ECOLOGICAL STUDIES ON THE STAPHYLINIDAE (COLEOPTERA) OF THE CHARNWOOD FOREST AREA, LEICESTERSHIRE

by

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1. INTRODUCTION

1.1 Statement of Problem

The Coleoptera is the largest order of insects, and comprises about 40% of known species in the Class Insecta (Borror and DeLong, 1971). Britton (1970) estimates that there are between 277,000 and 350,000 described species of beetles in the world. Of these, an estimated 27,000 species belong to the family Staphylinidae, making it one of the major families of beetles (Britton, 1970). In Britain alone, approximately 990 species of staphylinids have been recorded (Britton, loc. cit.; Kloet and Hincks, 1977).

In spite of the specific abundance of the Staphylinidae, an extensive review of literature reveals that this family has been relatively poorly studied, especially from an ecological point of view. Much of the work which has been done on the family is purely taxonomic and descriptive, e.g. Mank (1923), Voris (1934), Frank (1967, 1969), Horion (1967) and Kasule (1967, 1968, 1970).

Of the ecological studies on the Staphylinidae which have been reported, many have been carried out in conjunction with studies on the Carabidae since members of both these families are surface dwellers (Van der Drift, 1959; Evans, 1969, 1971; Nield, 1974). Most of these studies are descriptive records of staphylinid captures, the habitats in which they occur, their seasonal variations in abundance, and their life histories and feeding habits. Notwithstanding the diversity of habits and habitats which have been recorded in this way, few attempts have been made to quantify this diversity apart from the studies by Luff (1966a) and Jones (1976), and to make quantitative comparisons of staphylinid communities, as in the study by Hanski and Koskela (1977).

The object of this investigation was to study the Staphylinidae of the Charnwood Forest area of Leicestershire. The occurrence and seasonal variations in the abundance of various staphylinid species in different habitats in Charnwood Lodge Nature Reserve and in Martinshaw Wood were examined using both pitfall traps and heat extraction of soil samples. As a complement to the field studies, laboratory cultures were attempted to determine the food preferences of selected Staphylinidae. To obtain sufficient live Staphylinidae for these laboratory studies, baited traps and handsorting were used.

The pattern of species diversity in the Staphylinidae of the different habitat types was examined from pitfall data using indices of diversity. These samples were then compared quantitatively using an index of similarity, and classificatory and ordinatory sorting techniques, to investigate whether habitat preferences or seasonal effects have a greater influence on staphylinid distribution and abundance.

1.2. Literature Review

An extensive survey of literature reveals the diversity of habits shown by the Staphylinidae, and of habitats in which they occur. Since these aspects of staphylinid ecology are too extensive to be examined on a world-wide basis, the following literature review is restricted to studies on the British Staphylinidae, but, where relevant, examples have been drawn from elsewhere.

1.2.1 Diversity of Habitats

Members of the family Staphylinidae are found in a wide variety of environments, ranging from grassland and woodlands, to mountains and aquatic and littoral environments. Common woodland species include <u>Philonthus</u> <u>decorus</u> (Grav.), <u>Othius</u> <u>punctulatus</u> Goez., <u>Quedius</u>

fuliginosus (Grav.), Tachinus rufipes (Degeer) and members of the Aleocharinae (Van der Drift, 1959; Evans, 1969, 1971; Nield, 1974). More open habitats such as woodland edges, fields and gardens are characterised by Tachyporus spp. (Nield, 1974), some members of the subfamily Steninae e.g. Stenus impressus Germ. and S. clavicornis (Scop) (Luff, 1966a,b), and some members of the subfamily Staphylinini such as Staphylinus aeneocephalus Degeer (Boyd, 1960) and S. ater Grav. (Allen, 1952). In open habitats, Luff (1966a,b) and Atty (1967) found Stenus clavicornis, S. impressus, Tachyporus nitidulus (F.), T. chrysomelinus (L.), T. hypnorum (F.), Amischa analis (Grav.), and Atheta spp., especially A. (Acrotona) fungi (Grav.), well represented among the beetle fauna of grass tussocks. Platystethus capito Heer is often found crawling on open chalky ground (Allen, 1954).

While some Staphylinidae e.g. T. chrysomelinus and T. hypnorum are more or less ubiquitous in distribution (Nield, 1974), others are somewhat restricted to specific habitats. According to Johnson (1966a), Quedius boopoides Munster and Q. umbrinus auctt. Brit. are restricted to montane environments in Britain, being found in sphagnum at altitudes above 2000 ft. above sea level, where climatic conditions are severe. Quedius fodinarum S. Uéno et Y. Watanabe, Quedius cephalotes S. Uéno et Y. Watanabe and Quedius troglodytes S. Uéno et Y. Watanabe are confined to caves in Japan (Uéno and Watanabe, 1966).

Many Staphylinidae are restricted to aquatic or marine environments. Colonies of Bledius defensus Fauvel are found on vertical river banks which are often submerged after heavy rain (Steel, 1953). Species of Lesteva can also withstand prolonged immersion in water - Lesteva fontinalis Kies.* appears restricted to moss on rocks in

*presumably = hanseni Lohse, 1953 (cf. Kloet and Hincks, 1977) waterfalls, or on rocks and stones washed by the spray from them. Lesteva longo-elytrata (Goez.), L. pubescens Man., and L. monticola Kies. have also been found submerged, but these species have a wider habitat range and are also found in drier situations, such as among the roots of grass (Steel, 1952). Trogophloeus arcuatus Steph. is restricted to aquatic environments, and is found submerged on debris in fast flowing streams (Allen, 1953).

Some staphylinids eg. Bledius spp., are found in maritime environments (Steel, 1955; Johnson, 1966b). Bledius spectabilis Kr. is limited to sand below the high tide mark, where its burrows are periodically submerged (Steel, loc. cit.). B. germanicus Wagn. is more widespread, being found in salt marshes and in sandy, clayey and muddy areas near the sea which are always moist but submerged only infrequently. B. tricornis Heer and B. unicornis Germ. are also salt marsh species (Steel, loc. cit.; Johnson, loc. cit.).

Many staphylinids are associated with decomposing animal matter. Using baited traps, Kaufmann (1937a, b) lists Atheta crassicornis Fab., Tachinus subterraneus Linn., Quedius mesomelinus Marsh, and Proteinus ovalis Steph. among the necrophilous Staphylinidae, while Walsh (1931) includes Proteinus brachypterus F., Oxypoda spectabilis Maerk., and O. lividipennis Mann.. The succession of Coleoptera associated with carrion in varying stages of decomposition has been studied by Moore (1955), Easton (1966) and Smith (1975) among others. Among the Staphylinidae commonly occurring in carrion they list Aleochara curtula (Goez.), Proteinus brachypterus, Omalium rivulare (Pk.), Autalia impressa (Ol.), Creophilus maxillosus (L.), Atheta aquatica (Thoms.), Philonthus politus (L.), and Atheta laticollis Stephens.

Poultry manure has C. maxillosus, Philonthus sordidus Grav. and P. politus associated with it (Peck and Anderson, 1969), while

Falagria dissecta Erichson, Atheta analis Grav., Philonthus rectangulus Sharp and Oxytelus suspectus Casey are among the staphylinids found in cattle dung (Thomas, 1967). Platystethus arenarius (Fourcroy) is known to feed exclusively on cow dung, although their larvae are facultative carrion feeders, feeding on the dead larvae of other Staphylinidae (Hinton, 1944).

Mank (1923) records Philonthus brunneus Grav., P. longicornis Steph. and Tachinus flavipennis Dej. from decaying plant material, while Pototskaya(1975) lists Phloeonomus pusillus Grav., P. planus Payk. and Siagonium vittatum Fauv. among the Staphylinidae associated with decaying wood. Some staphylinids e.g. Gyrophaena spp. are specialised fungal inhabitants, occurring in many Agaricales and Polyporaceae (White, 1977).

Many Staphylinidae are of potential economic importance, as pests of crop plants. Adults of Carpelimus pusillus (Grav.) feed on, and injure, seedlings of cucumbers, melons and chrysanthemums (Tullgren, 1917 cited in Hinton, 1945) while adults of Oxytelus sculptus Grav. feed on young cucumbers (van Poeteren, 1937 cited in Hinton, 1945).

1.2.2 Diversity of Habits

Associated with their ability to colonise a diversity of habitats, the Staphylinidae have evolved a variety of habits. Many staphylinids are free living predators, of importance in both natural and artificial ecosystems. The staphylinids associated with decomposing animal or vegetable matter are generally predatory, preying mainly on the dipteran larvae present (Mank, 1923; Abbott, 1937; Fichter, 1949; Johnson, 1975). In agricultural ecosystems, staphylinids have potential economic importance as predators of pest species. The larvae of Tachyporus obtusus L. and T. hypnorum prey on the strawberry aphid, Capitophorus fragariae Theo.

(Dicker, 1944), while Tachyporus chrysomelinus has been observed feeding on the lettuce root aphid, Pemphigus bursarius (L.) (Dunn, 1960). Staphylinid predators of all stages of the cabbage root fly, Erioschia brassicae (Bouché) include Orus punctatus Casey, Xantholinus hamatus Say., Hisperobium californicum Lec., and Aleochara bilineata Gyll. in North America (Treherne, 1916; Wishart, Doane and Maybee, 1956; Finlayson, 1976), and Oxytelus rugosus (F.), Xantholinus longiventris Heer and Philonthus succicola Thom. in England (Coaker and Williams, 1963).

Fox and Maclellan (1956) have shown by the precipitin test that species of Philonthus, Staphylinus and Tachyporus are predators of the wireworm, Agriotes sputator (L.) in Nova Scotia. In Californian orchards, Oligota oviformis Casey has been recorded as a predator of various red spider mites (Quayle, 1913; Badgley and Fleschner, 1956; Fleschner, 1958), while in English orchards, Oligota flavicornis (Boisduval and Lacordaire) preys on the fruit tree red spider mite, Metatranychus ulmi (Koch) (Collyer, 1953). Paederus alfierii Koch is an important predator of the cotton leaf worm, Prodenia litura F. in Egypt (Ahmed, 1957), and Staphylinus olens Müller is a voracious consumer of snails, Helix aspersa Müller, which are severe garden, nursery and orchard pests in California (Orth, Moore, Fisher and Legner, 1975).

Some of these free living predatory staphylinids are parasitic in the larval stage. Larvae of Aleochara bilineata Gyll. and A. bipustulata (L.) parasitise cabbage root fly puparia, which they use for overwintering (Finlayson, 1976). Aleochara inconspicua Aubé parasitises pupae of the wheat bulb fly, Leptohylemyia coarctata (Fall.) (Dobson, 1961), and in North America, A. bimaculata (Grav.) is a minor parasite of the face fly, Musca autumnalis de Greer (Thomas, 1967).

A sub-social habit has evolved in the Staphylinidae, in

Platystethus arenarius (Fourcroy) (Hinton, 1944) where the female builds a nest in cow dung, remains in it throughout the incubation of the eggs, and during the first few days of larval life, actively guards the eggs and larvae against other insect intruders and against fungi. The larvae sometimes aid the female in killing intruders or in repairing the brood chamber.

Some staphylinids are social parasites, living in the nests of ants and termites. These myrmecophiles and termitophiles show varying degrees of integration into their respective hosts' societies. Most species of Dorylocerus from Africa, for example, are not well integrated into ant (Dorylus spp.) society (Baker and Kistner, 1972), while in Britain, Myrmedonia funesta Gr. are 'hostile persecuted lodgers' in nests of the tree ant, Lasius fuliginosus (Donisthorpe, 1913). Of the termitophilous Staphylinidae, members of the subtribe Termitusina are found in nests of Cubitermes sp. These termitophiles are adapted to the lives of their termite hosts but are not well integrated into their social life (Kistner, 1974). Staphylinid myrmecophiles which are well integrated into their host colonies include Anepipleuronia spp. from Africa (Kistner, 1977) and Procantonnetia spp. and Mimaenictus spp. from Malaya (Kistner and Jacobson, 1975). In Britain, Lomechusa strumosa (F), for example, is a true guest of the ant Formica sanguinea. The female beetle lays her eggs on the eggs or young larvae of the ants. Since the larvae of the beetle are very similar in appearance to ant larvae, they are fed and tended by the ants (Donisthorpe, 1913).

2. MATERIALS AND METHODS

2.1 Study Sites

A. Charnwood Lodge Nature Reserve

A large part of the field study was carried out at Charnwood Lodge Nature Reserve, Leicestershire (SK 4615), situated approximately 18 km from Leicester in a north-westerly direction (Fig. 2.1). Charnwood Lodge Nature Reserve comprises some 230 ha. of woodland, rough grassland and arable land, bequeathed to the Leicestershire and Rutland Trust for Nature Conservation in 1973.

The Reserve overlies some of the oldest rocks found in Britain, belonging to the Precambrian series. The rocks are volcanic in origin and are overlain by an acidic siliceous clay soil. The rock outcrops in many parts of the Reserve, e.g. at Flat Hill, Collier's Wood and Timberwood Plantation. As will be seen later, these rocky outcrops constituted a limiting factor to the systematic layout of pitfall traps.

In the Reserve, five sites were selected for study, namely Collier's Wood (SK 472156), Flat Hill (SK 468157), the bank of a stream (SK 466156), Timberwood Hill (SK 472149), and Timberwood Plantation (SK 469146) (Fig. 2.2).

Site 1, situated on Collier's Hill, comprises deciduous woodland (Plate 1), with the oak, Quercus robur L.*, as the dominant tree species while elder, Sambucus nigra L., and sycamore, Acer pseudoplatanus L., are also fairly abundant. Fraxinus excelsior L., and Crataegus oxycanthoides Thuill. occur only infrequently. Different herbaceous species are dominant on the woodland floor, depending on the season. Endymion nonscriptus (L.) is

*Plant nomenclature in accordance with Clapham, Tutin & Warburg, 1962.

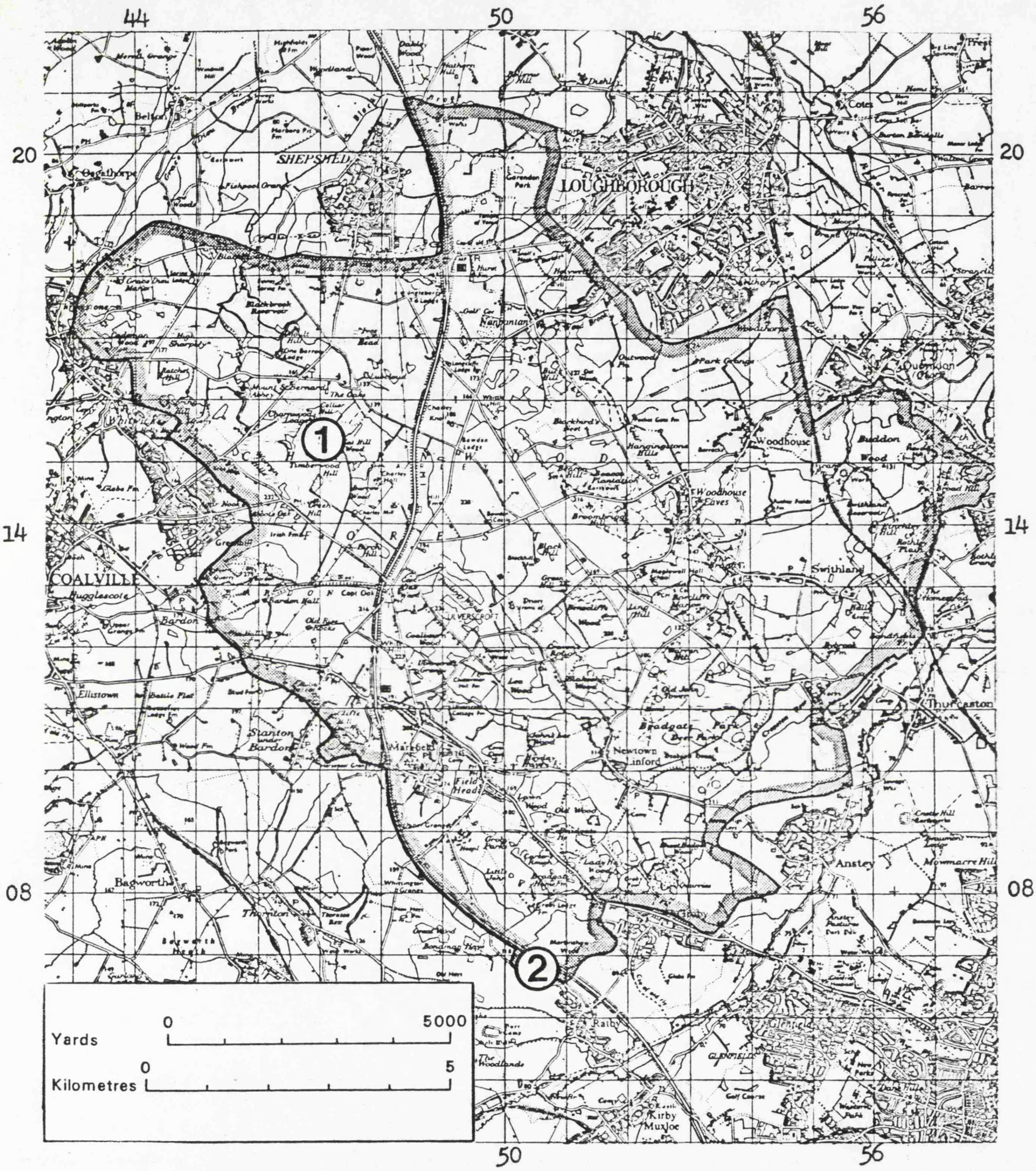


Fig. 2.1 Map of Charnwood Forest Area, Leicestershire, showing locations of (1) Charnwood Lodge Nature Reserve, and (2) Martinshaw Wood.

Fig. 2.2 Map of Charnwood Lodge Nature Reserve, showing locations of study sites.

Site 1 - Collier's Wood

Site 2 - Flat Hill

Site 3 - Stream bank

Site 4 - Timberwood Hill

Site 5 - Timberwood Plantation

dominant from April to June, while Digitalis purpurea L., and Epilobium angustifolium L. become more common later in the summer. Pteridium aquilinum (L.), Urtica dioica L., Prunella vulgaris L. and Galeopsis tetrahit L. are also found, but are less frequent.

At Site 2, on Flat Hill, grassland merges into bracken (Plate 2). The grassland is dominated by Deschampsia flexuosa (L.), with Galium saxatile L., Nardus stricta L., and Holcus mollis L. fairly common. Rumex acetosella L., and Agrostis tenuis Sibth. are infrequent occurrences. As the grassland changes to bracken, P. aquilinum replaces D. flexuosa as the dominant, although the latter remains common, with H. mollis, N. stricta and A. tenuis also present but less commonly.

Study Site 3 is the southern bank of a small slow-moving stream which acts as a sluice flow from Colony Reservoir (Plate 3). The vegetation on the stream bank is very varied, with no clear dominant. The grasses H. mollis, N. stricta, D. flexuosa, Molinia caerulea (L.), and Anthoxanthum odoratum L. are found, together with Cirsium palustre (L.), D. purpurea, Teucrium scorodonia L., Rubus fruticosus agg. L., Calluna vulgaris (L.), P. aquilinum, Ulex europaeus L., Vaccinium myrtillus L., Erica tetralix L., and Juncus effusus L.

The vegetation on Timberwood Hill, Site 4 (Plate 4), is dominated by bracken, P. aquilinum, which reaches a maximum height of 1.2 - 1.5 m in the summer. D. flexuosa and V. myrtillus are found interspersed among the bracken, but where this intergrades into more 'open' moorland, V. myrtillus and C. vulgaris take over as the dominant vegetation, with G. saxatile, H. mollis, and Potentilla erecta (L.) occurring less frequently. Empetrum nigrum L., though rare in Leicestershire, occurs here.

Timberwood Plantation (Plate 5), which includes site 5, is planted with Scots Pine, Pinus sylvestris (L.). This, together with a few trees of *Fagus sylvatica* L., constitutes the only vegetation in Timberwood Plantation, since there is no undergrowth here.

B. Martinshaw Wood

For comparative purposes, Martinshaw Wood (SK 505067) was chosen as a subsidiary study area. Martinshaw Wood is situated approximately 10 km north-west of Leicester, and 10 km south south-west of Charnwood Lodge, on the southern border of the Charnwood Forest area (Fig. 2.1). This wood is managed by the Forestry Commission, and over the last 40 years, the native trees of this wood have been clear felled and replanted with mixed conifers and deciduous species.

Four study sites which are similar in habitat type to four of the Charnwood Lodge sites were chosen in Martinshaw Wood (Fig. 2.3) - these are best referred to by their vegetation type as grass, bracken, oak wood and pine wood.

Site 1 is situated in grass at the side of a grassy ride leading from the conifer nurseries into the plantation (Plate 6). The grasses consist mainly of *D. flexuosa* and *H. mollis*, interspersed with the forb *P. erecta* and a few seedlings of *Quercus* spp. Site 2 is situated in bracken, on the opposite side of the ride to Site 1 (Plate 7). *Betula pubescens* Ehrh., and *P. sylvestris* are found on the woodland edge of the bracken, which comprises mainly *P. aquilinum*, interspersed with *G. saxatile*, *Festuca ovina* L., and *H. mollis*.

In Martinshaw Wood, pines and oaks are planted in alternate strips. Site 3, in the oak wood (Plate 8), is dominated by *Quercus robur* L. On the woodland floor, *H. mollis* and *P. aquilinum* are scattered. Site 4, in the pine wood (Plate 9), is dominated by *P. sylvestris*, with *H. mollis* and *P. aquilinum* as the major undergrowth species.

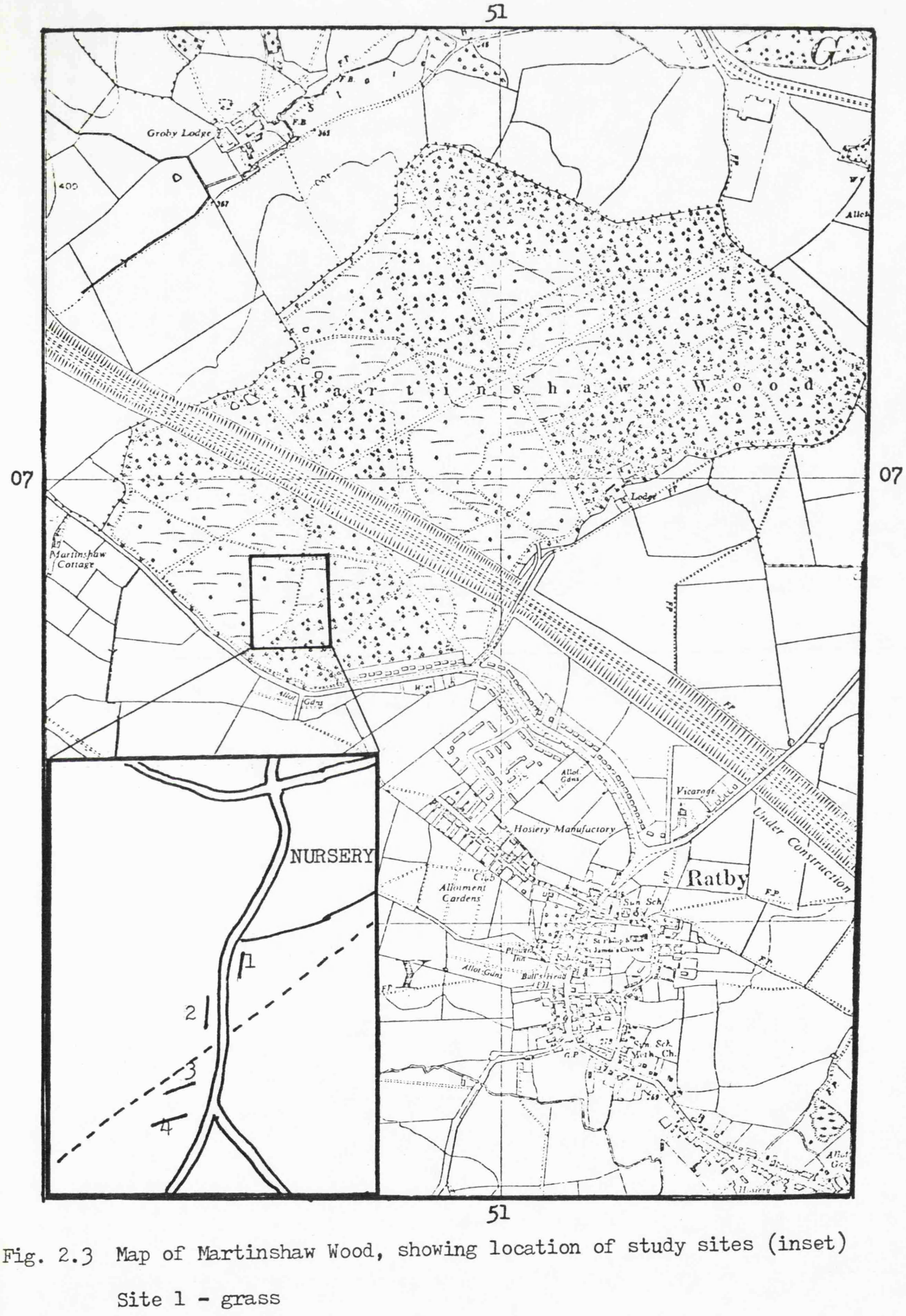


Fig. 2.3 Map of Martinshaw Wood, showing location of study sites (inset)

Site 1 - grass

Site 2 - bracken

Site 3 - oak

Site 4 - pine

2.2. Field Experiments

2.2.1. Pitfall Traps

To obtain data on the relative abundance of the Staphylinidae in different habitat types in Charnwood Lodge Nature Reserve, a series of six pitfall traps was set out in each of four sites at Charnwood Lodge Nature Reserve - Timberwood Plantation, Timberwood Hill, Collier's Wood and Flat Hill, on 23rd October, 1975. A further set of six pitfall traps was set out on the stream bank on 20th November, 1975. Pitfall traps were spaced approximately 8 feet apart, in a straight line, except where the rock outcropped or the underlying rock lay too close to the soil surface, especially on Collier's Hill, Flat Hill and Timberwood Plantation. Large tree roots also disrupted the systematic layout of the pitfalls. Whenever this was the case, the pitfall trap was placed as close as possible to its intended position.

