalmus* Latr. guarding egg cocoon on *Calluna.*

The specimens were brought back to the British Museum (Natural History) where one was photographed by Mr.K.H.Hyatt of the Arachnida Section (Figs. 1 & 2).

The camera used was an Exakta with bellows attachment and electronic flash; film, Ilford Pan F.