Each pitfall trap consisted of an 8 cm high plastic screw top jar with a mouth 5.5 cm wide. A few drainage holes were made in the base of the jar using a heated mounted needle. Inside this plastic jar, a disposable plastic cup with smooth, slightly sloping sides was fitted. The top of this cup was trimmed so that its edge was flush with the rim of the plastic jar. Drainage holes were made in the walls of the plastic cup about 2 cm above its base, to prevent flooding of the pitfall trap by heavy rain, and resultant losses of trapped meiofauna. Each pitfall trap was filled with ethylene glycol to a depth of about 1 cm. Ethylene glycol, while having a low freezing point, kills and preserves any specimens caught, thus preventing losses due to escape and predation. Each pitfall trap was sunk into the soil, so that its rim was flush with the soil surface. A rainfall shield was then placed over it (Plate 10). This consisted of a 12.5 cm square piece of aluminium sheet. 1 cm wide strips, 3.5 cm long, were cut along the diagonals, and bent downwards to form the supports of the rain shield, so that it was raised approximately 3 cm above the pitfall trap.

Pitfall traps were emptied and reset at approximately monthly intervals, the precise date depending on the availability of transport to the study area. The pitfall traps were readily cleared by removing the plastic cups, emptying their contents into labelled glass tubes, refilling the cups with ethylene glycol, and then replacing them. In this way, the monthly clearing and resetting of the pitfall traps caused minimal disturbance to the habitat.

Since total numbers of Staphylinidae caught in the six pitfalls were relatively low, the number of pitfall traps was increased in June 1976, to reduce sampling error. At each of Sites 1, 2 and 4 therefore, a further 12 pitfall traps were set out, in two rows parallel to the original set of six pitfalls. The number of pitfall traps in Site 3 could not be increased in the same way, because the parallel rows would have lain in a different habitat, while extension of the line was not possible because of bank topography. It was not considered worthwhile to increase the number of pitfalls in Site 5, as the six pitfalls originally set out there were constantly being uprooted by rabbits. This study site was also affected by regular felling of the trees, and undoubtedly this influenced the pitfall catch.

To obtain comparative data on the relative abundance of Staphylinidae outside Charnwood Lodge Nature Reserve, studies were initiated in Martinshaw Wood on 27th July, 1976. In each of the four habitats chosen, a series of six pitfalls was set out as in the Charnwood Lodge sites. It was considered unnecessary to set more than six pitfalls per site, due to the relative 'compactness' of the study sites chosen and also since the results from these sites were only to be used in comparison with those from Charnwood

Lodge Nature Reserve. These pitfalls were also emptied and reset approximately once a month.

Pitfall trapping was carried out for two years in Charnwood Lodge Nature Reserve, until 26th October 1977. In Martinshaw Wood, pitfall trapping was discontinued in March 1977, at Sites 1 and 2, as the widening of the ride in conjunction with the development of the conifer nurseries as a caravan site resulted in their destruction. In the oak and pine woods, however, monthly sampling was carried on until 2nd November 1977.

2.2.2. Modified Pitfall Traps

2.2.2.1. Gutter Pitfall

To compare the trapping efficiencies of different pitfall traps, modifications of the basic jar pitfall were used, based on the guttering trap of Nield (1974) and the 'ditch' pitfall of Schjøtz-Christensen (1965). Plastic guttering, approximately 5 cm in diameter, was cut into ½ m lengths. Each length of guttering was then cut in two longitudinally and buried with its long rim flush with the soil surface. Wooden pegs were placed at intervals along both sides of the pitfall to prevent it rolling over. 3.8 cm wide plastic collecting tubes were placed at either end of the guttering, in such a way that the end of the guttering overhung each tube by about 2 cm. This overhang allowed for slight lengthwise displacement of the guttering, so that any meiofauna which fell into the gutter would eventually fall into the collecting tubes.

Since live specimens were required for laboratory studies, the collecting tubes were left empty, except for the inclusion of a few strips of damp filter paper, which prevented the trapped meiofauna from drying out, and provided prey species with protection from predaceous species. Four gutter pitfalls were set out on 21st May 1976, in Collier's Wood, since, among the five sites in the Reserve, this appeared to have the most abundant staphylinid fauna. These gutter pitfalls were emptied and reset once a week, and the catch of live staphylinids brought back to the laboratory. After three weeks, this method was discontinued, since the traps were constantly being uprooted by rabbits.

2.2.2.2. Square Pitfalls

To overcome the constant displacement of gutter traps, a square pitfall was developed. This consisted of four gutters, rectangular in cross-section, made of 1/16th galvanised steel, which were jointed together to form a square pitfall trap (Figs. 2.4 & 2.5: Plate 11). Four circular holes, 4 cm in diameter, were cut into the floor of the pitfall, near the corners, as shown. The rims of circular plastic collecting tubes fitted exactly into these holes, and were flush with the floor of the gutter. The collecting tubes were filled with ethylene glycol to a depth of about 1 cm. Most of the meiofauna falling into the square pitfall would run along the guttering until they fell into a collecting tube. The 'roof' of the pitfall, which overhangs the gutter, served as a rain shelter. 5 cm wide circular holes were cut into the roof of the trap, immediately above the collecting tubes, to facilitate the removal and replacement of the collecting tubes. These holes were protected from rain by removable rectangular covers, 7 cm wide.

This pitfall was set up in Collier's Wood on 11th May 1977. For the first 1½ months, the collecting tubes were emptied at weekly intervals, but from then on they were cleared and reset at approximately monthly intervals at the same time as the jar pitfalls.

Theoretically, this pitfall should trap only meiofauna from within the area it enclosed, but in practice, leaf litter and twigs falling over the roof of the pitfall formed 'bridges' over which meiofauna from the

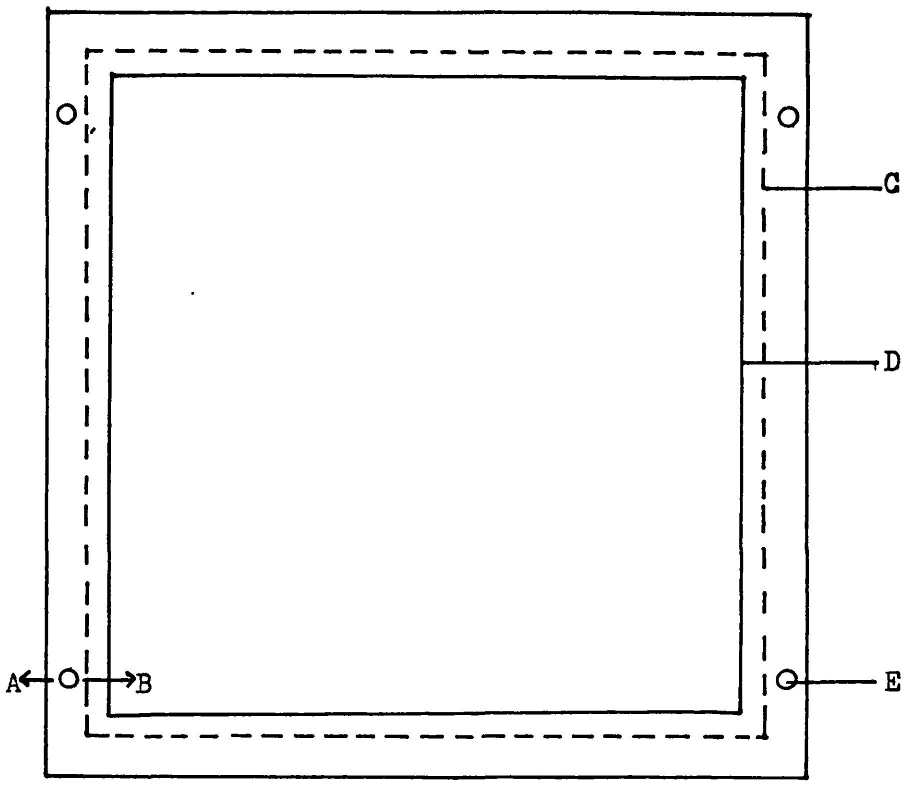


Fig. 2.4 Square pitfall trap (SP1) - viewed from above, rectangular covers removed. (Scale : 1 cm represents 10 cm.)

C - inner edge of gutter

D - inner edge of roof

E - hole in roof for removal and replacement of collecting tubes

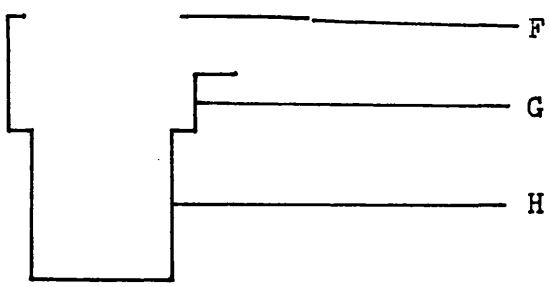


Fig. 2.5 Cross-section through one side of square pitfall trap (SP1), along AB. (Scale : 1 cm represents 2 cm.)

F - roof of pitfall trap

G - gutter

H - plastic collecting tube

surroundings could enter into the enclosed area, and those within the area could escape.

To overcome this difficulty, another square pitfall (Plate 12) was designed. This consisted essentially of two square pitfalls, one inside the other, as shown in Figs. 2.6 - 2.8. The inner pitfall traps meiofauna from within the area it encloses and the outer one traps meiofauna from the surroundings. Each square pitfall retained the same basic design as the original square pitfall (SP1) except that the roof was raised 15 cm above the floor of the pitfall. The collecting tubes could be removed and reset from the open side of the outer gutter so that holes in the roof were unnecessary. Two sections of the roof of the inner square gutter were hinged onto the adjacent roofs of the outer gutter. These could thus be opened outwards to facilitate removal and replacement of the collecting tubes in the inner gutter.

This square pitfall (SP2) was set out in Collier's Wood on 14th December 1977. Initially the collecting tubes were emptied fortnightly, but after about two months they were cleared at approximately monthly intervals.

2.2.3. Baited Traps

To obtain large numbers of certain species of Staphylinidae for laboratory cultures, it was decided to use baited traps although preliminary experiments by Greenslade (1964) showed no increase in the catches of Carabidae in baited pitfall traps.

Initially, pitfall traps baited with fish were used. Small scraps of uncooked cod were tied up in nylon gauze and suspended in each of three glass jars. They were set in Collier's Wood on 6th May 1976, with their rims flush with the soil surface, and examined at intervals of a few days. Since these traps were not very effective in attracting large numbers

Fig. 2.6 Square pitfall trap (SP2), viewed from above.
(Scale : 1 cm represents 10 cm.)

A - roof of outer gutter

B - roof of inner gutter

C - hinge

Fig. 2.7 Square pitfall trap (SP2), viewed from below.
(Scale : 1 cm represents 10 cm.)

D - outer gutter

E - inner gutter

F - holes for collecting tubes

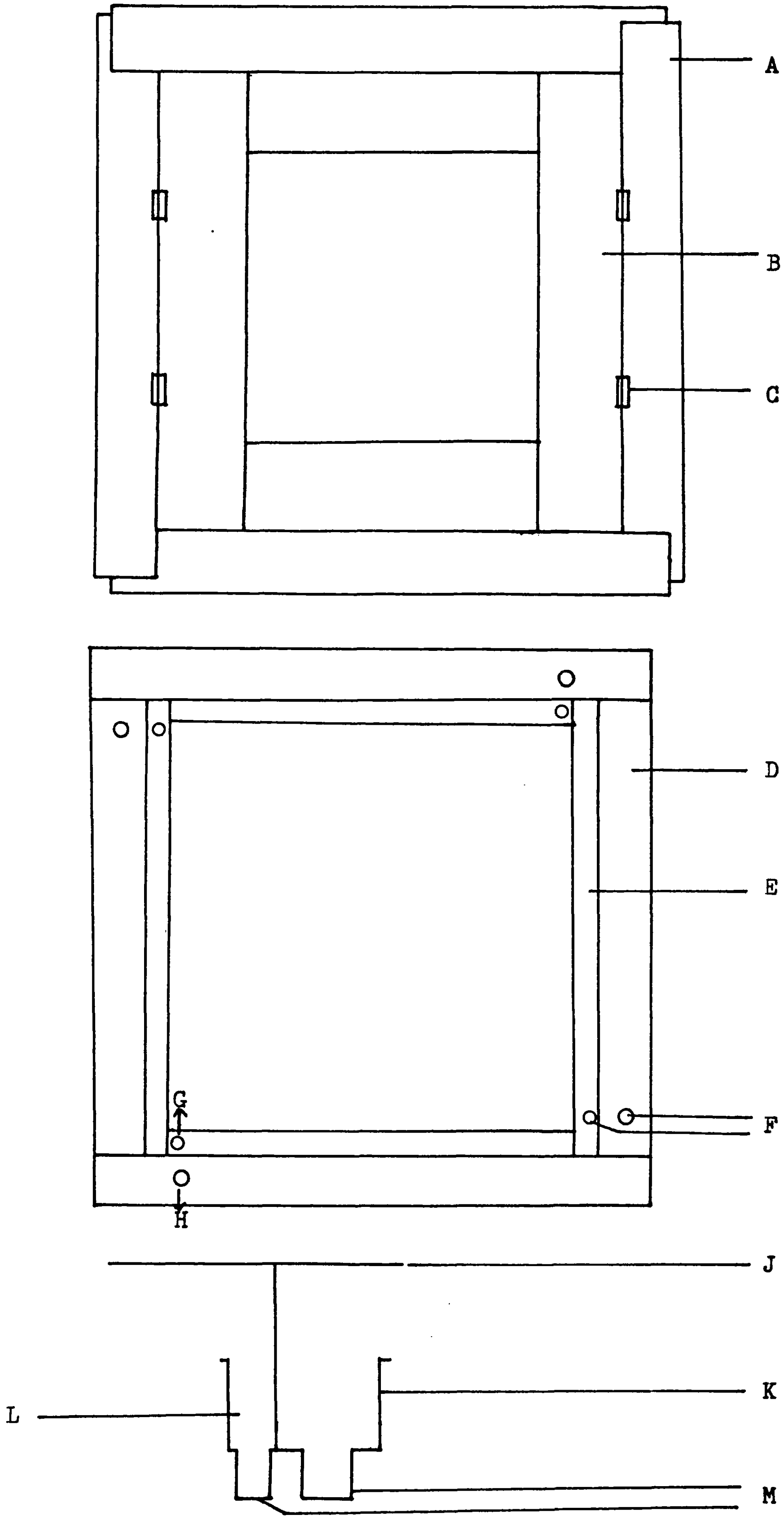
Fig. 2.8 Cross-section through one side of square pitfall trap (SP2), along GH. (Scale : 1 cm represents 5 cm.)

J - roof

K - outer gutter

L - inner gutter

M - collecting tubes


A
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of live staphylinids, different baited traps were devised.

On 27th July 1976, fresh rat carrion was left exposed on metal traps near Flat Hill. Since very few staphylinids were attracted to this bait, and it was constantly being carried off by small mammals, baited pitfalls were set in Collier's Wood, and also in Martinshaw Wood, to check the possibility that necrophilous Staphylinidae are scarce in Charnwood Lodge Nature Reserve.

These baited pitfall traps consisted of 500 ml plastic reagent bottles, the top third of which had been cut off and inverted to form a close-fitting funnel over the rest of the bottle, in which fresh rat carrion was placed (Fig. 2.9). A muslin cloth was tied across the base of this funnel. The whole trap was set with its rim flush with the soil surface. Any meiofauna attracted to the carrion and falling into the trap were prevented from getting into the carrion by the gauze at the bottom of the funnel. Pieces of damp filter paper placed in the funnel served to protect the more vulnerable prey species from their predators.

Four of these baited traps were set up in Collier's Wood on 30th July 1976 and in Martinshaw Wood, on the eastern edge of the plantation in which pitfall trapping was going on, on 3rd August 1976. These baited traps were checked at intervals of a few days. All Staphylinidae trapped were brought back to the laboratory while other captured species were released.

On 14th June 1978, baited pitfall traps were again set out in Charnwood Lodge Nature Reserve, to obtain large numbers of Staphylinidae for laboratory experiments. Each consisted of a plastic screw top jar similar to those used as ordinary pitfall traps. The cover of a 4 cm wide plastic pillbox was glued onto the base of this jar and a piece of raw cod was placed in it. The pillbox, with small holes made in its side walls, was then fitted

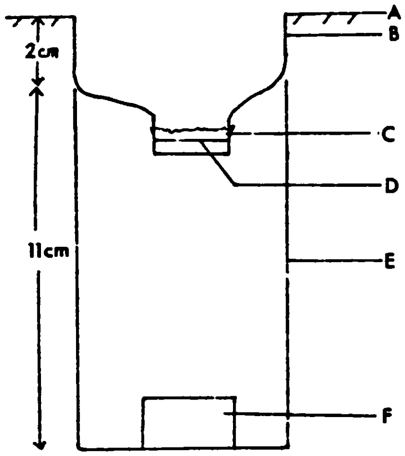


Fig. 2.9 Rat baited plastic pitfall trap in section

A - Soil surface

B - close fitting funnel

C - nylon gauze of 0.08mm mesh size, which prevents entry of attracted meiofauna into bait

D - wire to hold gauze in place

E - plastic pitfall trap

F - rat bait

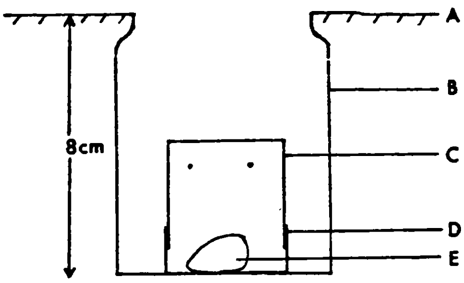


Fig. 2.10 Fish baited pitfall trap in section

A - soil surface

B - plastic pitfall trap

C - pillbox with holes in sides

D - cover of pillbox

E - fish bait

into its cover (Fig. 2.10). The smell of the rotting fish escapes through these holes and attracts necrophilous meiofauna, but when these fall into the pitfall traps they are not drowned in the fluid exuding from the decaying fish, as these are contained within the pillbox.

On 14th June 1978, six of these baited pitfalls were set up on Flat Hill and another six in Collier's Wood. The pitfalls were set in two rows of three pitfalls each. The whole set-up was then covered by chicken mesh which was securely pegged to the ground to prevent small mammals from uprooting the pitfall traps. The pitfalls were checked every few days and live Staphylinidae collected and brought back to the laboratory.

2.2.4. Heat Extractions

Since pitfall traps only estimate relative abundance, it was decided to extract staphylinids from known quantities of soil from each of the study sites. Soil samples were collected with a circular soil auger 11 cm in diameter, giving a soil core 95.03 cm^2 in cross-sectional area. The volume of this core varied, depending on the depth to which the auger could be sunk. Two soil samples were taken at random from each study site, in both study areas on each occasion that pitfalls were cleared. The soil samples were placed in labelled polythene bags and brought back to the laboratory for extraction of the meiofauna.

Immediately upon return to the laboratory, the soil samples were weighed on a Mettler top pan balance to 0.05 g accuracy, to determine their fresh weight for moisture content determinations. Extraction of the meiofauna from the soil samples was then begun, using a modified Kempson, Lloyd and Ghelardi extractor (Salmon, 1973; Workman, 1975). Since only live meiofauna can be extracted using this dynamic extraction method, it is important that extraction is not delayed as this would decrease the efficiency of extraction (Murphy, 1962).

The modified Kempson, Lloyd and Ghelardi extractor (Fig. 2.11) consists of a circular metal tray, 35 cm in diameter, the base of which is made of 6 mm gauge wire mesh. The soil sample is inverted upon this 'sieve' and the meiofauna are extracted from the sample in response to heat and humidity gradients. The heat gradient is produced by three 40 watt light bulbs arranged in triangular formation, supported 36 cm above the tray. The whole apparatus is enclosed within a galvanised steel cylinder which closely fits the circular tray. The humidity gradient is produced by the evaporation of the collecting fluid, saturated tri-sodium orthophosphate, in the plastic collecting basin below the sieve.

To prevent the escape of the meiofauna, an elasticated nylon gauze sleeve of mesh size 0.08 mm was stretched over the tray, and under the lip of the collecting basin, enclosing the sample so that the only way out of the sample was downwards into the collecting fluid. During both the preparation of the sample and the extraction, the extractor was handled as gently as possible to prevent contamination of the fluid in the collecting basin by sample debris.

Extraction was carried out for a week, during which the light bulbs were checked daily to ensure that they had not fused. Initially, the voltage was set at 50 volts. On each successive day, the voltage was stepped up by 50 volts until by the fourth day of extraction, the voltage reached 240 volts. Block (1966) and Salmon (1973) reported that for each increase in voltage, the temperature rose quickly for six hours after the voltage increase, and then levelled off. The temperature of the air 5 cm above the sample surface increased from 13°C at the start of extraction, to above 40°C by day 5 of extraction, while that 9 cm below the sample increased only slightly - from 13°C initially, to 16°C after day 5 (Workman, 1975). Details of the temperature changes within the sample in the extractor are described by Workman (_loc. cit._).

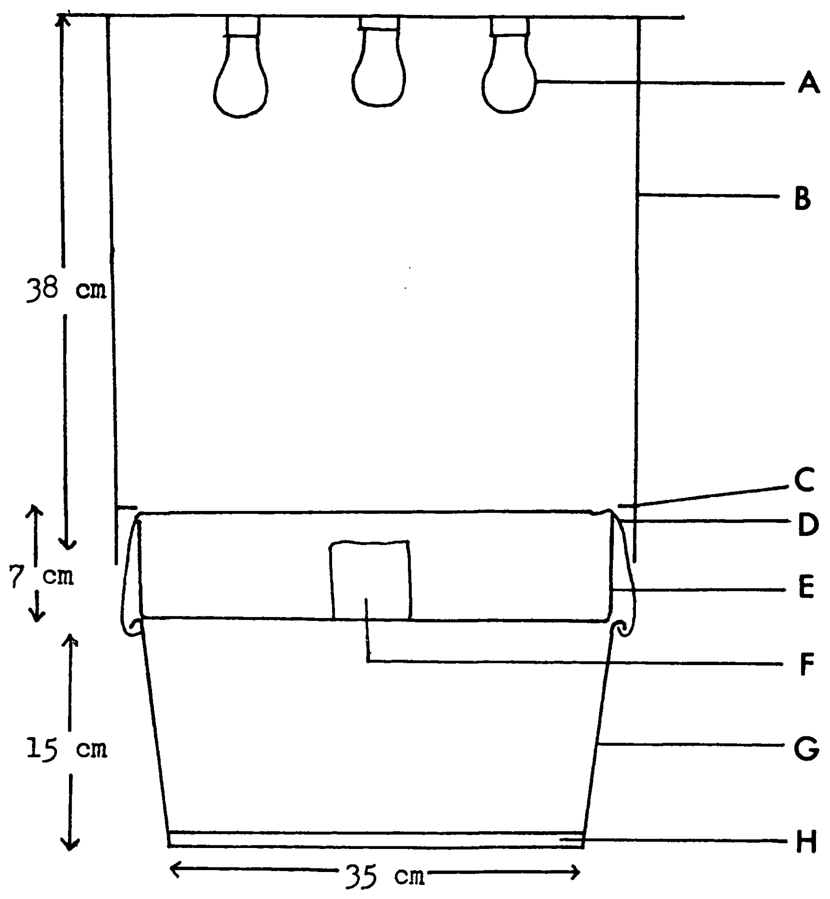


Fig. 2.11 The modified Kempson, Lloyd and Ghelardi extractor, in section.

A - 40 watt light bulb

B - galvanised steel cylinder

C - support flange

D - nylon gauze sleeve, of 0.08mm mesh size

E - circular metal tray with 6 mm gauge wire mesh bottom

F - inverted sample

G - plastic collecting basin

H - collecting fluid, tri-sodium orthophosphate

After extraction, the extracted meiofauna were removed from the collecting fluid and preserved in 70% alcohol. The Staphylinidae were kept separately in 70% alcohol until they could be sorted and identified.

The extracted soil and litter samples were then oven-dried at 60°C for four days to constant weight, for moisture content determinations.

2.2.5. Handsorting

In a further effort to obtain live Staphylinidae for laboratory cultures, samples of leaf litter from the various study sites were brought back to the laboratory, and handsorted as soon as possible.

2.3. Environmental Measurements

2.3.1. Moisture Content

The moisture content of all Tullgren extracted samples were determined. The initial fresh weight of each sample was determined prior to extraction of the meiofauna (see 2.2.4.). After extraction, the soil and litter samples were oven-dried at 60°C for four days, to constant weight. The dry weight of each sample was then determined to 0.05 g using a top pan balance. The moisture content of the sample was then determined as

$$\frac{\text{Fresh Weight - Dry Weight}}{\text{Dry Weight}} \times 100$$

2.3.2 Climatic Data

The Meteorological Office at Bracknell, Berkshire, has a meteorological station at Newtown Linford, approximately 7 km from Charnwood Lodge, and 3 km from Martinshaw Wood. Since the climatic variation recorded at Newtown Linford is adequate for a generalised study of this kind, daily maximum and minimum temperatures, rainfall, snow, hours of sunshine and wind speed data were obtained from this station over the duration of the study period.

To estimate how well rainfall and temperatures at Charnwood Lodge Nature Reserve were correlated with the data obtained from Newtown Linford, three simple rain gauges and a maximum-minimum thermometer were set up on Flat Hill. Each rain gauge consisted of a 20 cm wide funnel, supported in a one litre conical flask sunk about 5 cm in the soil, so that the mouth of the funnel was not obstructed by the surrounding vegetation. The volume of rain water collected in each of these rain gauges was measured on each sampling occasion, and any staphylinids found in the water recorded. Since the only way into the conical flask was through the mouth of the funnel, and since this was raised about one foot above ground level, these rain gauges could also be used to provide evidence that certain staphylinids are capable of flight.

On each sampling occasion, maximum and minimum temperatures over each pitfall trapping period were recorded, and the thermometer was reset.

2.4. Laboratory Studies

2.4.1. Analysis of Staphylinid Populations

The specimens obtained from the various traps set out in the field were brought back to the laboratory and sorted. All Coleoptera were counted and their numbers recorded. The adult Staphylinidae were then identified, as far as possible, to species level, using the keys of Fowler (1888), Joy (1932), Tottenham (1954), and Freude, Harde and Lohse (1964; 1974).

In community studies where the comparison of species lists is involved, taxonomic precision must be high (Macfadyen, 1962). The identification of the various species of Staphylinidae was therefore checked and confirmed by Mr. P.M. Hammond, of the British Museum (Natural History), London. Members of the Aleocharinae, especially some species of Atheta, however, proved very difficult to identify with certainty because of their small size and fragility, and especially since the taxonomy of some members of this group has not been satisfactorily worked out (Hammond, pers. comm.). Hence, only those species of Aleocharinae which are relatively easily recognisable and distinct were identified to species level. All others were grouped together under 'Other Aleocharinae'.

The number of individuals belonging to the various species of Staphylinidae were counted for each sample and recorded.

2.4.2. Laboratory Cultures

Staphylinid eggs, and live larvae and adults obtained from handsorted samples and from baited traps were cultured in the laboratory.

Eggs were kept singly in 3.8 cm wide, 4 cm high plastic rearing chambers containing filter paper which was moistened daily. These rearing chambers were maintained at room temperature.

On hatching, the larvae were fed with punctured early instar Drosophila maggots. Initially, the larvae were retained in the same rearing chambers as the eggs, but as a result of high larval mortalities in these chambers, larvae were transferred to rearing chambers containing soil collected from the same habitat type as the eggs.

Live larvae and adults obtained from the field were also reared in this way, the soil in the rearing chambers being moistened daily and the larvae and adults being fed with punctured Drosophila larvae.

2.4.3. Feeding Studies

When sufficient numbers of staphylinids of one species were obtained, they were fed with a variety of food materials, such as Drosophila larvae and pupae, yeast, Collembola, pieces of earthworm, woodlice and decaying raw beef. Observations were made on Philonthus varius (Gyllenhal), Tachinus humeralis Gravenhorst, Oxypoda lividipennis Mannerheim, Anthobium atrocephalum (Gyllenhal) and Bryocharis sp., as soon as the food was placed in the rearing chamber, and at five minute intervals after that for the first 45 minutes. 24 hours later, the rearing chambers were examined for remains of the food offered the previous day.

2.4.4. Activity Studies

General observations on the diurnal activity of the various species in culture were made at various times during the day, and their state of activity or inactivity just before the rearing chambers were cleared of fungal growth, moistened and the staphylinids fed, was noted.

An attempt was made to study the diurnal activity of the various species of Staphylinidae using a time-lapse camera. However, these studies had to be abandoned due to technical difficulties which could not be overcome.

3. EVALUATION OF METHODS

3.1 Introduction

In community studies involving comparisons between species lists, although taxonomic precision must be high, absolute abundances on an area or volume basis such as are required for trophic studies are not essential, and estimates of species abundance need only be comparative (Macfadyen, 1962), especially where presence-absence data or rank correlation methods may be used for community comparison.

In the present study, it was therefore decided to use pitfall trapping in conjunction with heat extraction methods, to obtain data on the Staphylinidae, for the comparison of the Staphylinidae of different habitats in the Charnwood Forest area. In this chapter, the factors affecting pitfall trap captures and the advantages and disadvantages of pitfall trapping are discussed. The effect of trap numbers and layout and trap shape on the number of staphylinid species and individuals captured in the present study is then examined. The principles behind heat extraction techniques, and the factors affecting them are also discussed, and the extraction efficiency of the modified Kempson, Lloyd and Ghelardi (1963) extractor used in the present study is examined. The climatic data obtained on Flat Hill is compared with that obtained from the meteorological station at Newtown Linford, and the use of Newtown Linford data in the present study is justified.

3.2 Pitfall Trapping

3.2.1 Theoretical Considerations

The number of individuals trapped in pitfalls depends on at least three factors: the population abundance or density, their activity, and the relative efficiency with which a particular species is caught by a particular trap type (Mitchell, 1963; Greenslade, 1964; Luff, 1975). Briggs (1961), however, considers that in the carabid Harpalus rufipes (Deg.) the size of the population plays a minor role in determining the numbers trapped, temperature being the major factor determining the numbers trapped on any occasion.

The activity of any particular species is very variable, being dependent on various factors amongst which are: -

a) weather - rainfall, humidity, and especially temperature - affects the numbers of Carabidae trapped (Briggs, loc. cit; Greenslade, 1961, cited in Greenslade, 1964), e.g. increased temperatures increase the locomotory activity of Harpalus rufipes (Briggs, loc. cit.).

b) the behaviour of the species and the time of its activity (Greenslade, 1964) - e.g. diurnal Carabidae, such as Notiophilus spp. may be able to see and avoid traps (van der Drift, 1951, cited in Greenslade, 1964), so that catches of nocturnal species are significantly greater than those of diurnal species (Greenslade, loc. cit.).

c) the surrounding vegetation and ground cover (Greenslade, loc. cit.) - the larger, mainly predatory Carabidae, e.g. Pterostichus madidus (F.) and P. caerulescens (L.) are ground dwellers, while the larger phytophagous Carabidae, e.g. Harpalus rufipes and H. affinis (Schrank) move within the vegetation and the smaller phytophagous species, e.g. Calathus fuscipes (Gz.) and C. melanocephalus (L.) mainly move on the surface of the vegetation, so that within one vegetation type, different species of Carabidae are trapped at different rates in any given trap type, at any season. Pitfall trap catches are also influenced by the depth of the litter layer, and an inverse relationship exists between the depth of the litter layer around a trap and its catch of Nebria brevicollis (F.) (Greenslade, 1964).

The relative efficiency with which a particular species is caught by a particular trap type is determined by: -

a) the material, size and shape of the trap (Luff, 1975) - in field comparisons and laboratory experiments, Luff (loc. cit.) found that glass pitfall traps were more efficient than metal traps at trapping and retaining all types of Coleoptera, while plastic pots were the least efficient of the three materials, since they allowed many beetles to escape. There were no significant differences in the relative catches of Coleoptera in glass traps of different sizes, but larger plastic pots were relatively more efficient than smaller ones. Gutter traps were significantly more efficient than jar pitfalls at trapping various Carabidae, but the efficiency with which different species were caught was significantly different: Pterostichus spp. was underrepresented in gutter traps while Agonum dorsale (Pont.) was almost entirely confined to these traps (Luff, loc. cit.).

b) the bait or preservative used (Luff, 1968; Greenslade & Greenslade, 1971) - different species may be attracted or repelled by different baits or preservatives. Oxytelus spp. and members of the Aleocharinae and Omaliinae, for example, are attracted by alcohol-glycerol (Greenslade & Greenslade, loc. cit.).

Since pitfall trap catches are dependent not only on the density of a species, but also on its activity, which is in turn influenced by a complex of variables, the data obtained from pitfall trapping is very difficult to interpret (Greenslade, 1964; Southwood, 1978). Pitfall traps are thus of little value for obtaining absolute estimates of population densities of Carabidae and of other species, and for the quantitative comparison of the fauna of different habitats (Greenslade, loc. cit.).

Despite their limitations, however, pitfall traps are cheap and easy to set up and maintain. (Gist & Crossley, 1973; Luff, 1975). Also, diurnal fluctuations in the activity of the species need not affect estimates of numbers, as estimates may be integrated over several days and over a large area (Gist & Crossley, loc. cit.). Further, pitfall traps may be the only method available for the study of certain populations or species, e.g. of Carabidae, in which direct quadrat counts, though preferable, cannot be used because of low densities or other factors (Greenslade, 1964).

Pitfall trapping has been widely used to study the relative abundance of surface active invertebrates, especially the Coleoptera and Aranea (Luff, 1975). In woodlands, the surface activity of various Coleoptera, particularly the Carabidae and Staphylinidae, has been investigated by various authors - Van der Drift (1959), Frank (1967), Evans (1969; 1971), East (1974) and Kowalski (1976). Pitfall traps have also been used to assess the activity of beetles, particularly the Carabidae and Staphylinidae, in agricultural ecosystems (Boyd, 1960; Obrtel, 1968; Edwards, Butler & Lofty, 1975; Jones, 1976; Speight & Lawton, 1976; Topp, 1977). A comparison of the coleopteran fauna of different habitat types has also been investigated using pitfall traps - by Kleinert (1977), who studied the Carabidae, Nield (1974) who studied the Carabidae and Staphylinidae, and Ericson (1968), who studied the seasonal activity and life cycles of the staphylinids *Olophrum piceum* Gyll. and *O. assimile* Payk.

3.2.2 Practical Considerations

3.2.2.1 Trap Numbers and Layout

In the present study, a linear series of six pitfall traps was used initially at all the sites. In June 1976, however, the number of traps in Collier's Wood, Flat Hill and Timberwood Hill was increased to 18, laid out in a 3 x 6 grid (Fig. 3.1), in an attempt to reduce sampling variation.

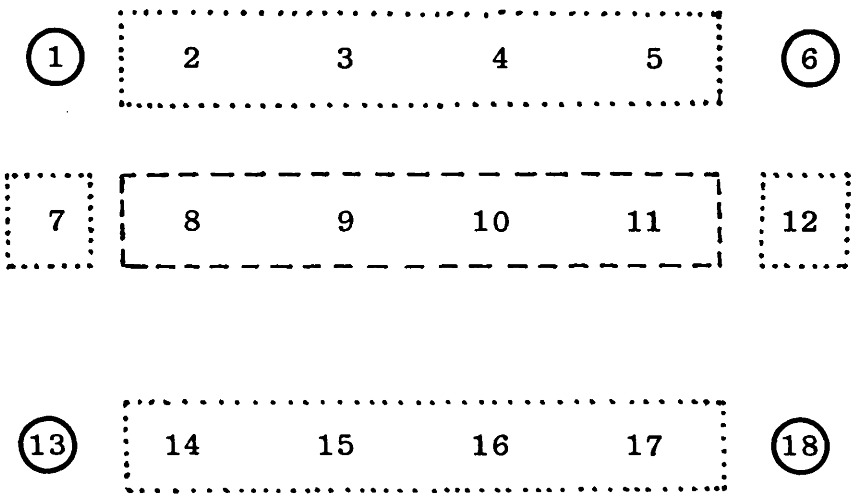


Fig. 3.1 Layout of 18 pitfall traps in a 3 x 6 grid to show

(i) order of numbering of pitfalls and

(ii) groupings of pitfalls with varying trapping efficiencies

'Corner' group = Pitfall traps 1, 6, 13, 18

'Side' group = Pitfall traps 2, 3, 4, 5, 7, 12, 14, 15, 16, 17

'Centre' group = Pitfall traps 8, 9, 10, 11

To determine whether sampling variation was, in fact, reduced by the use of increased numbers of traps, the trapping efficiencies of the various traps in the grid were examined. A two-way analysis of variance was performed on three month (July - September 1976) staphylinid totals from Collier's Wood, Flat Hill and Timberwood Hill. To determine whether it is necessary to transform these totals for analyses, the means and variances of staphylinid captures from 18 pitfalls from the three sites on five randomly selected sampling periods were calculated. Applying Taylor's power law,

$$\log s^2 = \log a + b \log \bar{x} \text{ (Taylor, 1961)}$$

the regression of $\log s^2$ on $\log \bar{x}$ was calculated and b was found to be 1.48 which is ≈ 1.5. In this case, either the root or log transformations may be used, but since most staphylinid captures tend to be aggregated (see 4.4.5), a $\log (x + 1)$ transform was selected. Two way analyses of variance on the transformed three month totals, with rows as treatments and the six pitfalls in a row as replicates, showed no significant differences between rows at all three sites (Table 3.1). However, there was a significant ($P < 0.01$) difference between replicates at Flat Hill. Using the Student-Newman-Keuls test, significant differences were found between replicates 1 and 3 and 1 and 4 ($P < 0.05$) which is due to a high catch of Drusilla canaliculata and various Tachyporus species in pitfalls 3, 9 and 15 (replicate 3) and pitfalls 4 and 10 (replicate 4) over these particular sampling periods.

When pitfall traps are laid out in a closely spaced grid, the potential catch of each may be reduced by the extent to which animals are caught previously by the other traps in the grid. Its trapping efficiency may thus be reduced. The layout of the 18 pitfalls in a 3 x 6 grid could thus result in three groups of pitfalls with varying trapping efficiencies (Fig. 3.1) with the trapping efficiencies decreasing in the order 'corner' traps > 'side' traps > 'centre' traps, depending on the degree of exposure

Table 3.1 Two-way Analyses of Variance on 3 Month (15.6.76 - 24.9.76) Staphylinid Totals for 18 Pitfall Traps, Transformed to log (x + 1), at (i) Collier's Wood, (ii) Flat Hill, and (iii) Timberwood Hill.

(i) Collier's Wood

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.9473	2	0.4737	3.4079 NS.
Replicates	0.8675	5	0.1735	1.2482 NS.
Error	1.3902	10	0.1390	
Total	3.2050	17		

(ii) Flat Hill

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.3172	2	0.1586	1.8043 NS.
Replicates	2.4941	5	0.4988	5.6746 **
Error	0.8792	10	0.0879	
Total	3.6905	17		

(iii) Timberwood Hill

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.0002	2	0.0001	0.0008 NS.
Replicates	0.3761	5	0.0752	0.5940 NS.
Error	1.2663	10	0.1266	
Total	1.6426	17		

of the various traps to Staphylinidae from outside the grid. One way analyses of variance were therefore carried out to test for differences in the staphylinid captures of the 'corner', 'side' and 'centre' groups of traps, using log (x + 1) transformed values of three month (July - September 1976) totals from Collier's Wood, Flat Hill and Timberwood Hill. These analyses (Table 3.2) showed that there were no significant differences in the staphylinid captures, and therefore, the trapping efficiencies of the 'corner', 'side' and 'centre' traps at all three sites.

Having determined that there were no significant differences in the total staphylinid captures of the various trap positions in the grid of 18 pitfalls, and no significant differences between rows of six pitfalls, it is necessary to determine whether the residual variation is largely due to chance, or background, variation or whether it may be attributed to variation within rows or subsets of pitfalls within each row. A nested analysis of variance was therefore selected to examine the variation between rows and between the two sets of three pitfalls in each row of six. This analysis was performed on staphylinid totals in each of the 18 pitfall traps, transformed to log (x + 1), from Collier's Wood, on each of three randomly selected trapping periods.

In the August 1976 sample from Collier's Wood, there was no significant difference between rows but a difference between the two sets of three pitfalls in each row was significant ($P < 0.05$) (Table 3.3). This suggests that there is increased heterogeneity or that the row of six pitfalls may be running along a habitat gradient so that sets of three pitfalls were insufficient to account for changes in staphylinid totals along this gradient. However, in March and May 1977, there were no significant differences between rows and between the sets of three pitfalls in each row of six.

Table 3.2 One-way Analysis of Variance on 3 Month (15.6.76 - 24.9.76) Staphylinid Totals for 'Corner', 'Side' and 'Centre' Traps, Transformed to log (x + 1) at (i) Collier's Wood, (ii) Flat Hill and (iii) Timberwood Hill.

(i) Collier's Wood

Items	SS.	Df.	Variance	VR.(=F)
Between series	1.0263	2	0.5132	3.5344 NS.
Within series	2.1787	15	0.1452	
Total	3.205	17		

(ii) Flat Hill

Items	SS.	Df.	Variance	VR.(=F)
Between series	0.9660	2	0.4830	2.6597 NS.
Within series	2.7245	15	0.1816	
Total	3.6905	17		

(iii) Timberwood Hill

Items	SS.	Df.	Variance	VR.(=F,
Between series	0.0527	2	0.0264	0.2487 NS.
Within series	1.5895	15	0.1060	
Total	1.6422	17		

Table 3.3 Nested Analyses of Variance on Staphylinid Totals for 18 Pitfall Traps from Collier's Wood, Transformed to log (x + 1), Over the Trapping Periods:

(i) 8.7.76 - 13.8.76

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.4612	2	0.2306	2.4923 NS.
Sets of 3 in rows of 6	1.2024	3	0.4008	4.3330*
Error	1.1103	12	0.0925	
Total	2.7739	17		

(ii) 14.2.77 - 16.3.77

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.2555	2	0.1278	0.6503 NS.
Sets of 3 in rows of 6	0.0569	3	0.0190	0.0965 NS.
Error	2.3583	12	0.1965	
Total	2.6707	17		

(iii) 27.4.77 - 25.5.77

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.1941	2	0.0971	0.6838 NS.
Sets of 3 in rows of 6	0.3566	3	0.1189	0.8373 NS.
Error	1.7042	12	0.1420	
Total	2.2549	17		

Similar analyses were performed on Timberwood Hill samples taken during the same three trapping periods. In the August 1976 sample there was no significant difference between rows, but the difference between the catches of the sets of three pitfalls in each row of six was significant ($P < 0.05$) (Table 3.4). In the March and May 1977 samples there were no significant differences between rows and between the sets of three pitfalls.

At Collier's Wood and Timberwood Hill therefore, the variation in the monthly captures of the various traps in the grid was largely due to background or chance variation, although in August 1976 some of this variation may be attributed to differences between the two sets of three pitfalls in each row.

To complement the nested analyses of variance on monthly samples, similar analyses were performed on amalgamated three month totals (July - September 1976) from Collier's Wood, Flat Hill and Timberwood Hill.

At Collier's Wood, differences between rows were significant ($P < 0.05$) while differences between sets of three pitfalls in each row were not significant (Table 3.5). However, a two-way analysis of variance on the same data, with rows as treatments and the six pitfalls as replicates, showed that differences between rows were not significant (Table 3.1). Comparison of these analyses reveals that differences between sets of three pitfalls accounted for more of the attributable variation than differences between replicates, resulting in a reduced error term in the nested analysis. Consequently, differences between rows became significant. At Flat Hill, there were no significant differences between rows and between sets of three pitfalls (Table 3.5). At Timberwood Hill, there was no significant difference between rows; the difference between sets of three pitfalls was significant ($P < 0.05$), indicating the inadequacy of three pitfall traps.

Table 3.4 Nested Analyses of Variance on Staphylinid Totals for 18 Pitfall Traps from Timberwood Hill, Transformed to log (x + 1), Over the Trapping Periods:

(i) 8.7.76 - 13.8.76

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.0150	2	0.0075	0.0786 NS.
Sets of 3 in rows of 6	1.2083	3	0.4028	4.2219*
Error	1.1453	12	0.0954	
Total	2.3686	17		

(ii) 14.2.77 - 16.3.77

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.1359	2	0.0680	0.4033 NS.
Sets of 3 in rows of 6	0.2554	3	0.0851	0.5049 NS.
Error	2.0226	12	0.1686	
Total	2.4139	17		

(iii) 27.4.77 - 25.5.77

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.9625	2	0.4813	2.6119 NS.
Sets of 3 in rows of 6	0.4513	3	0.1504	0.8162 NS.
Error	2.2113	12	0.1843	
Total	3.6251	17		

Table 3.5 Nested Analyses of Variance on 3 Month (15.6.76 - 24.9.76) Staphylinid Totals for 18 Pitfall Traps, Transformed to log (x + 1) at (i) Collier's Wood, (ii) Flat Hill, and (iii) Timberwood Hill.

(i) Collier's Wood

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.9473	2	0.4737	4.7041*
Sets of 3 in rows of 6	1.0488	3	0.3496	3.4717 NS.
Error	1.2089	12	0.1007	
Total	3.2050	17		

(ii) Flat Hill

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.3172	2	0.1586	0.6018 NS.
Sets of 3 in rows of 6	0.2110	3	0.0703	0.2668 NS.
Error	3.1623	12	0.2635	
Total	3.6905	17		

(iii) Timberwood Hill

Items	SS.	Df.	Variance	VR.(=F)
Rows	0.0002	2	0.0001	0.0015 NS.
Sets of 3 in rows of 6	0.8271	3	0.2757	4.0604*
Error	0.8153	12	0.0679	
Total	1.6426	17		

The nested analyses of variance on both monthly and quarterly staphylinid totals thus indicate that generally the variation is largely due to chance. However, in some monthly samples and in the quarterly sample from Timberwood Hill, some of the variation may be attributed to differences between the catches of sets of three pitfalls within rows.

Since much of the variability of staphylinid captures in the various pitfall traps was due to chance or background variation, the effect of increasing numbers of pitfall traps on this variability and therefore on the accuracy of the calculated means, was examined.

A measure of how accurately a calculated mean estimates the true population mean is provided by its standard error, which is given by

$$\text{S.E.} = (s^2/n)^{1/2}$$

where s^2 = variance of the estimate

and n = number of samples on which the estimate is based.

The S.E. thus varies as $(1/n)^{1/2}$. As values of n increase, the difference between $n^{1/2}$ and $(n + 1)^{1/2}$ decreases. Hence, theoretically the S.E's of means based on increasing numbers of pitfall traps should decrease with increasing numbers of pitfall traps.

The effect of increasing numbers of pitfall traps on the S.E's of mean staphylinid captures was therefore examined. The mean number of individuals captured per trap and the S.E. associated with this mean, was therefore calculated, based on staphylinid captures in pitfalls 1 - 3 (cf. Fig. 3.1) for each of four randomly selected sampling periods at Collier's Wood, Flat Hill and Timberwood Hill. The process was repeated, taking an additional three pitfalls at a time, and the means and S.E's based on captures in pitfalls 1 - 6, 1 - 9, 1 - 12, 1 - 15 and 1 - 18 were determined, for each of the sampling periods at each of the sites (Table 3.6).

Table 3.6 Average catch sizes of Staphylinidae obtained in 3, 6, 9, 12, 15 and 18 pitfall traps, and associated standard errors, at (i) Collier's Wood, (ii) Flat Hill and (iii) Timberwood Hill.

Sampling periods	8.7.76 - 13.8.76		16.12.76 - 13.1.77		14.2.77 - 16.3.77		27.4.77 - 25.5.77	
Number of traps	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
(i) Collier's Wood								
3	11.33	2.03	8.67	2.19	2.00	1.00	2.33	0.88
6	7.50	3.59	4.50	2.11	2.17	1.14	3.67	2.14
9	5.33	1.97	4.00	1.39	3.78	1.75	3.56	1.55
12	4.58	1.52	3.50	1.11	3.75	1.32	2.67	1.23
15	5.40	1.29	3.93	0.93	3.53	1.11	2.40	1.00
18	4.83	1.11	4.39	0.85	3.56	0.96	2.33	0.84
(ii) Flat Hill								
3	0.67	0.67	0.67	0.33	2.67	1.45	5.33	4.37
6	1.83	1.28	2.17	1.05	4.33	1.26	6.33	2.59
9	2.11	0.92	1.56	0.75	3.33	1.03	5.00	1.88
12	2.67	1.18	1.17	0.59	3.08	0.79	4.42	1.47
15	2.67	1.01	1.13	0.50	3.00	0.65	3.93	1.20
18	2.28	0.86	1.11	0.41	3.44	0.93	4.33	1.11
(iii) Timberwood Hill								
3	10.67	4.81	1.67	1.20	2.00	1.53	15.33	4.18
6	5.50	3.16	1.17	0.65	3.17	1.01	16.00	3.25
9	4.67	2.13	1.33	0.50	3.44	1.33	13.11	3.31
12	4.17	1.60	1.17	0.41	2.92	1.03	12.08	2.66
15	3.80	1.30	1.53	0.48	2.60	0.87	11.67	2.13
18	3.72	1.13	1.33	0.41	2.61	0.75	13.94	2.80

The S.E.'s associated with increasing numbers of pitfall traps are shown for each of the four selected sampling periods at Collier's Wood, Flat Hill and Timberwood Hill in Fig. 3.2.

At Collier's Wood, there was a general decrease in the S.E.'s with increasing numbers of pitfall traps. However, the decrease was not very marked, and the S.E. associated with three pitfall traps was less than that associated with six pitfall traps for the August 1976 samples, while for the March 1977 sample, the S.E. associated with nine pitfall traps was maximal. In August 1976, pitfalls 1 - 3 trapped 11, 8 and 15 individuals respectively, while pitfalls 4 and 5 trapped 0 individuals and pitfall 6 trapped 11 individuals. The increase in S.E. associated with increasing the number of pitfall traps from 3 to 6 was therefore due to increased variation. Similarly, the increase in S.E. associated with the increase from 6 to 9 pitfalls in the March 1977 samples was largely due to the 16 individuals trapped in pitfall 8 as compared to the less variable catch of 4, 1, 1, 0, 7 and 0 individuals respectively in pitfalls 1 - 6.

At Flat Hill, only samples taken in May 1977 showed a trend of decreasing S.E.'s with increasing number of pitfall traps. On all other trapping periods, the S.E.'s fluctuated around a value of 1.0, regardless of the number of pitfall traps on which the S.E.'s were based. This was largely because of the low and relatively unvarying catches in these traps. However, comparisons of the S.E.'s with their associated means showed that generally, S.E.'s associated with means based on larger numbers of traps constituted a smaller proportion of these means than those based on fewer traps.

In the Timberwood Hill samples, there was a general decrease in the S.E.'s with an increase in the number of pitfall traps. However, in the March 1977 samples, the S.E. associated with 6 pitfalls was slightly lower than that associated with a larger number of pitfall traps, largely

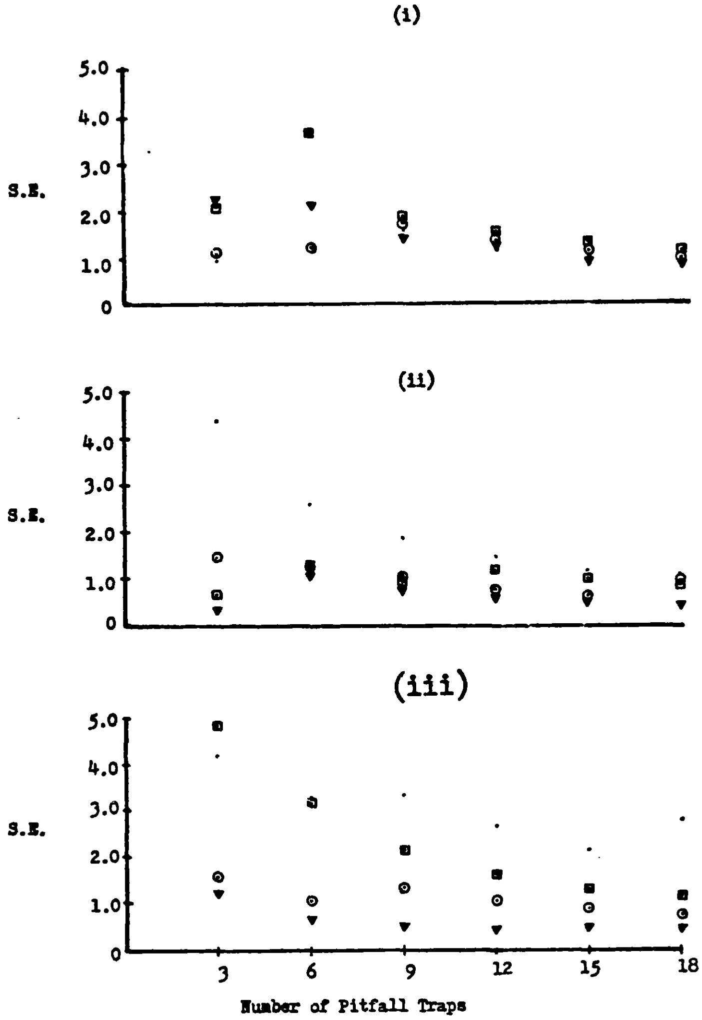


Fig. 3.2 Standard errors associated with increasing number of pitfall traps, on each of four selected sampling periods at

(i) Collier's Wood

(ii) Flat Hill and

(iii) Timberwood Hill

Symbol	Sampling period
▣	8.7.76 - 13.8.76
▼	16.12.76 - 13.1.77
⊙	14.2.77 - 16.3.77
•	27.4.77 - 25.5.77

because of the relatively less variable catch of 0, 1, 5, 2, 6 and 5 individuals in each of pitfalls 1 - 6 respectively. In the May 1977 samples, the S.E.s associated with mean staphylinid captures based on 18 pitfall traps were higher than those based on 12 and 15 traps. This was largely due to the very high catch of 51 individuals in pitfall 17 which comprised 20% of the total catch and markedly boosted the variance. At Flat Hill however, when the number of pitfalls was increased above six, the S.E.s constituted a relatively constant proportion of the associated means and no further increase in the accuracy of the estimate was obtained by increasing the number of pitfalls beyond nine.

Since the nested analyses of variance and the effect of increasing numbers of pitfall traps on S.E.s did not provide conclusive evidence on the number of traps beyond which further increase does not produce further increase in the accuracy of estimates of staphylinid means, the effect of increasing numbers of pitfall traps on the number of species trapped was examined.

The cumulative number of species trapped by pitfalls 1 - 18, in that order (Fig. 3.1), at Collier's Wood, Flat Hill and Timberwood Hill, was determined for each of four randomly selected sampling periods. The mean cumulative number of species trapped, averaged over the four sampling periods, was then determined for each of the pitfalls in each of the sites.

At all sites, the initial increase in the mean cumulative number of species trapped was steep, so that the first six pitfalls had trapped more than half of the total number of species recorded at these sites over the four sampling periods chosen (Fig. 3.3). The species which were trapped by the first six pitfalls generally included the numerically most abundant species. Increasing the number of pitfall traps beyond six resulted in a less steep increase in the mean cumulative number of species.

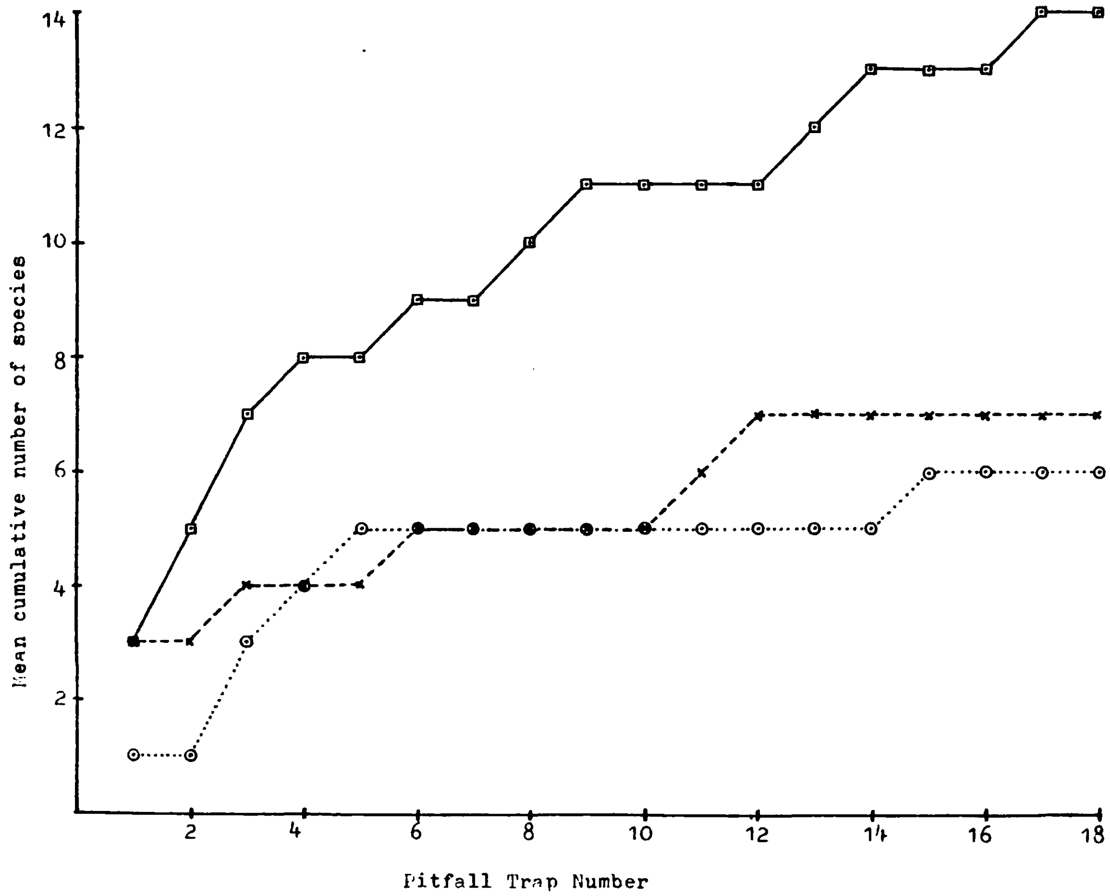


Fig. 3.3 Increase in the mean cumulative number of species of Staphylinidae with increasing number of pitfall traps, at Collier's Wood, Flat Hill and Timberwood Hill.

- ◻——◻ Collier's Wood
- ⊙……⊙ Flat Hill
- ×---× Timberwood Hill

Each point represents the mean number of species at each site, calculated over four sampling periods:-

8.7.76 - 13.8.76; 16.12.76 - 13.1.77 ; 14.2.77 - 16.3.77

and 27.4.77 - 25.5.77

Further, this increase may be attributed to the occurrence of the numerically less abundant species. Since six pitfalls trapped more than half of the species recorded at these sites over the four selected trapping periods and these included the numerically more abundant species, the use of six pitfalls in sites where space or other factors is limiting is adequate, although additional information, especially on the numerically less abundant species, may be obtained by increasing the number of pitfall traps used.

3.2.2.2 Trap Shape

At Collier's Wood, in addition to ordinary jar pitfalls, gutter pitfalls and square pitfalls were used, and the trapping efficiencies of these traps were compared with that of jar pitfalls. However, since the various traps were constructed of different materials and set at different times, the trap efficiencies are not strictly comparable.

To obtain an estimate of the trapping efficiency of a single jar pitfall, pitfall trap 4 from Collier's Wood, was selected at random, and the number of staphylinids trapped each month over one year (20.11.75 - 18.11.76) was calculated. In this pitfall, 18 staphylinid species were trapped, and the mean monthly catch was 8.1 $\pm$ 3.2 individuals. Since the catches of circular and rectangular traps may be compared on the basis of their perimeter lengths (Luff, 1975), and the jar pitfall has a circumference of 11 cm, its mean trapping efficiency may be expressed as 73.6 staphylinids per month per m trapping edge. The minimum catch of pitfall 4 in 1975/76 was 0 staphylinids per month, while its maximum catch was 345.5 staphylinids per month per m trapping edge.

During the limited period (21.5.76 - 9.6.76) when the four gutter pitfalls were in operation in Collier's Wood, 10 species of Staphylinidae were trapped in these pitfalls (Table (i), Appendix I), and the mean staphylinid catch based on four traps, each ½m long, ranged from

6.6 - 63.75 staphylinids per month per m trap length.

The square pitfall SP1 was in operation from 11.5.77 - 16.8.78. During this period, 28 species of Staphylinidae were trapped (Table (ii), Appendix I), and the mean catch of staphylinids ranged from 0.3 - 9.6 individuals per month per m trap length. Since this pitfall trapped staphylinids from within the area it enclosed, the maximum catch was obtained during the first month. As the enclosed area became progressively depleted, catches tended to decrease after that, as shown in Fig. 3.4. This progressive depletion of the staphylinid fauna of the enclosed area also accounted for the lower mean trapping efficiency of square pitfall SP1 as compared to the jar pitfall. However, the enclosed area never became completely depleted of its staphylinid fauna, and as can be seen in Fig. 3.4, the staphylinid catch in SP1 increased in January 1978 and June 1978. The first increase was due to the resetting of the trap after it was uprooted in November 1977, and the second was largely due to an increased capture of O. lividipennis which has been observed to spread its wings in preparation for flight on sunny days. Thus, entry into the area, and exit, is possible by flying Staphylinidae, and via 'bridges' formed over the pitfall trap by overhanging vegetation, e.g. Endymion non-scriptus, which is at its peak of growth around May - June, or leaf litter.

The square pitfall SP2, was in operation from 14.12.77 - 16.8.78 (Table (iii), Appendix I). 26 staphylinid species were trapped in the outer gutter, and 16 in the inner one. Four of the latter species were not trapped in the outer gutter, so that SP2 trapped a total of 30 different species during the eight months that it was in operation. The number of individuals trapped in the outer gutter ranged from 2.8 - 31.1 staphylinids per month per m trapping edge and in the inner gutter the numbers ranged from 1.1 - 11.8 staphylinids per month per m trapping edge. As expected,

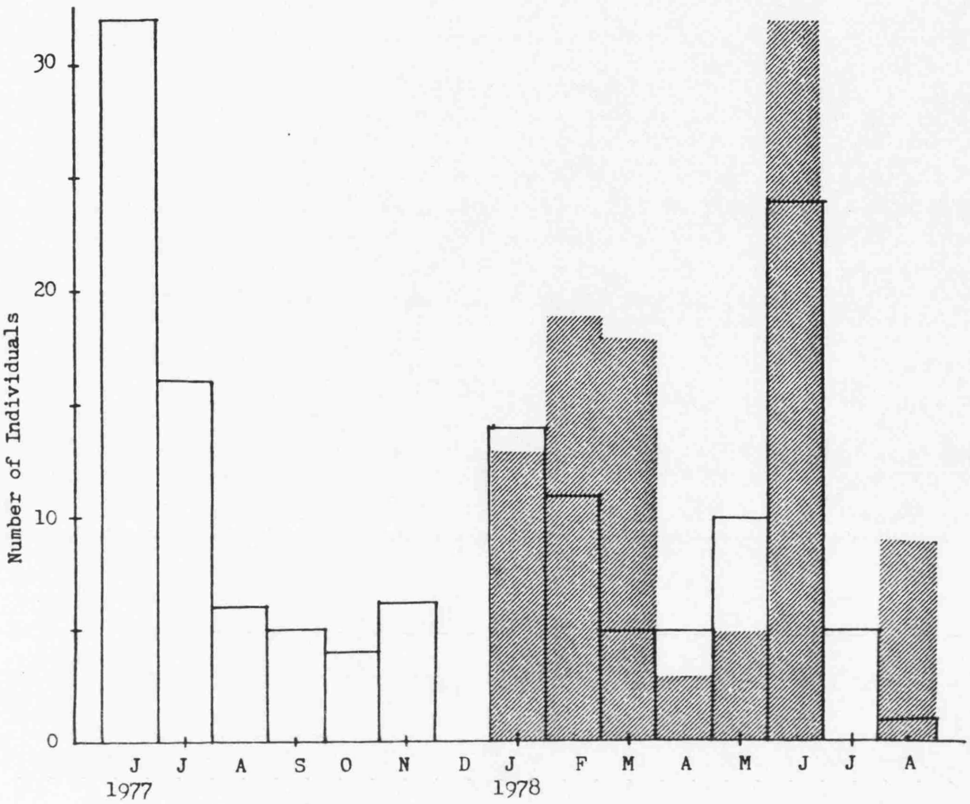
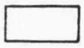


Fig. 3.4 Variations in the total number of Staphylinidae trapped in square pitfall SP1 and the inner gutter of SP2, with time.

 represents the number of individuals trapped in SP1

 represents the number of individuals trapped in the inner gutter of SP2.

more individuals were trapped in the outer gutter, which trapped the surrounding area, than in the inner gutter, which trapped only from the area it enclosed.

Since the inner gutter of SP2 and the square pitfall SP1 trap the areas they enclose ($0.46m^2$ and $0.69m^2$ respectively), their staphylinid captures may be compared, if the different sizes of the enclosed areas and the different trapping periods of these traps are taken into consideration. 13 staphylinid species were common to both traps. Generally, these were the numerically more abundant species, e.g. Anthobium atrocephalum, Omalium italicum and Oxypoda lividipennis. Only three species, Proteinus brachypterus, Philonthus varians and Tachyporus nitidulus, represented by 2, 1 and 1 individuals respectively, occurred in the inner gutter of SP2 but not in SP1, while 15 species occurred in SP1 but not in SP2. The larger number of species trapped by SP1 as compared to the inner gutter of SP2 may be largely explained by the longer trapping period of SP1. Further, the uprooting of SP1, which necessitated its resetting in November 1977, allowed for the reinvasion of the area enclosed by SP1 by various staphylinid species. The variations in the total staphylinid captures in SP1 and in the inner gutter of SP2 were fairly similar (Fig. 3.4), peak captures occurring around January and February and again in June 1978. In the inner gutter of SP2, the high staphylinid captures from January to March 1978 were probably due to the initial trapping of the area it enclosed, while the second peak was due to the increased captures of Mycetoporus lepidus and O. lividipennis, both of which were also trapped in large numbers in the outer gutter of SP2 during this period. This suggests that SP2 is not much more effective than SP1 in preventing the entry of these two species from the surroundings into the enclosed area.

The results discussed above are summarised for the various traps in Table 3.7. Though not readily comparable, they indicate that

Table 3.7 Comparison of Features and Trapping Efficiencies of Various Pitfall Trap Types used in the Present Study.

Trap type and period of operation	Perimeter length (m)	Trapping Efficiency (staphylinids/month/ m trapping edge)	Number of species trapped
Plastic jar (20.11.75 - 18.11.76)	0.11	0 - 345.5	18
Plastic gutter (21.5.76 - 9.6.76)	1	6.6 - 63.8	10
Galvanised steel square pitfall SP1 (11.5.77 - 16.8.78)	3.32	0.3 - 9.6	28
Galvanised steel square pitfall SP2 (outer gutter) (14.12.77 - 16.8.78)	3.6	2.8 - 31.1	26
SP2 (inner gutter) (14.12.77 - 16.8.78)	2.72	1.1 - 11.8	16

pitfall traps with larger perimeters, i.e. gutter or square, trap a greater number of staphylinid species than jar pitfalls.

In terms of the number of staphylinid individuals caught per month per m trapping edge, however, jar pitfalls are more efficient than gutter pitfalls and square pitfalls are less efficient than either the jar or gutter pitfalls. The larger size of gutter and square pitfalls also limits the number of such traps which may be set within any particular area so that more staphylinids are likely to be outside the 'trapping range' of these traps, whereas a greater number of small circular traps, spaced at regular intervals over the same area, would be more effective in trapping the entire area.

Thus, in the Charnwood Forest area, where rock outcrops are common and the laying of large unwieldy square pitfalls is impractical, large numbers of jar pitfalls are the most convenient and effective means of providing information on the staphylinid fauna of various sites.

3.3 Heat Extraction

3.3.1 Theoretical Considerations

Since pitfall traps do not provide comprehensive data for the comparison of the staphylinid faunas of different habitats, heat extraction was used to provide more complete information. Handsorting of soil and litter samples was tested, but proved to be inefficient and tedious especially as staphylinid densities at the various study sites were very low. Dynamic heat extraction was chosen in preference to mechanical methods because

a) the Staphylinidae are very active insects

b) Staphylinidae are obtained undamaged, a very important consideration for their identification

c) less time and labour are involved than in mechanical methods

d) a suitable apparatus was already available.

The use of heat extraction methods for the study of beetles is relatively uncommon. Kasule (1968) used Berlese funnels for extracting Staphylinidae from grass and leaf litter samples, but concluded that numbers obtained in this way were too low and variable for studies on population fluctuations. Edwards and Lofty (1974), in an investigation into the effects of various manurial treatments on the productivity of old pasture, used modified Macfadyen-type high gradient, air-conditioned Tullgren funnels for extracting Coleoptera and other soil invertebrates from soil cores.

In heat extraction methods, heat, in conjunction with a funnel, is used for the collection of meiofauna expelled from samples through the repellant effects of dessication. Many variations of the basic Berlese and Tullgren funnels have been developed, and these are listed in Macfadyen (1962). These modifications are aimed at improving the efficiency of various aspects of the extraction process, depending on the nature of the sample, the group to be extracted, and the accuracy of results required, and are discussed in Macfadyen (1962), Murphy (1962), Edwards and Fletcher (1971) and Southwood (1978).

Since a review of these works suggests that the modified Kempson, Lloyd and Ghelardi apparatus (Kempson, Lloyd & Ghelardi, 1963; Salmon, 1973; Workman, 1975) is satisfactory for the extraction of dessication resistant forms such as adult beetles, and this apparatus was already available, it was used for the extraction of soil and litter samples obtained from the various habitats.

3.3.2 Extraction Efficiency

Estimates of the efficiency of extraction by dynamic extraction methods are difficult to obtain (Murphy, 1962), due to the great variety of responses possible from the various groups of meiofauna, and the difficulty in obtaining good estimates of the actual numbers present in the sample prior to extraction. Workman (1975) assumes the efficiency of extraction of grassland spiders by the modified Kempson, Lloyd and Ghelardi extractor to be over 70%. The efficiency of these extractors for the extraction of Staphylinidae from soil samples was not tested but comparison of the results obtained from these extractions with those obtained from hand-sorting similar samples showed no striking differences - most samples yielded less than ten staphylinids per sample and the majority of samples yielded only 1 or 2 staphylinids.

Although the number of staphylinid individuals obtained from soil samples by heat extraction is low, heat extraction methods, used in conjunction with pitfall trapping, provide useful complementary information on the composition of the staphylinid fauna at the various study sites, especially with respect to the 'non-pitfall trap' specific species such as Anthobium atrocephalum, Othius myrmecophilus, Tachyporus chrysomelinus and T. hypnorum (cf. 4.2).

3.4 Climatic Data

Rainfall and temperature data were recorded on Flat Hill over the period 15.6.77 - 20.7.78. The mean rainfall per day in mm, over each sampling period, was determined by dividing the mean volume collected per rain gauge, by the area of the collecting surface of each rain gauge, i.e. a circle of radius 10 cm. For each sampling period, the mean rainfall at Flat Hill was compared with that obtained by the Meteorological Station at Newtown Linford over the same period. The rainfall data obtained from these two sites are significantly correlated ($r = 0.909$; df. = 14; $P < 0.001$) over the period 15.6.77 - 21.12.77. Hence, the use of rainfall data from Newtown Linford for the present study is justified, although more accurate rainfall figures for Flat Hill may be obtained by using the correction

$$P_F = 0.497\ p_n + 0.297$$

where P_F = precipitation at Flat Hill (mm)

p_n = precipitation recorded at Newtown Linford (mm)

The maximum and minimum temperatures recorded at Flat Hill were also compared with those obtained at the Meteorological Station at Newtown Linford. Both maximum and minimum temperatures are significantly correlated at these two sites ($r = 0.916$; df. = 14; $P < 0.001$ and $r = 0.874$; df. = 14; $P < 0.001$ respectively), and more accurate values of maximum and minimum temperatures on Flat Hill may be obtained by using the formulae

$$T_{Fmax} = 0.832\ t_{nmax} + 2.281 \quad \text{and}$$

$$T_{Fmin} = 0.902\ t_{nmin} + 1.388 \text{ respectively,}$$

where T_{Fmax} = maximum temperature (^{o}C) expected on Flat Hill

T_{Fmin} = minimum temperature (^{o}C) expected on Flat Hill

t_{nmax} = maximum temperature (^{o}C) recorded at Newtown Linford

and t_{nmin} = minimum temperature (^{o}C) recorded at Newtown Linford.

The mean temperature over each sampling period was determined at both sites by taking the average of the daily maximum and minimum temperatures. Comparison of these values shows that mean temperatures at both sites are significantly correlated ($r = 0.937$; df. = 14; $P < 0.001$), so that temperature data from Newtown Linford may reasonably be used in the present study, although more accurate estimates of mean temperature at Flat Hill may be obtained by using the correction

$T_F = 0.964\ t_n + 0.042$

where T_F = mean temperature (^{o}C) at Flat Hill and

t_n = mean temperature (^{o}C) at Newtown Linford.

4. THE STAPHYLINIDAE: SPECIES COMPOSITION AND ABUNDANCE

4.1. Introduction

In this chapter, the data on the Staphylinidae of the Charnwood Forest area is presented and discussed with special reference to species composition and abundance, so that the influence of habitat type and temporal effects may be examined.

The results obtained by the various sampling methods are listed in Appendix I. Since field trips to both study areas in connection with the sampling programme could not be made on the same day, the dates of the various trapping periods (for jar pitfall traps) and sampling occasions (for heat extractions) at Charnwood Lodge and at Martinshaw Wood are recorded and categorised with respect to month in Tables (vi) and (vii) in Appendix I.

Since the data from jar pitfall traps, held in files NAMES and DATAMS (Tables (iv) and (v) in Appendix I) constitute the bulk of the data on the Staphylinidae obtained in the present study, a computer program, STAPHS (Program 1 in the Appendix II), was written so that these data could be decoded, analysed and stored by the Cyber 7600 for later use. Using this program, the abundances of the various species trapped in the pitfalls at the different study sites during the various trapping periods were calculated. Histograms showing the variations in abundance of the numerically more abundant species were then plotted using subroutine HISTOG. These results were then compared with those obtained from the other sampling methods used in the present study.

It would be impossible and indeed superfluous to discuss in detail every species found in the different study sites individually. Consequently the species which were numerically most abundant, and those which appeared most regularly over the study period were selected for further investigation. To determine the relative abundances of the various species at any site during any one trapping period, the total number of individuals of all species for each site, over any one trapping period, was calculated, using subroutine TOTAL. The percentage that each species constituted of this total at any site over this particular sampling period was also calculated using subroutine PERCEN.

The species selected for further study are then grouped according to their apparent habitat preferences, and their temporal variations in abundance are examined to determine whether there is any pattern in the activity of the various species. Since activity is related to breeding and feeding (Kasule, 1968; Evans, 1969), the food preferences of the various species from different habitats are investigated. Since food preferences would to a certain extent, be determined by the size of the beetles, the various species are classified into various size groupings for this purpose. Temporal variations in abundance of the species within each size grouping are then examined, to determine if peaks of abundance of the major species within a size grouping are spread relatively evenly throughout the year so that interspecific competition is minimised and there is optimal allocation and utilisation of the resources available within a particular habitat. Considerable overlap in the peaks of abundance of the major species within a size grouping may indicate differences in food preferences of the various species, or a very variable habitat in which a variety of micro-habitats are available, or that there is a sufficiency or even superfluity of the limiting factors at a particular time of year and that abundances are limited at other times.

Finally, to determine whether the distribution of the various species captured in pitfalls is aggregated, whenever the number of captures of any species exceeded 10 individuals per trapping period at any particular site, subroutine MEANVAR was used to calculate the mean:variance ratio for that species at that site, over the trapping period in question. Whenever the mean:variance ratio was <1, indicating an aggregated distribution, a χ^2 test,

$$\chi^2 = \frac{s^2\ (n - 1)}{\bar{x}}$$

with (n - 1) degrees of freedom, where $\bar{x}$ = mean, s^2 = variance and n = number of pitfalls on which the mean was based, was performed to test whether the aggregation was significant.

4.2. Comparison of Sampling Methods

4.2.1. Pitfall Trap Captures

A total of 90 identified species of Staphylinidae, as well as individuals referred to the grouping 'Other Aleocharinae' were trapped in jar pitfalls. Of these, 87 species were trapped in the Charnwood Lodge Nature Reserve (Table 4.1), and 38 in Martinshaw Wood (Table 4.2). The 34 species which were common to both study areas included *Anthobium atrocephalum*, *Othius punctulatus*, *Quedius nigriceps*, *Tachyporus chrysomelinus*, *T. hypnorum*, *Ocalea badia*, *Drusilla canaliculata* and *Oxypoda lividipennis*. 53 species were trapped in the Charnwood Lodge Nature Reserve but not in Martinshaw Wood, notably *Micropeplus staphylinoides*, *Omalium italicum*, *Xantholinus linearis*, and less commonly, *Omalium caesum*, *Othius angustus*, *Staphylinus aeneocephalus*, *Mycetoporus lepidus*, *Geostiba circellaris* and *Dinaraea angustula*. Only four species found in Martinshaw Wood were not trapped in Charnwood Lodge Nature Reserve - *Lathrobium brunnipes*, *Philonthus intermedius*, *Autalia impressa* and *Oxypoda alternans*.

The number of species trapped at each of the study sites in the two study areas are shown in Table 4.3. The greater number of species

Table 4.1 Staphylinidae trapped in jar pitfalls at Charnwood Lodge from November 1975 to October 1977.

Micropeplus porcatus (Paykull, 1789)

Micropeplus staphylinoides (Marsham, 1802)

Proteinus brachypterus (Fabricius,1792)

Proteinus ovalis Stephens 1834

Anthobium atrocephalum (Gyllenhal, 1827)

Anthobium unicolor (Marsham, 1802)

Olophrum fuscum (Gravenhorst, 1806)

Olophrum piceum (Gyllenhal, 1810)

Acidota cruentata Mannerheim 1830

Lesteva heeri Fauvel, 1872

Omalium caesum Gravenhorst, 1806

Omalium excavatum Stephens, 1834

Omalium italicum Bernhauer, 1902

Omalium oxyacanthae Gravenhorst, 1806

Omalium rivulare (Paykull,1789)

Omalium rugatum Mulsant & Rey 1880

Syntomium aeneum (Muller, P.N.J., 1821)

Anotylus rugosus (Fabricius, 1775)

Anotylus sculpturatus (Gravenhorst, 1806)

Anotylus tetracarinatus (Block, 1799)

Stenus clavicornis (Scopoli, 1763)

Stenus impressus Germar,1824

Lathrobium fulvipenne (Gravenhorst, 1806)

Ochthephilum fracticorne (Paykull, 1800)

Othius angustus Stephens, 1833

Othius myrmecophilus Kiesenwetter, 1843

Othius punctulatus (Goeze, 1777)

Table 4.1 (cont'd)

Atrecus affinis (Paykull, 1789)

Gyrohypnus fracticornis (Muller, O.F., 1776)

Xantholinus gallicus Coiffait, 1956

Xantholinus linearis (Olivier, 1759)

Xantholinus longiventris Heer, 1839

Philonthus cognatus Stephens 1832

Philonthus decorus (Gravenhorst, 1802)

Philonthus laminatus (Creutzer, 1799)

Philonthus varians (Paykull, 1789)

Philonthus varius (Gyllenhal, 1810)

Staphylinus aeneocephalus Degeer 1774[B]

Staphylinus olens Muller, C.F., 1764

Quedius curtipennis Bernhauer 1908

Quedius fumatus (Stephens, 1833)

Quedius mesomelinus (Marsham, 1802)

Quedius molochinus (Gravenhorst, 1806)

Quedius nemoralis Baudi, 1848

Quedius nigriceps Kraatz, 1857

Quedius nitipennis (Stephens, 1833)

Quedius picipes (Mannerheim, 1830)

Quedius tristis (Gravenhorst, 1802)

Mycetoporus clavicornis (Stephens, 1832)

Mycetoporus lepidus (Gravenhorst, 1802)

Mycetoporus rufescens (Stephens, 1832)

Bolitobius analis (Fabricius, 1787)

Bolitobius cingulatus (Mannerheim, 1830)

Bolitobius inclinans (Gravenhorst, 1806)

Table 4.1 (cont'd)

Sepedophilus marshami (Stephens, 1832)

Sepedophilus nigripennis (Stephens, 1832)

Tachyporus chrysomelinus (Linnaeus, 1758)

Tachyporus hypnorum (Fabricius, 1775)

Tachyporus nitidulus (Fabricius, 1781)

Tachyporus obtusus (Linnaeus, 1767)

Tachyporus solutus Erichson, 1839

Tachinus humeralis Gravenhorst, 1802

Tachinus marginellus (Fabricius, 1781)

Tachinus pallipes (Gravenhorst, 1806)

Tachinus signatus Gravenhorst, 1802

Tachinus subterraneus (Linnaeus, 1758)

Cypha longicornis (Paykull, 1800)

Boreophilia islandica (Kraatz, 1857)

Aloconota gregaria (Erichson, 1839)

Geostiba circellaris (Gravenhorst, 1806)

Dinaraea angustula (Gyllenhal, 1810)

Liogluta nitidula (Kraatz, 1856)

Atheta gagatina (Baudi, 1848)

Mocyta amplicollis (Mulsant & Rey, 1873)

Atheta crassicornis (Fabricius, 1792)

Atheta fungicola (Thomson, C.G., 1852)

Dimetrota atramentaria (Gyllenhal, 1810)

Dimetrota marcida (Erichson, 1837)

Drusilla canaliculata (Fabricius, 1787)

Ocalea badia Erichson, 1837

Oxypoda annularis Mannerheim, 1830

Oxypoda islandica Kraatz, 1857

Table 4.1 (cont'd)

Oxypoda lividipennis Mannerheim, 1830

Oxypoda opaca (Gravenhorst, 1802)

Oxypoda umbrata (Gyllenhal, 1810)

Tinotus morion (Gravenhorst, 1802)

Other Aleocharinae

Table 4.2 <u>Staphylinidae trapped in jar pitfalls in Martinshaw Wood from August 1976 to November 1977.</u>

<u>Proteinus</u> <u>brachypterus</u> (Fabricius, 1792)

<u>Anthobium</u> <u>atrocephalum</u> (Gyllenhal, 1827)

<u>Anthobium</u> <u>unicolor</u> (Marsham, 1802)

<u>Olophrum</u> <u>piceum</u> (Gyllenhal, 1810)

<u>Acidota</u> <u>cruentata</u> Mannerheim, 1830

<u>Anotylus</u> <u>tetracarinatus</u> (Block, 1799)

<u>Stenus</u> <u>impressus</u> Germar, 1824

<u>Lathrobium</u> <u>brunnipes</u> (Fabricius, 1792)

<u>Othius</u> <u>myrmecophilus</u> Kiesenwetter, 1843

<u>Othius</u> <u>punctulatus</u> (Goeze, 1777)

<u>Xantholinus</u> <u>longiventris</u> Heer, 1839

<u>Philonthus</u> <u>cognatus</u> Stephens, 1832

<u>Philonthus</u> <u>decorus</u> (Gravenhorst, 1802)

<u>Philonthus</u> <u>intermedius</u> (Boisduval & Lacordaire, 1835)

<u>Staphylinus</u> <u>olens</u> Muller, O.F., 1764

<u>Quedius</u> <u>curtipennis</u> Bernhauer, 1908

<u>Quedius</u> <u>fumatus</u> (Stephens, 1833)

<u>Quedius</u> <u>molochinus</u> (Gravenhorst, 1806)

<u>Quedius</u> <u>nemoralis</u> Baudi, 1848

<u>Quedius</u> <u>nigriceps</u> Kraatz, 1857

<u>Mycetoporus</u> <u>rufescens</u> (Stephens, 1832)

<u>Bolitobius</u> <u>analis</u> (Fabricius, 1787)

<u>Bolitobius</u> <u>inclinans</u> (Gravenhorst, 1806)

<u>Sepedophilus</u> <u>marshami</u> (Stephens, 1832)

<u>Sepedophilus</u> <u>nigripennis</u> (Stephens, 1832)

<u>Tachyporus</u> <u>chrysomelinus</u> (Linnaeus, 1758)

<u>Tachyporus</u> <u>hypnorum</u> (Fabricius, 1781)

Table 4.2 (cont'd)

Tachyporus nitidulus (Fabricius, 1781)

Tachinus signatus (Gravenhorst, 1802)

Tachinus subterraneus (Linnaeus, 1758)

Autalia impressa (Olivier, 1795)

Atheta gagatina (Baudi, 1848)

Ocalea badia (Erichson, 1837)

Drusilla canaliculata (Fabricius, 1787)

Oxypoda alternans (Gravenhorst, 1802)

Oxypoda islandica Kraatz, 1857

Oxypoda lividipennis Mannerheim, 1830

Other Aleocharinae

Table 4.3 Number of species of Staphylinidae trapped in jar pitfall traps at (i) Charnwood Lodge Nature Reserve, and (ii) Martinshaw Wood, over whole study period.

(i) Charnwood Lodge Nature Reserve		(ii) Martinshaw Wood	
Study Site	Number of species	Study Site	Number of species
1. Collier's Wood	54	1. Grass	15
2. Flat Hill	46	2. Bracken	18
3. Stream	27	3. Oak	26
4. Timberwood Hill	38	4. Pine	17
5. Timberwood Plantation	29		

recorded in pitfalls in Charnwood Lodge than in Martinshaw Wood is possibly due to several factors. First, traps were run longer in Charnwood Lodge, two years, than at Martinshaw Wood, with 16 months in the oak and pine sites, and only 7 and 8 months respectively at the grass and bracken sites. Further, six pitfalls were used in each of the study sites at Martinshaw, while in three of the Charnwood Lodge sites, grids of 18 pitfalls were used.

Because of the different numbers of pitfalls used and the different sampling periods at Charnwood Lodge and Martinshaw Wood sites, comparisons of the various sites in terms of the number of species recorded per site are not readily made. However, since the shortest period of sampling was from August 1976 to February 1977, at the grass site in Martinshaw Wood, and a row of six pitfalls was used at this site, the number of species occurring during this period in six pitfalls was determined for each of the sites. For this purpose, pitfalls 1 - 6 were selected at random from the 18 pitfalls set in Collier's Wood, Flat Hill and Timberwood Hill. The number of species per site, obtained from six pitfalls from August 1976 to February 1977 are tabulated in Table 4.4. In Charnwood Lodge, the greatest

Table 4.4 Number of species recorded in (i) pitfalls 1 - 6, and (ii) two heat extracted soil samples from August 1976 to February 1977 at Charnwood Lodge and Martinshaw Wood sites.

Site	Number of species (i) Pitfalls 1 - 6	Number of species (ii) Two soil samples	Total number of different species
Collier's Wood	24	8	25
Flat Hill	14	1	14
Stream	6	3	6
Timberwood Hill	12	3	12
Timberwood Plantation	14	3	14
Martinshaw Grass	14	6	17
Martinshaw Bracken	18	4	19
Martinshaw Oak	19	2	20
Martinshaw Pine	11	1	11

number of species was recorded in Collier's Wood. Fewer specimens were recorded on Flat Hill, Timberwood Hill and Timberwood Plantation, and only six species were recorded at the stream site. The differences in the number of species trapped at the various sites probably reflects differences in the history of the sites. Collier's Wood has been the least disturbed by man, while all the other sites have a history of human interference. Flat Hill, and the fields on both sides of the stream are used for rough grazing, while Timberwood Hill has been drained and Timberwood Plantation is constantly being logged. The result of this disturbance to the habitat is a reduction in the number of species.

In Martinshaw Wood the oak wood had the highest number of species, but differences between the number of species trapped at the various sites are less striking than in Charnwood Lodge. This is possibly because the proximity of the former sites - within an area of approximately 2,900 m^2, the grass site is separated from the bracken site by a 3 m wide ride and the bracken borders on the woodland, in which 9 m wide rows of oaks alternate with rows of pines - allows for the free movement of species between sites.

4.2.2. Modified Pitfall Traps

The number of species recorded in the gutter and square pitfall traps set out in Collier's Wood were discussed in 3.2.2.2. and comparisons were made of the efficiency of these traps with that of jar pitfalls. The results of these traps were not strictly comparable to those from jar pitfalls traps because of differences in the period of sampling. However, the numerically more dominant species in jar pitfalls, e.g. *A. atrocephalum*, *O. italicum*, *Philonthus decorus*, *M. lepidus*, *Tachinus signatus*, *O. badia* and *O. lividipennis* were also well represented in the modified pitfall traps. *O. italicum* and *O. badia* were never trapped in gutter pitfalls, because they were inactive during the limited period that these traps were in operation. The order of abundance of the species was not necessarily the same in all these traps, however, possibly again because of the different trapping periods.

4.2.3. Baited Traps

The Staphylinidae attracted to various baited traps are shown in Tables (viii) - (x) in Appendix I. The first set of jar pitfall traps baited with uncooked cod were not very effective in attracting large numbers of staphylinids as shown in Table 4.5. The majority of staphylinids had drowned in the juices exuding from the decaying fish and collected at the

Table 4.5 Staphylinidae attracted to various baited traps in the Charnwood Forest Area.

Bait	Site	Sampling Period	Species	Total number of individuals trapped
Cod	Collier's Wood	6.5.76 - 21.5.76	Omalium caesum	10
			Philonthus decorus	1
			Cypha longicornis	1
			Aleochara curtula	1
Cod	Collier's Wood	14.6.78 - 28.6.78	Philonthus spp.	> 40
			Tachinus humeralis	> 200
			Aleochara curtula	2
	Flat Hill	14.6.78 - 28.6.78	Philonthus spp.	5
Rat carrion	Martinshaw Wood	3.8.76 - 11.8.76	Omalium caesum	2
			Philonthus succicola	16
			Philonthus varius	1
			Tachyporus chrysomelinus	1
			Aleochara curtula	3
			Other Aleocharinae	3

bottom of the jars. In these traps, only four species of Staphylinidae were recorded over a two week period in May 1976 and *Omalium caesum* occurred most commonly. There is no record of *O. caesum* being attracted to fish bait although other species of *Omalium*, e.g. *O. rivulare* and *O. septentrionis* have been recorded on fish and mammalian carrion (Walsh, 1931, 1933; Kaufmann, 1937b; Moore, 1955; Easton, 1966; Smith, 1975). However, Walsh (1933) has found *A. curtula* and various species of *Philonthus*, *Tachinus*, *Proteinus* and *Atheta* in fish baited pitfall traps set in woodlands in May - June.

The fish baited pitfall traps set on Flat Hill and in Collier's Wood in June 1978 were very effective in trapping large numbers of Staphylinidae. Only five staphylinids, all *Philonthus* spp., were recorded from the traps set on Flat Hill, but the number of staphylinids found in the traps set in Collier's Wood was so large that the abundance of the various species had to be estimated.

The number of Staphylinidae found in the cod bait reached a maximum after one week of decomposition; more than 200 individuals of *Tachinus humeralis* and more than 40 individuals belonging to various *Philonthus* species, particularly *P. succicola* and *P. varians* were recorded. Two individuals of *A. curtula* were also observed. After a further week of decomposition, the numbers of *Philonthus* spp. and *T. humeralis* were drastically reduced, although a total of more than 50 Staphylinidae remained. *T. humeralis* has been recorded on carrion (Walsh, 1931; Easton, 1966), but less commonly than other species of *Tachinus*, e.g. *T. rufipes* and *T. subterraneus* (Walsh, 1931, 1933; Kaufmann, 1937b; Easton, 1966).

When rat carrion was left exposed on trays near Flat Hill towards the end of July 1976, only one specimen of *A. curtula* was found on the carrion although the bait was examined every two days. Kaufmann

(1937b) has also observed A. curtula in July - August in pitfall traps baited with raw mammalian lung tissue, while Moore (1955) observed that this species was very common in bird and mammalian carrion from May - October.

In the rat baited pitfall traps set in Collier's Wood, no Staphylinidae were found before all the traps were uprooted by small mammals and the carrion removed.

Similar traps set in Martinshaw Wood were more successful (Table 4.5). During the first eight days of decomposition, the rat carrion attracted six different taxa of Staphylinidae. Initially, Tachyporus chrysomelinus and three members of the Aleocharinae were found. By the fifth day of decomposition, A. curtula appeared, and on the sixth day, this species was present together with Philonthus succicola and 1 specimen of P. varius. By the eighth day, the numbers of P. succicola had increased, and Omalium caesum now made an appearance. The occurrence of a single individual of T. chrysomelinus in the baited pitfall traps may be accidental, as T. chrysomelinus was frequently found in unbaited pitfalls in Martinshaw Wood during this period; Walsh (1931) records one T. chrysomelinus in carrion bait. A. curtula and the Philonthus spp. are,however, well documented as necrophilous species (Walsh, 1933; Bartindale and Bartindale, 1948; Moore, 1955; Easton, 1966; Bacchus and Hammond, 1972; Smith, 1975).

4.2.4. Heat Extraction

A total of 23 different species of Staphylinidae, as well as 'Other Aleocharinae' were extracted from soil samples obtained from Charnwood Lodge, while only 9 identified species plus the group 'Other Aleocharinae' were extracted from samples obtained from Martinshaw Wood (Tables (xi) - (xix) in Appendix I). This is probably a reflection of the longer period of sampling at Charnwood Lodge Nature Reserve, as compared to that at Martinshaw Wood (see 4.2.1.).

Of the 23 species obtained from heat extracted soil samples from the Charnwood Lodge sites, seven species, notably T. chrysomelinus, T. hypnorum, and Geostiba circellaris, were also extracted from samples taken from Martinshaw Wood. Two species, A. atrocephalum and Quedius curtipennis, were found in samples taken from the bracken site in Martinshaw Wood, but not in the Charnwood Lodge samples.

The number of species obtained from heat extracted soil samples from each of the study sites from August 1976 to February 1977 (Table 4.4) shows that in Charnwood Lodge, the greatest number of species was obtained from Collier's Wood, with 8 different species. Three species were recorded at the stream site, Timberwood Hill and Timberwood Plantation while Flat Hill had only one species. In Martinshaw Wood, the grass site had most species, with the bracken site second, while the oak and pine sites had only two and one species respectively.

Tachyporus hypnorum and 'Other Aleocharinae' were obtained most regularly from heat extracted samples (Tables (xi) - (xix) in Appendix I). Othius myrmecophilus, T. chrysomelinus and Geostiba circellaris were also commonly extracted, but T. obtusus, T. solutus, Tachinus signatus, Acrotona muscorum, O. badia, O. lividipennis and Tinotus morion were obtained from these samples only once.

Comparison of the results obtained from pitfall trapping with those obtained from heat extraction shows that certain species which commonly occurred in pitfall traps, e.g. A. atrocephalum, O. myrmecophilus, T. chrysomelinus and T. hypnorum were also obtained from heat extracted samples. Three species, namely Oxytelus fulvipes, Mocyta orbata and Acrotona muscorum which occurred infrequently, were obtained solely by heat extraction, while M. staphylinoides and Drusilla canaliculata, although very conspicuous in some pitfall traps, were completely absent from heat extracted soil samples and may be regarded as 'pitfall trap specific'. Some larger species especially members of the Staphylinidae, e.g. P. decorus, S. aeneocephalus, S. olens, Q. molochinus and Q. nigriceps were also conspicuously absent from heat extracted samples. The large size, keen sight and agility of these species may enable them to escape from the soil samples during sampling, although Al-Dabbagh (pers. comm.) extracted large numbers of S. olens from soil and litter samples taken from Weeting Heath using the same heat extractors.

Notwithstanding the possibility of escape during sampling, heat extraction of soil samples can provide estimates of population densities. However, since only two samples per site were extracted on each sampling occasion, and each soil sample was only 0.0095 m^2 in cross-sectional area, estimates of the mean density at each study site on every sampling occasion would be very unreliable especially since staphylinids have a tendency to aggregate.

Estimates of the mean density of Staphylinidae present at each site over the whole of the study were therefore obtained by dividing the total number of staphylinids extracted during the whole study period by the total number of soil samples taken and the area of a sample. The results were expressed as numbers per m^2 and are shown in Table 4.6.

Mean staphylinid densities at the Charnwood Lodge sites were generally higher than those at Martinshaw Wood, although the differences in the number of soil samples on which these estimates are based must be considered. The stream and Flat Hill appeared to have higher densities of staphylinid individuals than the other study sites. This was largely due to the presence of a larger number of individuals belonging to the grouping 'Other Aleocharinae' in samples taken from these sites.

Table 4.6 Mean densities of Staphylinidae at (i) Charnwood Lodge Nature Reserve, and (ii) Martinshaw Wood

Charnwood Lodge Nature Reserve		Martinshaw Wood	
Study Site	Numbers of Staphylinidae/m^2	Study Site	Numbers of Staphylinidae/m^2
Collier's Wood	55	Grass	75
Flat Hill	72	Bracken	53
Stream	105	Oak	11
Timberwood Hill	55	Pine	18
Timberwood Plantation	46		

NOTE: At all the Charnwood Lodge sites, estimates of staphylinid densities were based on 48 soil samples, while at the grass and bracken sites in Martinshaw Wood, estimates were based on 14 soil samples, and at the oak and pine sites, estimates were based on 30 soil samples.

4.3. Environmental Factors and Total Staphylinid Numbers

Monthly variations in the total numbers of Staphylinidae trapped in jar pitfalls at the various study sites are shown in Table 4.7. Of the Charnwood Lodge sites, the greatest number of staphylinid individuals occurred in jar pitfalls in Collier's Wood. The catch on Timberwood Hill and Flat Hill was generally less than that in Collier's Wood, while fewest individuals were trapped at the stream site and Timberwood Plantation respectively where only one-third the number of traps were used. Staphylinid captures in jar pitfall traps at the Martinshaw Wood sites were not strictly comparable because of differences in the trapping periods at the various sites. However, comparison of the captures during the first eight sampling periods at the various sites showed that higher numbers of Staphylinidae were caught at the bracken and grass sites than at the oak and pine sites. Table 4.7 shows that generally, in the woodland sites, i.e. Collier's Wood, Timberwood Plantation and the oak and pine sites in Martinshaw Wood, more staphylinids were caught in pitfalls from October to January, whereas in the more open habitats such as Flat Hill, Timberwood Hill and the stream, peaks of staphylinid activity generally occurred around April and May with secondary peaks around August and November. Thus it would appear that the shelter offered by the trees and the litter layer in woodland habitats is a factor which might promote the increase in numbers and activity of winter-active species, whereas the exposure associated with the more open sites decreases the numbers and activity of winter-active species at these sites.

The mean maximum, mean minimum and mean temperatures (^{o}C), mean rainfall (mm), mean daily hours of sunshine and mean wind speed, recorded for each month of the study period at Newtown Linford, are tabulated in Table (xx) in Appendix I. To investigate the effects of various climatic factors on the activity of the Staphylinidae at the various study sites,

Table 4.7 Variations in the abundance of total Staphylinidae in jar pitfalls in Charnwood Lodge and Martinshaw Wood

Site	1975 N	D	1976 J	F	M	A	M	J	J	A	S	O	N	D	1977 J	F	M	A	M	J	J	A	S	O	N	Site Totals
<u>Charnwood</u>																										
Collier's Wood	188	170	150	79	44	26	74	36	50	85	40	80	129	174	78	39	64	74	40	34	22	23	42	218		1959
Flat Hill	41	27	20	5	18	22	22	19	25	41	24	18	68	71	23	48	60	83	84	21	23	22	48	49		882
Stream	0	7	3	3	5	5	3	14	9	5	3	0	7	7	3	4	6	29	14	5	8	2	3	1		146
Timberwood Hill	12	9	6	9	10	22	29	6	18	67	17	37	123	28	24	49	47	247	251	35	44	23	61	44		1218
Timberwood Plantation	17	4	2	5	5	8	12	17	9	12	6	6	2	3	1	2	2	1	0	3	2	0	2	1		122
<u>Martinshaw</u>																										
Grass										61	26	10	10	13	4	6										130
Bracken										33	9	10	32	37	7	11	8									147
Oak										9	0	39	17	7	7	7	4	21	7	3	16	0	5	10	24	176
Pine										1	0	79	20	0	3	1	7	11	4	2	6	0	2	2	0	138

these monthly values were correlated with the total numbers of Staphylinidae trapped at each site, except Flat Hill, during the corresponding month. Since correction formulae were available for the maximum, minimum and mean temperatures and the mean rainfall at Flat Hill, corrected values for temperature and rainfall were used for correlations with total staphylinid numbers at this site.

The correlation coefficients, r, for the comparison of the total Staphylinidae trapped at the various sites, with various climatic factors (Table 4.8) are significant only for certain climatic factors at Collier's Wood and the stream site at Charnwood Lodge, and the grass site in Martinshaw Wood. At Collier's Wood, the total Staphylinidae trapped were negatively correlated with the average maximum, minimum and mean daily temperatures, and with sunshine. Numbers trapped at the stream site were significantly correlated with the daily mean hours of sunshine received, while at the grass site in Martinshaw Wood, total captures in jar pitfalls were positively correlated with temperatures and hours of sunshine received daily, and negatively correlated with wind speed.

At the more exposed sites, i.e. the stream site and the grass site in Martinshaw Wood, the correlation between weather factors and staphylinid captures would be explicable, especially since the weather data used were also collected from an open site. Although Flat Hill, Timberwood Hill and the bracken site in Martinshaw Wood are also relatively open sites, the bracken present at these sites, especially during the summer and autumn, probably acts as a buffer, modifying the effects of temperature, rainfall, wind speed and sunshine, so that no correlation was apparent between staphylinid captures at these sites and climatic data obtained from Newtown Linford. Of the staphylinid captures in woodland sites, only those in Collier's Wood were correlated with temperatures and mean daily duration of sunshine,

Table 4.8 Values of Pearson's correlation coefficient, r, for the comparison of the total number of Staphylinidae trapped at the various sites, with various climatic factors.

x y Total staphylinid numbers at sites	Maximum Temperature (°C)	Minimum Temperature (°C)	Mean Temperature (°C)	Rainfall (mm)	Sunshine (hrs.)	Wind Speed (knots)
Collier's Wood	- 0.4909 *	- 0.4416 *	- 0.4845 *	- 0.0998NS	- 0.5137 *	0.2441NS
Flat Hill	- 0.1966NS	- 0.2451NS	- 0.2299NS	0.0663NS	0.0255NS	0.1917NS
Stream	0.1145NS	- 0.0099NS	0.0599NS	- 0.2332NS	0.4547 *	0.1789NS
Timberwood Hill	0.0101NS	- 0.0623NS	0.0239NS	- 0.0507NS	0.2684NS	0.2000NS
Timberwood Plantation	0.3586NS	0.2591NS	0.3145NS	- 0.2704NS	0.3396NS	- 0.3242NS
Martinshaw Grass	0.8787 *	0.8008 *	0.8491 *	- 0.5426NS	0.9925 ***	- 0.7590 *
Martinshaw Bracken	0.0936NS	- 0.0059NS	0.0130NS	- 0.4524NS	0.4227NS	- 0.4886NS
Martinshaw Oak	- 0.1547NS	- 0.1392NS	- 0.1653NS	- 0.0458NS	- 0.1534NS	0.2874NS
Martinshaw Pine	- 0.0504NS	- 0.0019NS	- 0.0405NS	0.0792NS	- 0.2736NS	- 0.0915NS

increased temperatures and sunshine resulting in decreased total staphylinid numbers. A further factor which might affect abundance is soil moisture, which was determined in the heat extracted samples. Correlations were therefore calculated between the total numbers of Staphylinidae in the soil samples at each site, on various sampling occasions, and the moisture contents of the soil samples. In all cases the numbers of Staphylinidae extracted from soil samples were not significantly correlated with their moisture contents (Table 4.9).

4.4. Habitat preferences and variations in abundance of staphylinid species

4.4.1. Bases for Separation

The habitat preferences and seasonal variations in the abundance of the more common species encountered in the present study were assessed by examination of the raw data (Table 4.10). Only the more abundant and frequently occurring species are listed, except where a species is common in one study area but rare in the other. Such rare occurrences are included for comparative purposes. Where a species mainly occurred at Collier's Wood and Timberwood Plantation in the Charnwood Lodge study area and at the oak and pine sites in Martinshaw Wood, its habitat preference is recorded as woodland. When the species only occurred in the more open, exposed sites, namely Flat Hill, the stream and Timberwood Hill in Charnwood Lodge, and the grass and bracken sites in Martinshaw Wood, its habitat preference is recorded as 'open site'. Where no such generalisations can be made, the site or sites in which it was trapped most frequently are recorded as its preferred site. Since the number of staphylinids obtained by heat extraction was relatively low, all sites from which a particular species was obtained by this method are recorded. The months over which a species was present in pitfalls or in soil samples are also recorded, except where

i) no distinct seasonal variations in abundance were perceptible, when the classification 'indistinct' is used, and

Table 4.9 Values of Pearson's Correlation Coefficient, r, for the Comparison of the Total Numbers of Staphylinidae Extracted From Soil Samples, with Soil Moisture Content.

y Total Staphylinid numbers at sites \ x	Moisture content (% dry weight)
Collier's Wood	- 0.0481 NS
Flat Hill	- 0.1629 NS
Stream	0.1756 NS
Timberwood Hill	0.1942 NS
Timberwood Plantation	- 0.0491 NS
Grass	0.9843 NS
Bracken	- 0.4052 NS
Oak	0.5495 NS
Pine	0.5399 NS

Table 4.10 Habitat preferences and temporal variations in the abundance of various staphylinid species of Charnwood Lodge (CL) and Martinshaw Wood (MS).

Site Abbreviations:-

CF = Collier's Wood
ST = Stream
TP = Timberwood Plantation
MB = Bracken site, Martinshaw Wood
MP = Pine site, Martinshaw Wood
FH = Flat Hill
TH = Timberwood Hill
MG = Grass site, Martinshaw Wood
MQ = Oak site, Martinshaw Wood

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
MICROPEPLINAE					
Micropeplus staphylinoides	CL	CF	Aug. - Apr. common	-	-
PROTEININAE					
Proteinus brachypterus	CL	woodland	Sep. - Mar. rare	-	-
	MS	MQ	sporadic	-	-
OMALIINAE					
Anthobium atrocephalum	CL	CF	Oct. - May common	-	-
	MS	MQ	sporadic	MB	Nov., Mar.

Table 4.10 (cont'd)

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
_A_. _unicolor_	CL	CF	Sep.-Apr. fairly common	-	-
	MS	MQ	sporadic	-	-
Olophrum _piceum_	CL	FH,TH,CF	Nov.-May few	CF	Jul.
	MS	MB	Nov.-Dec. rare	-	-
Omalium _caesum_	CL	CF	indistinct few	ST	Dec.
_O_. _italicum_	CL	CF	Oct.-May fairly common	-	-
OXYTELINAE					
Anotylus _tetracarinatus_	CL	woodland	Apr.-Jun. rare	CF,ST TP	Jan.,Apr. Dec.,Apr.
STENINAE					
Stenus _impressus_	CL	FH,TH	indistinct rare	TP	Dec.

Table 4.10 (cont'd)

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
STAPHYLININAE					
<u>Othius</u> <u>angustus</u>	CL	FH,CF	indistinct rare	FH	Jan.
<u>O</u>. <u>myrmecophilus</u>	CL	all sites esp. CF,FH	all year few	all sites	Sept. - May
	MS	woodland	sporadic	MG,MQ, MP	Aug.,Feb., Apr.&Jun.
<u>O</u>. <u>punctulatus</u>	CL	CF	Nov.-Jun. rare	-	-
	MS	MQ	Aug.-Jul. rare	-	-
<u>Xantholinus</u> <u>gallicus</u>	CL	open	sporadic	-	-
<u>X</u>. <u>linearis</u>	CL	all sites esp. FH	Nov.-Jul. fairly common	FH,ST TP	Mar.,May,Aug. Oct.
<u>X</u>. <u>longiventris</u>	CL	FH	sporadic	-	-
<u>Philonthus</u> <u>cognatus</u>	CL	FH	Apr.-Jun. fairly common	-	-

Table 4.10 (cont'd)

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
Philonthus cognatus	CL	TH, CF	sporadic	-	-
P. decorus	CL	CF, FH	May-Oct. few	-	-
	MS	MQ	sporadic	-	-
Staphylinus aeneocephalus	CL	FH	Oct.-Apr. few	-	-
S. olens	CL	CF	May, Sep., Oct. few	-	-
	MS	MG	Sep., Oct	-	-
Quedius curtipennis	CL	open	indistinct rare	-	-
	MS	MB, MQ	sporadic	MB	Feb., Mar.
Q. fumatus	CL	CF	Oct.-Jan. rare	-	-
Q. molochinus	CL	open	indistinct rare	-	-
Q. nigriceps	CL	CF, TH, FH	sporadic	-	-
	MS	all sites, esp. woodland	Sep.-Jan. fairly common	-	-
TACHYPORINAE					
Mycetoporus lepidus	CL	CF	sporadic	-	-

Table 4.10 (cont'd)

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
Mycetoporus rufescens	CL	TH	Oct.-May few	-	-
Bolitobius analis	CL	TH	Apr.-Jun. rare	-	-
B. cingulatus	CL	TH	May-Jul. rare	-	-
B. inclinans	CL	CF	indistinct rare	-	-
Sepedophilus marshami	CL	open, esp.TH,ST	Apr.-Oct. few	-	-
	MS	woodland	Jun.-Nov. rare	-	-
S. nigripennis	CL	FH	Feb.-Nov. few	FH	Nov.
	MS	all sites	sporadic	-	-
Tachyporus chrysomelinus	CL	all sites esp. TH	all year common	all sites except TP	all year
	MS	all sites esp. open	all year fairly common	open	Nov.,Mar.,Apr.

Table 4.10 (cont'd)

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
Tachyporus hypnorum	CL	All sites esp. open	all year common	all sites esp. open	Nov.-Apr.
	MS	all sites esp.open	Aug.-May fairly common	open	Aug.,Nov.,Feb.
T. nitidulus	CL	all sites except ST	indistinct few	CF	May
	MS	woodland	Oct.-Jun. few	woodland	Feb.,Jun.
T. obtusus	CL	CF	Jun.,Sep. rare	CF	Apr.
Tachinus humeralis	CL	CF	Aug.,Oct. rare	-	-
T. signatus	CL	CF	Apr.-Sep. fairly common	ST	Feb.
ALEOCHARINAE					
Aloconota gregaria	CL	TP	Mar.-Jul. rare	-	-

Table 4.10 (cont'd)

Species	Study Area	Jar Pitfall Traps		Heat Extraction	
		Habitat/ Site Preference	Occurrence	Site	Occurrence
Geostiba circellaris	CL	woodland	May -Oct. few	all sites except FH	all year
Dinaraea angustula	CL	TH	May-Nov. rare	-	-
Autalia impressa	MS	all sites, esp. woodland	Oct.-Feb. fairly common	-	-
Ocalea badia	CL	CF	Sept.-May common	CF,FH	Oct.,Nov.
Drusilla canaliculata	CL	all sites, esp. TH,FH	May-Oct. fairly common	-	-
	MS	open	Aug.-Oct. fairly common	-	-
Oxypoda lividipennis	CL	CF	Oct.-Jun. common	CF	Nov.
Other Aleocharinae	CL	all sites, esp. CF,TH	variable fairly common	all sites	all year

ii) only one or two individuals occurred on less than five sampling occasions, when their occurrence is described as sporadic.

After comparisons of the various species abundances, the numerical abundance of each species caught in pitfall traps and obtained by heat extraction is classified as follows: -

Class	Number of individuals trapped over at least one sampling period
Common	> 50 individuals
Fairly common	10 - 50 individuals
Few	5 - 10 individuals
Rare	< 5 individuals

From Table 4.10, it may be seen that the major species of Staphylinidae encountered in the Charnwood Forest study area may be classified according to their habitat preferences, and/or their periods of activity. Using habitat preferences as a criterion, woodland species, species of open habitats, and ubiquitous species may be distinguished.

4.4.2. Woodland Species

Woodland species include Micropeplus staphylinoides, Proteinus brachypterus, Anthobium atrocephalum, A. unicolor, Omalium caesum, O. italicum, Anotylus tetracarinatus, Othius punctulatus, Mycetoporus lepidus, Bolitobius inclinans, Tachyporus obtusus, Tachinus humeralis, T. signatus, Aloconata gregaria, Geostiba circellaris, Autalia impressa, Ocalea badia and Oxypoda lividipennis. The temporal variations in the activity of the numerically more abundant of these species are shown in Table 4.11.

Although Micropeplus staphylinoides is recorded as 'common'

Table 4.11 Variations in the abundance of woodland staphylinids in jar pitfalls in Charnwood Lodge and Martinshaw Wood

	1975		1976												1977										Species
Species & Site	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	Totals
Micropeplus staphylinoides (Collier's Wood)	2	1	5	7	2	1	4	0	0	0	15	10	5	5	2	1	1	2	0	0	0	6	10	67		146
Anthobium atrocephalum (Collier's Wood)	41	10	20	17	12	16	23	0	0	0	0	23	43	43	37	4	32	54	4	0	0	0	0	41		410
A. unicolor (Collier's Wood)	6	5	8	3	1	0	1	1	0	0	1	20	23	21	8	6	7	4	0	0	0	0	0	15		130
Omalium italicum (Collier's Wood)	15	12	18	4	0	1	1	0	0	1	0	2	11	7	2	3	4	2	1	2	0	0	0	15		101
Tachinus signatus (Collier's Wood)	2	0	0	0	0	1	11	21	22	15	7	1	0	0	0	0	0	0	3	5	3	2	3	1		97
Autalia impressa (Martinshaw Oak)										0	0	13	3	0	1	0	0	0	0	0	0	0	2	6	4	29
(Martinshaw Pine)										0	0	42	3	0	0	0	0	0	0	0	1	0	0	0	0	46
Ocalea badia (Collier's Wood)	41	90	53	42	15	3	2	0	0	4	2	9	12	44	15	12	8	1	0	0	0	0	2	11	0	366
Oxypoda lividipennis (Collier's Wood)	68	32	36	4	4	1	0	1	0	0	0	5	12	44	4	5	4	0	3	11	1	0	0	35	0	270

in the British Isles by Joy (1932) and widespread by Tottenham (1954) this species is not mentioned in the various field studies published, such as those of Van der Drift (1959), Kasule (1967, 1968) and Evans (1969, 1971). In the present study, M. staphylinoides occurred frequently in jar pitfalls in Collier's Wood, where it constituted up to 41.7% of the total staphylinid catch, and also, though less frequently, in the square pitfall traps SP1 and SP2. M. staphylinoides was absent from jar pitfalls in Collier's Wood during the summer months, from about May to July, but was active at other times of the year with peaks of abundance in September 1976 and October 1977, when a maximum of 67 individuals were trapped (Table 4.11). It was, however, absent from jar pitfalls in Martinshaw Wood and was never obtained by heat extraction.

Both Anthobium atrocephalum and A. unicolor show a distinct preference for woodland habitats, especially Collier's Wood. This preference for woodland habitats was also recorded by Nield (1974). In Collier's Wood, A. atrocephalum occurred more frequently than A. unicolor in pitfall traps. Both these species appeared to be less frequent and abundant in pitfall traps in Martinshaw Wood, even taking into account the smaller number of pitfalls used in Martinshaw Wood. Both A. atrocephalum and A. unicolor showed similar patterns of variation in occurrence (Table 4.11), large numbers of individuals being trapped from October to May with peaks of activity in November and December, and decreasing during the summer so that both species were completely absent from jar pitfall traps during July and August 1976 and from June to September 1977. A. atrocephalum showed a second peak of abundance in jar pitfalls around March - May in Collier's Wood. At the other study sites, and in the square pitfall traps in Collier's Wood, isolated individuals occurred from November to March and were completely absent from July to October.

A. unicolor has been observed in pitfall traps in Cheshire (Evans, 1969, 1971) and in Stirlingshire (Kasule, 1968). In these studies its periods of activity were similar to those found in the present study, which is explained by the fact that this species is an autumn and winter breeder, which spends the summer aestivating in leaf litter (Kasule, *loc. cit.*).

The six species of *Omalium* encountered in the Charnwood Lodge study area showed a distinct preference for woodland habitats. Five species, namely *O. caesum*, *O. excavatum*, *O. italicum*, *O. oxyacanthae* and *O. rugatum* occurred in jar pitfalls in Collier's Wood. *O. caesum* and *O. italicum* were the most abundant species of *Omalium* in pitfall traps in Collier's Wood, and isolated individuals of these species occurred at Timberwood Plantation and Flat Hill. *O. italicum* was active from October to May, showing peaks of activity in October and November, the activity decreasing during the spring and summer months (Table 4.11). The occurrence of *O. italicum* in the square pitfall traps followed a similar pattern, especially in SP2, where the maximum number of individuals was trapped in January and February 1977, and captures decreased in the summer.

A maximum of 7 individuals of *O. caesum* were trapped in Collier's Wood, in October 1977. Individuals of this species were more commonly trapped in 1977 than in 1976, mainly from June to November.

Of the three species of *Othius* represented in the present study, namely *O. angustus*, *O. myrmecophilus* and *O. punctulatus*, only the last showed a definite preference for woodland habitats, occurring most frequently in Collier's Wood and in the oak wood in Martinshaw Wood. Although relatively few individuals of this species were recorded for each trapping period, distinct variations in its abundance were seen, most individuals being trapped during November to June, with a decrease from July to October.

Similar variations in the abundance of this species were observed by Van der Drift (1959), Evans (1969) and Kasule (1970) who concluded that _O. punctulatus_ is active throughout the year, producing eggs from autumn to midsummer, which appear as a new generation between the end of summer and the end of autumn.

Although five members of the Tachyporinae showed preferences for woodland habitats in the present study, only _Tachinus signatus_ occurred in sufficient numbers to show distinct seasonal variations in abundance (Table 4.11), with a peak of activity around June - July and absence from pitfall traps from December to March, a pattern similar to that observed by Kasule (1968) and Evans (1969, 1971). This is consistent with its life history, _T. signatus_ being a spring and summer breeder with summer larvae which hibernate as adults with immature gonads during the winter (Kasule, 1968).

Of the Aleocharinae, only _Autalia impressa_, _Ocalea badia_ and _Oxypoda lividipennis_ showed distinct woodland preferences. _A. impressa_ occurred only in Martinshaw Wood, while the latter two species occurred in both study areas, though both were more common in Charnwood Lodge than in Martinshaw Wood. At both the oak and pine sites in Martinshaw Wood, _A. impressa_ was active from October to February, with a peak of activity in October, after which its activity decreased, so that from February to August it was almost completely absent from pitfall traps (Table 4.11).

Variations in the occurrence of _O. badia_ and _O. lividipennis_ at Collier's Wood were strikingly similar (Table 4.11) with both species active from October to March with activity peaks around November - December and less frequently encountered in pitfall traps from April to August, 4.4.3. Open Habitat Species

Species which showed a preference for open habitats included Stenus impressus, Xantholinus gallicus, X. linearis, X. longiventris, Philonthus cognatus, Staphylinus aeneocephalus, Quedius curtipennis, Q. molochinus, Mycetoporus rufescens, Bolitobius analis, B. cingulatus, Sepedophilus marshami, S. nigripennis, Dinaraea angustula and Drusilla canaliculata. Of these, only X. linearis, P. cognatus, S. nigripennis and D. canaliculata occurred in sufficient numbers to show distinct temporal variations in abundance.

Stenus impressus was trapped at irregular intervals throughout this study on Flat Hill and Timberwood Hill, and the maximum number of individuals trapped over any one sampling period was five. Possibly this species evaded capture by clinging to the edge of pitfall traps, or by sight (Kasule, 1968). The preference of the Steninae for more open habitats instead of woodlands is recorded by Tottenham (1954) and Nield (1974) among others. By dissecting females and from observations on the occurrence of larvae in the field, Kasule (loc. cit.) suggested that this species is a late summer and autumn breeder, with autumn and winter larvae. The results of pitfall trapping in this study, though sporadic, seem to confirm this, more adults being trapped from April to October than during the rest of the year.

In this study, three species of Xantholinus were encountered - X. gallicus, X. linearis and X. longiventris. Of these, X. linearis was most frequent, especially on Flat Hill. As in the present study, other studies indicated that the Xantholinus spp. are non-woodland species appearing commonly in woodland edge habitats (Nield, 1974), in cultivated (Obrtel, 1968; Potts and Vickerman, 1974; Jones, 1976) or in uncultivated (Boyd, 1960) fields. On Flat Hill, X. linearis adults were most active from November to April with a peak of number of occurrences in December. Their activity decreased from May to October (Table 4.12). Similar seasonal variations in abundance have also been observed by Van der Drift (1959) and Evans (1969), although Van der Drift (loc. cit.) reported a later peak of activity, around March - May, associated with breeding in this species, which has summer larvae.

In the present study, P. cognatus showed a distinct preference for open habitats, although this species was encountered over a very limited period. On Flat Hill, a maximum of 37 individuals, representing 44.6% of the total staphylinid catch, were caught in May 1977 (Table 4.12). At Timberwood Hill and Collier's Wood, and in Martinshaw Wood, this species also occurred in pitfall traps around April to June, and it was almost completely absent at all other seasons. Edwards, Butler and Lofty (1975), however, reported the presence of P. cognatus in traps set in grassland throughout the year, with peaks of abundance around May and August.

Although a maximum of only 6 individuals of S. nigripennis were trapped during any one sampling period, this species showed distinct seasonal variations in activity and abundance at Flat Hill (Table 4.12), being trapped from March to November with a peak of activity in July. This species possibly hibernates during the winter, since an individual has been obtained by heat extraction during the winter.

Of the Aleocharinae, only D. canaliculata showed a preference for open habitats, similar to that recorded by Horion (1967) and Obrtel (1968). At the Charnwood Lodge sites, D. canaliculata appeared to be active from May to October with a peak of activity around July (Table 4.12). At the grass and bracken sites in Martinshaw Wood, peak numbers occurred around August - September but information from these sites is necessarily limited because of the short study periods involved. In lucerne fields in Czechoslovakia, Obrtel (loc. cit.) has observed D. canaliculata in pitfall

Table 4.12 Variations in the abundance of open site staphylinids in jar pitfalls in Charnwood Lodge and Martinshaw Wood.

Species and Site	1975 N	D	1976 J	F	M	A	M	J	J	A	S	O	N	D	1977 J	F	M	A	M	J	J	A	S	O	N	Species Totals
Xantholinus linearis (Flat Hill)	1	12	11	2	5	2	2	2	1	0	0	0	7	10	2	8	3	4	1	1	0	1	0	1		76
Philonthus cornatus (Flat Hill)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	37	5	0	0	1	0		45
Sepedophilus nigripennis (Flat Hill)	1	0	0	0	2	5	1	4	5	0	3	0	2	0	0	0	0	3	0	4	6	2	1	3		42
Drusilla canaliculata (Flat Hill)	0	0	0	0	0	1	0	0	12	9	4	0	0	0	0	0	0	0	2	3	11	6	3	4		55
Timberwood Hill	1	0	0	0	0	0	0	1	11	8	1	0	0	0	0	0	0	0	2	1	32	5	6	2		70
Martinshaw Grass										13	16	2	0	0	0	0	0	0	0	0	0	0	0	0	0	31
Martinshaw Bracken										16	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23

traps from April to October, with peaks of abundance around May and August - September.

4.4.4. Ubiquitous Species

The Staphylinidae which are considered to be 'ubiquitous' in the present study, i.e. occurring in both open and woodland habitats, include Olophrum piceum, Othius myrmecophilus, Philonthus decorus, Quedius nigriceps, Tachyporus chrysomelinus, T. hypnorum, and T. nitidulus.

The widespread distribution of O. piceum, in both open and woodland habitats was also reported by Nield (1974). At Flat Hill, and at Collier's Wood and Timberwood Hill, the majority of captures of O. piceum occurred during the first year of the study (Table 4.13). At all these sites, O. piceum appeared to be active only from November to May, with greatest activity in November or December, and callow individuals appearing around February/March. Although similar variations in the activity and abundance of O. piceum have been reported by Kasule (1968) and Erichson (1968), these authors recorded an additional peak of activity around March, which they attributed to the emergence of the new generation. They therefore concluded that O. piceum is an autumn and winter breeder which aestivates during the summer. The extraction of O. piceum from a soil sample taken from Collier's Wood in July, when no individuals of this species were trapped, seems to support the latter point.

Although Othius myrmecophilus was trapped at nearly all the sites, and Nield (1974) confirms its widespread distribution, relatively few individuals of this species were trapped in the present study, possibly because it is less surface active than other species, e.g. Philonthus decorus (Evans, 1969), or because its small size may enable it to evade capture (Kasule, 1970). It occurred sporadically throughout the year, except at Collier's Wood and Flat Hill where more definite seasonal variations in

Table 4.13 Variations in the abundance of ubiquitous staphylinids in jar pitfalls in Charnwood Lodge and Martinshaw Wood.

	1975		1976												1977										Species
Species and Site	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	Totals
Olophrum piceum (Flat Hill)	20	2	0	0	2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		28
Philonthus decorus (Collier's Wood)	0	0	0	0	0	0	10	7	3	2	8	2	0	0	0	0	0	0	5	8	5	2	4	5		61
Quedius nigriceps (Martinshaw Oak)										0	0	18	5	0	0	0	0	0	0	0	0	0	1	2	0	16
(Martinshaw Pine)										0	0	17	7	0	1	0	0	0	0	0	0	0	0	0	0	25
Tachyporus chrysomelinus (Flat Hill)	3	0	0	0	2	1	8	6	2	6	12	6	12	3	0	0	3	16	15	0	2	6	10	3		116
Timberwood Hill	1	0	0	1	2	8	18	1	2	21	1	14	27	3	0	2	3	71	140	4	1	0	0	3		323
Martinshaw Grass										17	6	1	0	2	0	0	0	0	0	0	0	0	0	0	0	26
Martinshaw Bracken										5	1	5	10	6	1	0	0	0	0	0	0	0	0	0	0	28

Table 4.13 (cont'd)

Species and Sites	1975 N	D	1976 J	F	M	A	M	J	J	A	S	O	N	D	1977 J	F	M	A	M	J	J	A	S	O	N	Species Totals
<u>Tachyporus</u> <u>hypnorum</u>																										
(Collier's Wood)	0	0	1	0	0	0	1	0	0	10	0	0	2	0	0	0	4	3	4	0	0	0	3	1		29
Flat Hill	0	1	0	2	1	5	0	2	1	18	2	8	42	52	20	36	51	53	24	5	1	6	27	26		383
Stream	0	0	1	1	1	1	0	0	0	3	0	0	4	5	1	4	4	20	4	0	0	0	0	0		49
Timberwood Hill	2	1	1	1	4	4	4	0	0	23	2	7	91	24	20	35	41	158	77	3	1	0	17	12		528
Martinshaw Grass										26	0	2	8	11	3	6	0	0	0	0	0	0	0	0	0	56
Martinshaw Bracken										10	0	0	8	23	2	5	7	0	0	0	0	0	0	0	0	55

activity were observed. At these sites, O. myrmecophilus appeared to be active throughout the year, but slightly more active from November to May than during the rest of the year. Similar activity periods were observed by Evans (1969) and Kasule (1970), consistent with the fact that O. myrmecophilus breeds throughout the year, mainly in autumn and spring (Kasule, loc. cit.).

In the present study, Philonthus decorus was trapped in both woodland and open sites, but was slightly more frequent and abundant in Collier's Wood than on Flat Hill. The widespread distribution of P. decorus has been reported by Nield (1974), while Evans (1971) considers that this species is probably characteristic of woodland edge habitats. In Collier's Wood, P. decorus was not recorded from pitfall traps from November to April. Peak numbers occurred in May/June, followed by a slight decrease in numbers and a second peak of activity around September/October (Table 4.13). Similar variations in numbers of P. decorus were seen on Flat Hill, although at this site, its occurrence was more sporadic. These variations in activity were remarkably similar to those observed by Frank (1967), Kasule (1967) and Kowalski (1976). Van der Drift (1959) and Evans (1969, 1971) have also observed similar patterns of activity, although in their studies, the second peak of activity appeared slightly earlier, around June/July. P. decorus is a spring and summer breeder, with summer larvae, the first peak of activity being associated with breeding, and the second with the emergence of the new generation and prehibernation feeding (Kasule, 1967).

Q. nigriceps occurred in both study areas, but was more abundant in Martinshaw Wood than in Charnwood Lodge, where its occurrence was sporadic. At the oak and pine sites in Martinshaw Wood, adults of Q. nigriceps were active only from September to January, with peak numbers occurring in October (Table 4.13).

The Tachyporinae are widely distributed, Tachinus and Tachyporus spp. being found in most situations (Nield, 1974). In the present study, three species of Tachyporus, namely T. chrysomelinus, T. hypnorum and T. nitidulus appeared to be 'ubiquitous' in habitat, occurring in all study sites, especially the more 'open' sites. Horion (1967) confirms the ubiquitous habits of these species, which are also common in cereal ecosystems (Potts and Vickerman, 1974; Speight and Lawton, 1976) and in ungrazed (Edwards, Butler and Lofty, 1975) and grazed grasslands (Boyd, 1960), where conditions are more extreme.

T. chrysomelinus was common in pitfalls at all study sites in both study areas, especially at Timberwood Hill. At Flat Hill, Timberwood Hill and the grass and bracken sites in Martinshaw Wood, and at other sites in the study areas, T. chrysomelinus was trapped throughout the year especially from April to November, at the Charnwood Lodge sites, and from August to December at the Martinshaw Wood sites (Table 4.13). Seasonal variations in the activity of this species were most clear cut at Flat Hill and Timberwood Hill, peaks of activity occurring around April/May and again in September. Similar variations in activity were noted by Horion (1967).

As with T. chrysomelinus, T. hypnorum occurred at all the study sites at various times throughout the year. Although periods of activity at the different sites were rather variable, peaks of activity occurred around April/May, and again around August/September (Table 4.13). Boyd (1960) found similar patterns of activity in T. chrysomelinus and T. hypnorum, taken as a group, while Horion (1967) confirms the year round activity of this species.

Although T. nitidulus occurred at all the study sites except the stream site and the grass site at Martinshaw Wood, it was far less abundant than T. chrysomelinus and T. hypnorum and in both study areas, it occurred sporadically through the year. This all year occurrence of T. nitidulus is also noted by Horion (1967).

4.4.5 Groupings by Size and Food Preferences

Since activity peaks in the Staphylinidae usually represent feeding and breeding activity (Kasule, 1968; Evans, 1969), within any particular habitat, it would be expected that for optimal allocation or utilisation of the resources available, peaks of activity and abundance of the various staphylinid species, especially those of similar size and feeding habits, would be staggered throughout the year so that interspecific competition would be minimised. The major staphylinid species encountered in the present study are therefore grouped according to their preferences for woodland or open habitats. Ubiquitous species are classified under both woodland or open site categories, except when species show very distinct peaks of abundance in one habitat and their occurrence is indistinct or sporadic in the other habitat, in which case they are only considered under the former habitat. Thus, O. piceum, T. hypnorum and T. chrysomelinus are designated open site species, P. decorus and Q. nigriceps are grouped together with the woodland staphylinids, and O. myrmecophilus is considered under both categories. The staphylinid species within each of these categories are further subdivided on the basis of size, since size may be related to feeding habits. Group I contains species <5 mm long, Group II contains species between 5 - 10 mm in length, and Group III contains species which exceed 10 mm in length. Within each size grouping species are then arranged according to their peak activity periods. The categorisation of the major staphylinid species with respect to habitat preference, size and periods of activity are represented diagrammatically in Figs. 4.1 and 4.2. Within each habitat type, peaks of activity of the various species within a size group tend not to overlap and even though the majority of the smallest woodland species tend to be trapped in the autumn and winter

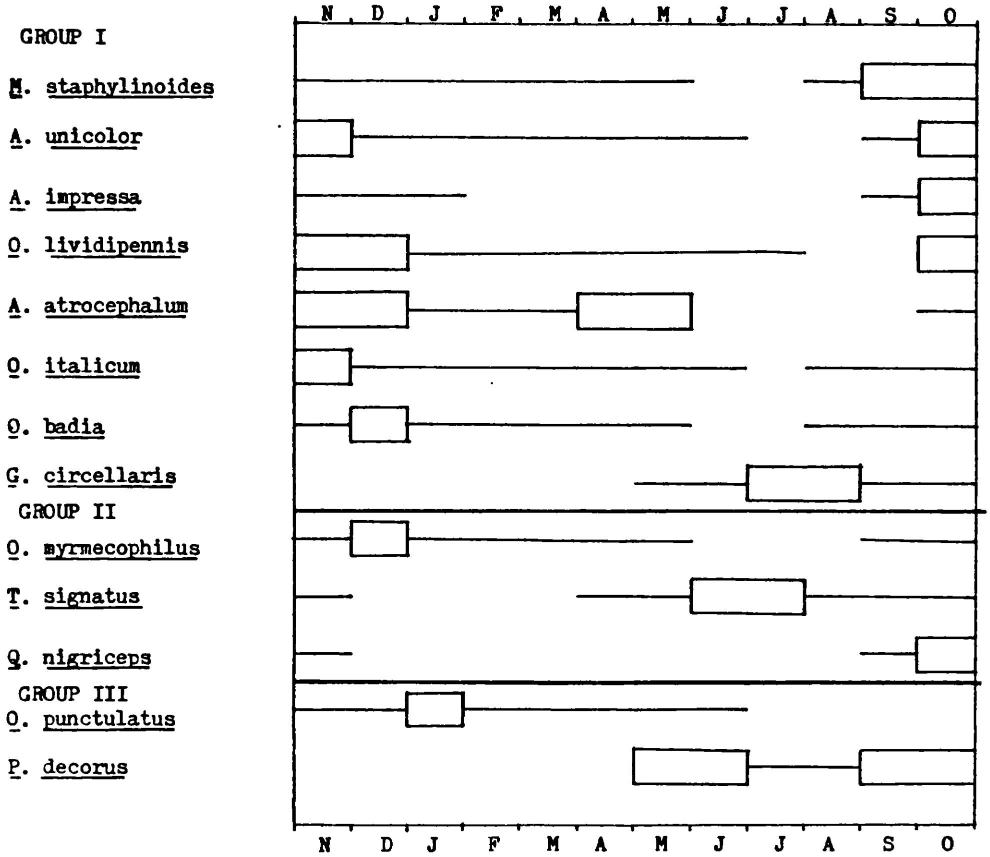


Fig. 4.1 Seasonal variations in the abundance of the commoner Staphylinidae trapped in pitfalls in woodland habitats in the Charnwood Forest Area.

Horizontal lines represent periods when species are present in pitfall traps. Blocks represent periods of maximum captures.

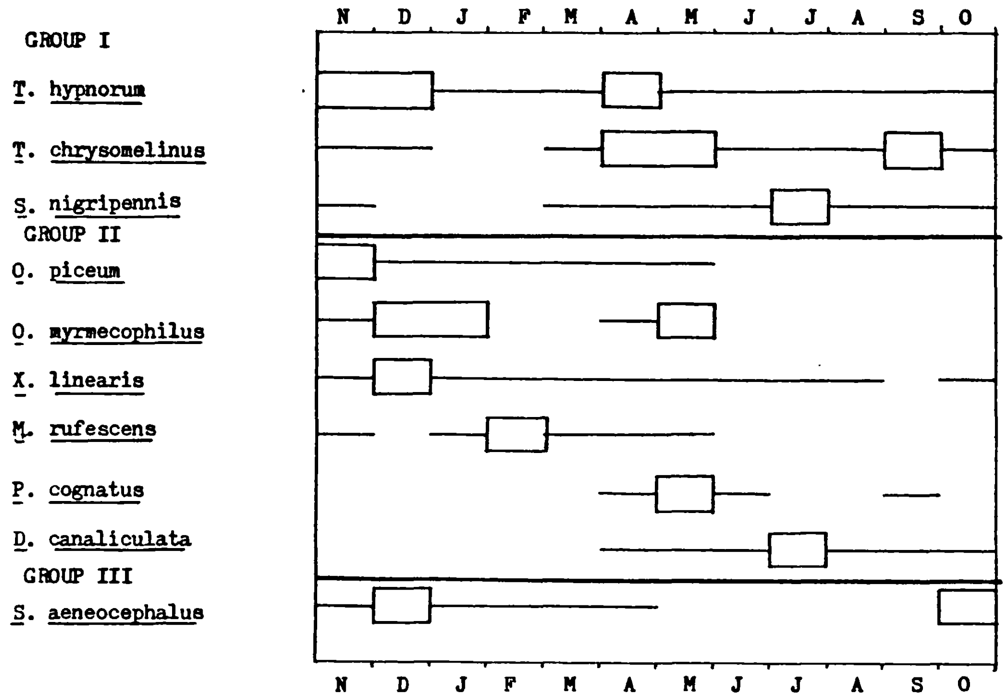


Fig. 4.2 Seasonal variations in the abundance of the commoner Staphylinidae trapped in pitfalls in open habitats in the Charnwood Forest Area.

Horizontal lines represent periods when species are present in pitfall traps. Blocks represent periods of maximum captures.

months, the peak activity periods of any one species in this group never exactly overlaps that of another.

Since many staphylinids tend to be fluid feeders which partially digest their food externally (Evans, 1964, 1967; Nield, 1976), gut content analysis and microscopical examination of their droppings are of little value in determining the food eaten by the various staphylinid species. Direct observations in the field, as well as food preference tests in laboratory cultures provide some information on the feeding habits of the Staphylinidae.

Most of the staphylinids observed in laboratory cultures appeared to accept all the different types of food offered - Drosophila larvae, Drosophila pupae, Tribolium larvae, Collembola, woodlice, pieces of earthworm, beef and yeast - except for Oxytelus species which did not accept Drosophila larvae and pupae.

Since the number of live staphylinids in culture were insufficient for exhaustive food preference tests, information on the feeding habits and food preferences of the major staphylinid species shown in Figs. 4.1 and 4.2 was obtained from the work of other authors wherever possible. Many woodland staphylinids, e.g. T. signatus, P. decorus, S. aeneocephalus, O. punctulatus, O. myrmecophilus, X. linearis, A. unicolor and members of the Aleocharinae are active predators of smaller arthropods e.g. Collembola, mites, adults and larvae of small Diptera and Coleoptera, spiders and woodlice (Evans, 1967, 1969). Adult P. decorus prey on the pupae of the winter moth, Operophtera brumata, while their larvae are general feeders, feeding on dipteran and lepidopteran larvae and on small pieces of meat (Frank, 1967). Adult T. hypnorum have been shown to feed on Sminthurus viridis (Collembola) in the laboratory (Potts and Vickerman, 1974), while in agricultural ecosystems, Tachyporus spp. prey on eggs of Leptohylemyia

(= Delia) coarctata (Fall.) (Diptera, Anthomyiidae) (Dobson, 1961) and Oscinella frit L. (Diptera, Chloropidae) (Jones, 1969). T. hypnorum and Philonthus spp. such as P. cognatus will prey on Erioischia brassicae (Bouché) (Diptera, Anthomyiidae) (Wishart, Doane and Maybee, 1956; Coaker and Williams, 1963), while T. chrysomelinus and T. signatus prey on Pemphigus bursarius (L.) (Hemiptera, Aphididae) (Dunn, 1960) and T. hypnorum on Chaetosiphon fragaefolii (Cock.) (Hemiptera, Aphididae) (Dicker, 1944). Fox and Maclellan (1956) have shown by the precipitin test that species of Philonthus, Tachyporus and Staphylinus feed on the larva of Agriotes sputator (L.) (Coleoptera, Elateridae).

The Staphylinidae are thus mainly predatory, accepting a wide range of live prey. They are also scavengers, feeding on dead or injured small arthropods as well as on meat offered in food preference tests. Since the Staphylinidae are such generalised feeders, the separation of the activity peaks of different species would not be as critical as the chronological separation of activity peaks of two closely related species, both highly specific in their food requirements.

Although the generalised feeding habits of the Staphylinidae may to some extent, explain the partial overlapping of the peak activity periods of the smaller woodland species during the autumn and winter months, a further reduction in interspecific competition may be achieved if different species are active at different times of the day or night. Laboratory observations on the diurnal activity of the Staphylinidae were limited by the small number of staphylinids in culture. However, Philonthus spp., Xantholinus linearis, Tachyporus chrysomelinus, T. hypnorum, Tachinus spp., and Oxypoda lividipennis were observed to be day-active species, and of these, the *Philonthus* spp., and *Tachinus* spp. appeared to be more active during the morning. Further studies on the diurnal activity patterns of the various species should show whether these activity patterns contribute to a reduction in interspecific competition which may further explain the lack of a distinct chronological separation of peak numbers of the smaller woodland species.

Examination of the mean:variance ratios of the pitfall trap captures of the various staphylinid species, calculated by subroutine MEANVAR of program STAPHS, shows that in the majority of the species, the mean < variance, indicating that these species tend to be aggregated. A χ^2 test shows that captures of *Micropeplus staphylinoides*, *Olophrum piceum*, *Omalium italicum*, *Philonthus cognatus*, *Tachyporus chrysomelinus*, *T. hypnorum*, *Tachinus signatus*, *Ocalea badia*, *Drusilla canaliculata*, and *Oxypoda lividipennis* were significantly aggregated ($P < 0.05$).

Only *X. linearis* showed a mean: variance ratio of >1, on two out of the three sampling periods that >10 individuals of this species appeared in pitfalls on Flat Hill, suggesting that captures of this species may be randomly distributed. Because of the generalised feeding habits of the Staphylinidae, this tendency of the various individual species towards aggregation is less likely to be due to food availability than to other factors of the habitat or microhabitat of the various species, e.g. shelter and microclimate. An investigation into these factors of the habitat or microhabitat would therefore be worthwhile.

5. THE STAPHYLINIDAE - SAMPLE DESCRIPTION

5.1 Introduction

The seasonal variations in abundance and the habitat preferences of the species occurring at the different sites have been discussed in Chapter 4. In this chapter, habitat differences and temporal variations in abundance are examined further by describing whole samples in terms of their overall staphylinid composition.

The number of individuals of each species occurring in all pitfalls at a site (held in files NAMES and DATAMS) was summed to give monthly (i.e. trapping period) totals using program MATRIX (subroutine MTOT) (Program 2 in Appendix II). The resulting totals were further summed to give three-monthly, six-monthly and yearly species totals for each site using subroutines QTOT, HYTOT and YTOT respectively (Table 5.1).

In Martinshaw Wood, the grass, bracken, oak and pine sites were sampled for 7, 8, 16 and 16 months respectively. Hence, two quarterly totals and one half-yearly total were calculated for the grass and bracken sites while four quarterly and two half-yearly totals were calculated for each of the oak and pine sites using the first 12 monthly totals.

5.2 Sample Description

The diversity of a community or biological collection is an intrinsic property of the community or collection which takes into account the number of species present in the collection and either includes a measure of the relative abundances of the constituent species, as in H', or assumes that the relative species abundances conform to a standard distribution such as the log series.

The simplest measure of species diversity is the number of species present in each sample (MacArthur, 1965; Pielou, 1967; Peet, 1974).

Table 5.1 Main Features of Matrices Resulting from Program MATRIX

Study Area	Groupings	Study Sites	No. of species	No. of samples	Dimension of Matrix
Charnwood Lodge Nature Reserve	Monthly totals (MTOT)	Collier's Wood(CF)	87	24	87 x 24
		Flat Hill (FH)	87	24	87 x 24
		Stream (ST)	87	24	87 x 24
		Timberwood Hill (TH)	87	24	87 x 24
		Timberwood Plantation (TP)	87	24	87 x 24
	Quarterly totals (QTOT)	All (CF - TP)	87	40 (8 x 5)[1]	87 x 40
	Half yearly totals (HYTOT)	All (CF - TP)	87	20 (4 x 5)[1]	87 x 20
	Annual totals (YTOT)	All (CF - TP)	87	10 (2 x 5)[1]	87 x 10
Martinshaw Wood	Monthly totals (MTOT)	Grass (MG)	38	7	38 x 7
		Bracken (MB)	38	8	38 x 8
		Oak wood (MQ)	38	16	38 x 16
		Pine wood (MP)	38	16	38 x 16
	Quarterly totals (QTOT)	All (MG - MP)	38	12 (2x2+4x2)[2]	38 x 12
	Half yearly totals (HYTOT)	All (MG - MP)	38	6 (1x2+2x2)[2]	38 x 6
Charnwood Lodge + Martinshaw Wood	(QTOT)	All	91	52 (40+12)[3]	91 x 52

[1] Data for all 5 sites held sequentially in a single matrix
[2] Data for all 4 sites held sequentially in a single matrix
[3] Data used only for sample comparison (see Chapter 6)

Species number is, however, a biased measure of diversity since it does not take into account species abundances and is dependent on sample size (Pielou, 1975).

To overcome these drawbacks, two different types of diversity indices have been developed, namely indices derived from theoretical distributions and indices which purely summarise the data without assuming any underlying distribution. The former indices include the parameters α of the log series (Fisher, Corbet and Williams, 1943) and s^* of the truncated discrete log-normal distribution (Preston, 1948). There are three basic indices which are free of assumptions about relative abundance, which summarise species richness and species abundances in samples.

i) The information indices (Margalef, 1958), in which the information content of a community or sample is used as a measure of 'uncertainty' or entropy within the sample.

ii) Simpson's Index of Diversity, λ (Simpson, 1949), which is based on the probability that two individuals selected at random and independently from a population will belong to the same species, and

iii) McIntosh's Index of Diversity, I (1967), in which a sample is conceived as being a point in multidimensional space. The coordinates of this point are specified by the number of individuals of each species present in the sample, the assumption being that these species axes are orthogonal.

Since, in the present study, the form of the underlying species-abundance relationships is unknown, non-distributional indices were selected for describing the samples, even though no tests of their validity are available. Two contrasting measures of diversity were selected, namely, an Information Index, H', and the modified Simpson's Index, $\tilde{D}$. McIntosh's Index, I, was rejected since it assumes orthogonality of species axes. Further, there are similarities between I and $\tilde{D}$ as

I is given by $1 - \left(\Sigma \left(\frac{n_i}{N} \right)^2 \right)^{\frac{1}{2}}$, while $\tilde{D}$ for an infinite population, approximates to $1 - \left(\Sigma \left(\frac{n_i}{N} \right)^2 \right)$ (see 5.2.2).

5.2.1 Information Indices

The information statistic is being used increasingly as a measure of diversity (Margalef, 1958; Lloyd and Ghelardi, 1964; Pielou, 1966, 1967, 1969; Peet, 1974). The information statistic is basically a measure of 'uncertainty', such that the greater the diversity of a multi-species sample, the greater the uncertainty involved in predicting the species identity of an individual selected at random from that sample.

Two information indices of diversity are in general use, Brillouin's H (1956) and Shannon's H' (1948). Brillouin's H provides a measure of the diversity of a finite population, and is given by

$$H = \frac{1}{N} \log \left(\frac{N!}{n_1! \; n_2! \ldots n_s!} \right)$$

where $N = \sum_{i=1}^{s} n_i$,

n_i = the number of individuals of species i (i = 1, 2, ...s),

and s = the number of species.

When a population is large enough to be regarded as effectively infinite, Shannon's H' (or the Shannon-Weiner information index) is an estimate of the diversity per individual of this population. If this population contains s species in proportions p_1 , p_2 , ...p_s , then,

$$H' = - \sum_{i=1}^{s} p_i \log p_i$$

The proportions, p_i, may be estimated from a sample as

$$p_i \approx \frac{n_i}{N} ,$$

and hence,

$$H' = -\Sigma \frac{n_i}{N} \log \frac{n_i}{N}$$

$$= \log N - \frac{1}{N} \Sigma n_i \log n_i$$

Pielou (1966) considers that when a biological collection is not too large for all its members to be identified and counted, it may be regarded as a population instead of as a sample from a larger population. The diversity of this collection is given by Brillouin's formula.

In this study, although all the Staphylinidae could be identified and counted, pitfall trap catches are regarded as random samples from a larger population. H' is thus the more appropriate index to use in this study, and the following discussions will be confined to H'.

When all individuals in a sample belong to a single species, that is, $s = 1$ and $n_1 = N$,

$$H' = -\frac{N}{N} \log \frac{N}{N}$$

$$H' = 0.$$

H' could also approximate to 0 in a multi-species sample - when N is very large, and tends to ∞, and s is relatively small, and

$$n_1 = N - (s - 1),$$

$$n_2 = n_3 = n_4 \ldots\ldots\ldots\ldots n_s = 1,$$

$$H' = -\Sigma \frac{N - (s - 1)}{N} \log \frac{N - (s - 1)}{N}$$

$$H' \approx 0.$$

Hence, $\lim_{\substack{N \to \infty \\ s \to 0}} H' = 0.$

When N decreases, and s remains constant, the sample tends towards greater evenness and H' will increase.

When all the individuals are equally distributed among the various species, i.e. the distribution of individuals among the species is perfectly even,

$$n_1 = n_2 = n_3 \ldots\ldots\ldots\ldots\ldots\ldots n_s = \frac{N}{s}$$

and

$$H' = - \sum_{i=1}^{s} \frac{N}{s}.\frac{1}{N} \log \frac{N}{s}.\frac{1}{N}$$

$$= - \log \frac{1}{s}$$

$$= \log s$$

This represents the maximum diversity of the sample, $H'_{max.}$

$\therefore \; H'_{max.} = \log s.$

When the individuals are not equally distributed among the various species, the value of H' will be less than its maximum possible value, depending on the evenness of the distribution of individuals among the species.

The evenness of the sample may thus be obtained as the ratio of the observed diversity of the sample to the maximum it could have given the same number of species. Hence, the measure of evenness, J', is given by

$$J' = \frac{H'}{H'_{max}}$$

$$= \frac{H'}{\log s}$$

The value of H' is thus a function of the number of species, s, in the sample, and of the evenness of the distribution of individuals among the species, J'.

(i) When s is small and J' is low i.e. the distribution of individuals among the species is uneven, the value of H' is low.

(ii) When s is small, but J' is high, the value of H' will show an increase over (i).

(iii) When s is large, and J' is low, the value of H' will also show an increase over (i).

(iv) When s is large, and J' is high, the value of H' will show an increase over both (ii) and (iii).

5.2.2 Simpson's Index

Simpson's Index (λ) (Simpson, 1949) may be interpreted as the probability that two individuals selected at random and independently from a population will belong to the same species. λ, as originally formulated is given by,

$$\lambda = \sum_{i=1}^{s} p_i^2$$

for an infinite sample.

For a finite sample in which individuals are being drawn at random without replacement, this probability becomes

$$\ell = \sum \frac{n_i (n_i - 1)}{N (N - 1)}$$

The maximum value of ℓ is obtained when all the individuals in a sample belong to the same species,

i.e. $s = 1$ and $n_i = N$

and $\ell = 1$.

Simpson's Index, as originally formulated, is conversely proportional to diversity. Since its maximum possible value is 1, Pielou (1969) advocates the use of a modified value, $\tilde{D}$, which is a direct measure of diversity and applies to finite sample sizes.

$\tilde{D}$ is given by the formula,

$$\tilde{D} = 1 - \sum_{i=1}^{s} \frac{n_i (n_i - 1)}{N(N-1)}$$

When all the individuals in a sample belong to a single species,

i.e. $n_i = N$,

$\tilde{D} = 0.$

The maximum possible value of $\tilde{D}$ will be obtained when all the species are represented by single individuals,

i.e. $\tilde{D} = 1 - \sum \frac{1(1-1)}{N(N-1)} = 1.$

When all the species in the sample are represented by equal numbers of individuals, the diversity of that sample is maximal,

i.e. $n_1 = n_2 = n_3 = \ldots\ldots\ldots\ldots\ldots n_s = \frac{N}{s}$

$$\text{and } \tilde{D}_{max} = 1 - \frac{\sum^{s} \frac{N}{s}\left(\frac{N}{s} - 1\right)}{N(N-1)}$$

$$= 1 - \frac{\left(\frac{N}{s} - 1\right)}{N - 1} \quad .$$

A sample containing N individuals will therefore be more diverse if these individuals are distributed evenly among a greater number of species than among a smaller number of species. Conversely, in a sample containing s species, with a perfectly even distribution of individuals among the species, the value of $\tilde{D}_{max.}$ will be smaller when N is large than when N is small.

The evenness of the sample, $\tilde{J}'$, is given by the ratio of the observed diversity of the sample to the maximum it could have given the same number of species.

$$\therefore \quad \tilde{J} = \frac{\tilde{D}}{\tilde{D}_{max.}} = \frac{\tilde{D}}{1 - \frac{\left(\frac{N}{s} - 1\right)}{(N-1)}}$$

In samples with N individuals,

(i) When s is large and $\tilde{J}$ is high, $\tilde{D}$ will be high.

(ii) When s is large and $\tilde{J}$ is low, $\tilde{D}$ will be less than (i) .

(iii) When s is small and $\tilde{J}$ is high, $\tilde{D}$ will be less than (i).

(iv) When s is small and $\tilde{J}$ is low, $\tilde{D}$ will be less than (ii) and (iii).

In samples with s species,

(i) When N is small and $\tilde{J}$ is high, $\tilde{D}$ will be high.

(ii) When N is small and $\tilde{J}$ is low, $\tilde{D}$ will be less than (i).

(iii) When N is large and $\tilde{J}$ is high, $\tilde{D}$ will be less than (i).

(iv) When N is large and $\tilde{J}$ is low, $\tilde{D}$ will be less than (ii) and (iii).

A computer program, DIVSTY (Program 3 in Appendix II) was then written to calculate the Shannon-Weiner Information Index per individual (H'), as well as the modified Simpson's Index, $\tilde{D}$ for each sample, given the various matrices of abundances generated by program MATRIX.

5.3 Application of Diversity Indices to Staphylinid Data

To study the overall pattern of diversity in the Staphylinidae of Charnwood Lodge, the diversities of the different sites were compared using the annual totals for each species in each of the five sites. Similar comparisons were made between the four Martinshaw Wood sites, but using half-yearly totals for each site because annual totals were not available for the grass and bracken sites.

The diversities of the monthly samples from each of the study sites in Charnwood Lodge were then examined for evidence of temporal trends. The diversities of the amalgamated quarterly data were examined for similar trends, and compared with the mean monthly diversity values for the corresponding quarters. Following this, half-yearly and yearly diversity values were calculated from amalgamated six-monthly and yearly totals, and compared with the means for each of the lesser periods (see Fig. 5.4).

The diversities of the samples obtained from Martinshaw Wood were investigated likewise, except that no annual comparisons were made.

5.3.1 Site Comparisons of Diversity

A. Charnwood Lodge sites

The annual diversity values of the five Charnwood Lodge sites are compared in Table 5.2 and Figure 5.1. Between site differences in the values of H' and $\tilde{D}$ were not very clear cut, especially in the first year of the study . During this period the values of H' and $\tilde{D}$ showed that the stream site was most diverse, followed in order of decreasing diversity by Flat Hill, Timberwood Plantation, Collier's Wood and Timberwood Hill. In 1976/77, variations in H' and $\tilde{D}$ between sites were more marked although values were generally lower than in 1975/76. These lower values were associated with a decrease in the number of species at each of the sites. Collier's Wood appeared most diverse, with values close to those for 1975/76. It was followed in order of decreasing diversity by Timberwood Plantation, the stream site, Flat Hill and Timberwood Hill. Generally, between site variations in the values of H' and $\tilde{D}$ showed that Collier's Wood was more diverse than Timberwood Plantation in 1976/77. However, in the second year of the study, Flat Hill appeared more diverse than Timberwood Hill when H' was used as a basis for comparison (H' = 0.72 and 0.67, respectively) whereas when $\tilde{D}$ was used, Timberwood Hill appeared slightly more diverse than Flat Hill. These differences in the estimate of diversity are probably due to differences in the relative importance attached to the species abundances by H' and $\tilde{D}$.

Table 5.2 Annual Variations in the Values of N,s, H' and $\tilde{D}$ at Charnwood Lodge Sites

Site	Year 1 (1975/76)				Site	Year 2 (1976/77)			
	N	s	H'	$\tilde{D}$		N	s	H'	$\tilde{D}$
Stream	57	24	1.22	0.93	Collier's Wood	938	40	1.08	0.87
Flat Hill	282	40	1.21	0.91	Timberwood Plantation	19	8	0.78	0.84
Timberwood Plantation	103	27	1.17	0.91	Stream	89	14	0.74	0.72
Collier's Wood	1023	44	1.09	0.87	Flat Hill	601	27	0.72	0.65
Timberwood Hill	242	27	1.02	0.85	Timberwood Hill	976	26	0.67	0.68

Table 5.3 Variations in the Half-yearly Values of N, s, H' and $\tilde{D}$ at Martinshaw Wood Sites

Site	Aug. 76 - Jan. 77				Site	Feb. 77 - Jul. 77			
	N	s	H'	$\tilde{D}$		N	s	H'	$\tilde{D}$
Oak	79	19	0.96	0.84	Oak	58	15	1.03	0.89
Bracken	128	17	0.85	0.80	Pine	31	12	0.98	0.91
Pine	103	12	0.72	0.74					
Grass	124	14	0.70	0.73					

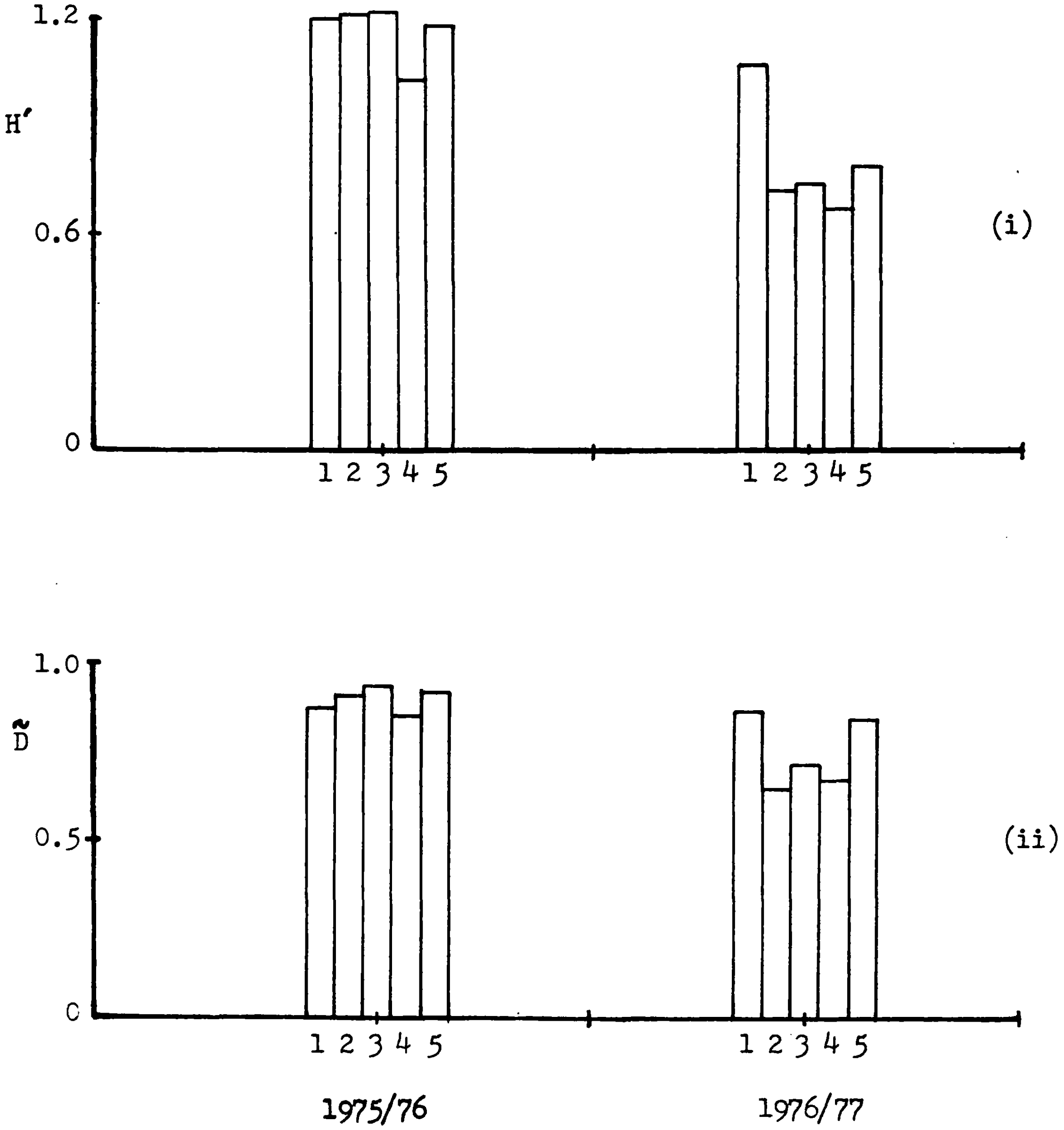


Fig. 5.1 Comparison of annual values of (i) H' and (ii) $\tilde{D}$ at the five Charnwood Lodge sites.

1 - Collier's Wood

2 - Flat Hill

3 - Stream

4 - Timberwood Hill

5 - Timberwood Plantation

B. Martinshaw Wood sites

Values of H' and $\tilde{D}$ based on half-yearly totals were used for the comparison of the four study sites in Martinshaw Wood. In the first half-year of the study (August 1976 - January 1977) both H' and $\tilde{D}$ indicated that the oak site was most diverse, followed in order of decreasing diversity by the bracken, pine and grass sites (Table 5.3 and Fig. 5.2).

In the second half-year (February 1977 - July 1977), no data were available for the grass and bracken sites and the oak and pine sites were almost equally diverse.

C. Charnwood Lodge and Martinshaw Wood sites

The diversities of half-yearly samples from Charnwood Lodge and Martinshaw Wood from 1976 and 1977 were not strictly comparable because of differences in the period of sampling in these two areas. The half-yearly totals from Charnwood Lodge thus included November '76 - April '77 samples and May - October '77 samples while those from Martinshaw Wood included August '76 - January '77 samples and February - July '77 samples. The half-yearly totals from the two study areas were thus three months out of phase. Nevertheless, comparison of the diversities of the various sites (Tables 5.3 and 5.4; Figs. 5.2 and 5.3) showed that in both Martinshaw Wood and Charnwood Lodge, the deciduous woodland sites were the most diverse sites. Collier's Wood was more diverse than the oak wood site in Martinshaw Wood. Since the individuals were more evenly distributed among the species at the Martinshaw oak site (J' = 0.75 in the first half-year and 0.88 in the second) than in Collier's Wood (J' = 0.61 and 0.76 respectively), the greater diversity of the Collier's Wood samples must be due to the greater number of species at this site. The diversities of all other Charnwood Lodge

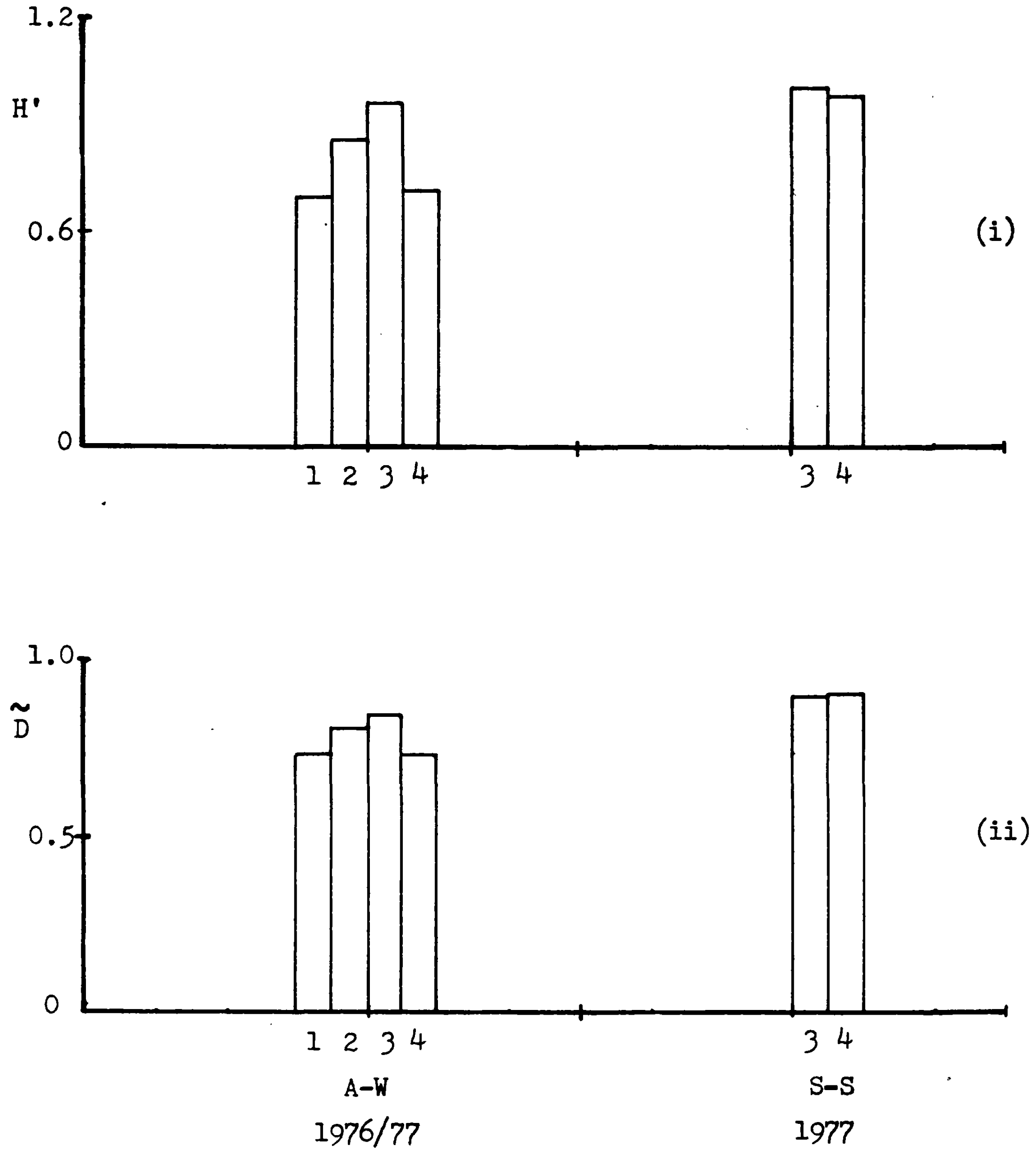


Fig. 5.2 Comparison of half-yearly values of (i) H' and (ii) $\tilde{D}$ of the four Martinshaw Wood sites.

1 - Grass site   2 - Bracken site

3 - Oak site   4 - Pine site

A-W - Autumn - winter (August - January)

S-S - Spring - summer (February - July)

Table 5.4 Variations in the Half Yearly Values of N, s, H' and $\tilde{D}$ at Charnwood Lodge Sites

Site	Nov. 76 - Apr. 1977				Site	May 1977 - Oct. 1977			
	N	s	H'	$\tilde{D}$		N	s	H'	$\tilde{D}$
Collier's Wood	558	27	0.88	0.79	Collier's Wood	380	32	1.15	0.90
Timberwood Plantation	11	5	0.59	0.76	Flat Hill	378	20	0.87	0.80
Flat Hill	353	16	0.48	0.46	Stream	33	10	0.80	0.80
Stream	56	7	0.46	0.52	Timberwood Hill	458	21	0.80	0.79
Timberwood Hill	518	12	0.40	0.45	Timberwood Plantation	8	5	0.60	0.79

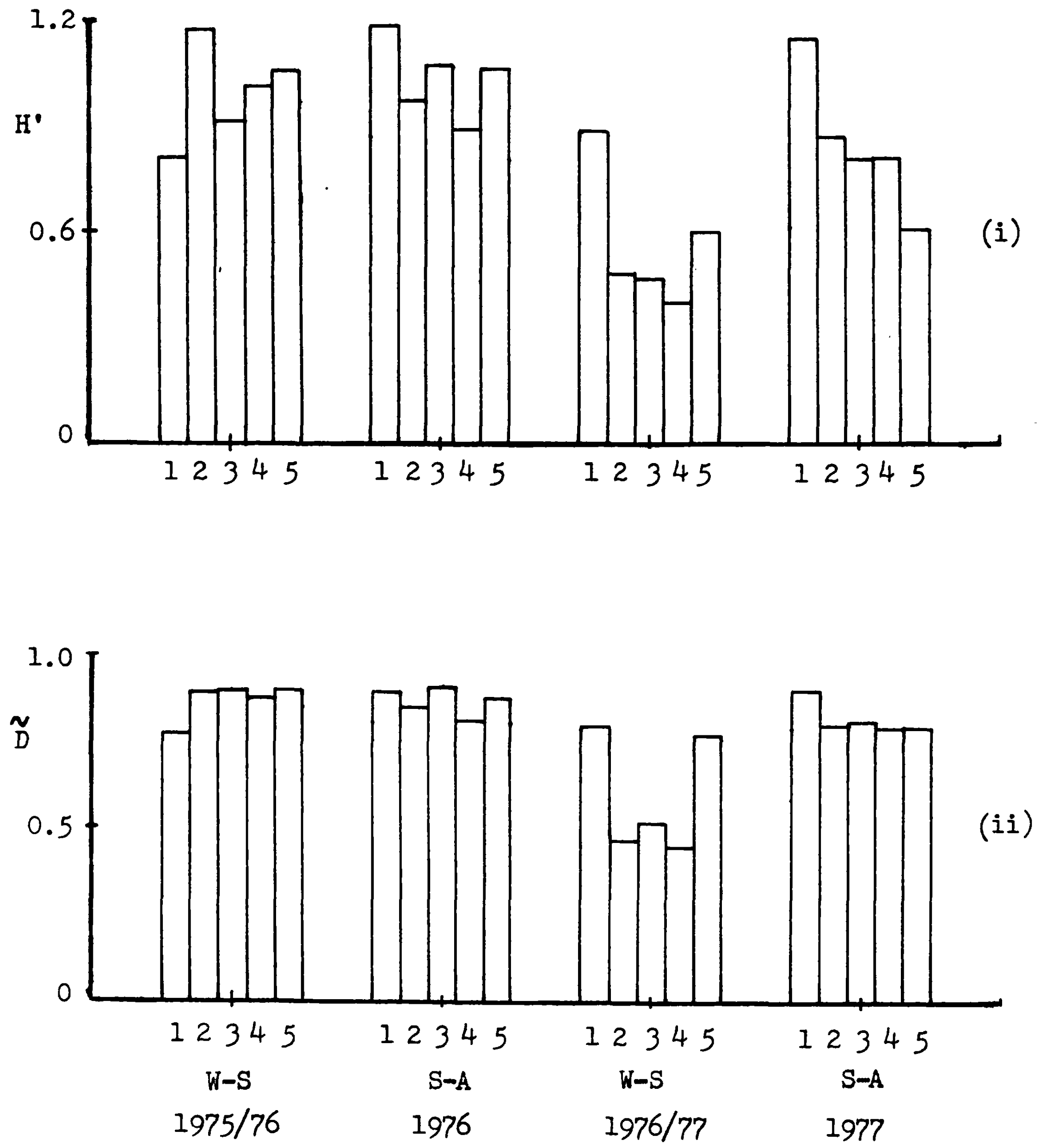


Fig. 5.3 Comparison of half-yearly values of (i) H' and (ii) $\tilde{D}$, of the five Charnwood Lodge sites.

1 - Collier's Wood
2 - Flat Hill
3 - Stream
4 - Timberwood Hill
5 - Timberwood Plantation

W-S - Winter - spring (November - April)

S-A - Summer - autumn (May - October)

sites were lower than those of the other Martinshaw Wood sites even though the Flat Hill and Timberwood Hill samples contained a greater number of species than the Martinshaw grass and bracken sites. This was because in the Flat Hill and Timberwood Hill samples, the individuals were less evenly distributed among the species (e.g. J' = 0.40 and 0.37 respectively for the November '76 to April '77 period) than in the Martinshaw grass and bracken samples (J' = 0.61 and 0.69 respectively for the corresponding period).

5.3.2 Comparison (between sampling occasions) within each site

Having determined that there were differences in the diversity of the Staphylinidae of Charnwood Lodge and of Martinshaw Wood, site by site comparisons were made to determine whether any temporal trends in diversity were apparent.

A. Charnwood Lodge sites

(i) Collier's Wood

Monthly comparisons

Values of H' in Collier's Wood samples ranged from 0.52 (April '77) to 1.07 (May '77) (Fig. 5.4.i). Although these values fluctuated throughout the study, there was a general decrease in the values of H' from November to April and one of increase from June to October. The least diverse samples were obtained in April in both years of the study, while the most diverse samples were obtained in May and August '76 and May and September '77.

In the April '76 and '77 samples, the number of species was low (8 and 12, respectively), and <u>Anthobium atrocephalum</u> was present in very large numbers, so that the evenness of the distribution of individuals among the species was low (J' = 0.66 and 0.50 respectively). This

<u>NOTE 1</u> - In Figs. 5.4 - 5.13, the months corresponding to the various quarters, half-years and years at Charnwood Lodge Nature Reserve are as shown below.

Year	Month	Quarter	Half-year	Year
1975	November			
	December			
1976	January	Winter (Win)		
	February			
	March			
	April	Spring (Sp)	Winter-spring(W-S)	
	May			
	June			
	July	Summer (Su)		
	August			
	September			
	October	Autumn (Aut)	Summer-autumn(S-A)	1975/76
	November			
	December			
1977	January	Winter (Win)		
	February			
	March			
	April	Spring (Sp)	Winter-spring(W-S)	
	May			
	June			
	July	Summer (Su)		
	August			
	September			
	October	Autumn (Aut)	Summer-autumn(S-A)	1976/77

In these figures,

——— represents actual monthly diversity values (i) or mean monthly values over corresponding quarters (ii), half-years (iii) and years (iv)

— — — represents actual quarterly diversity values (ii) or mean quarte[rly] values over corresponding half-years (iii) and years (iv)

—.—.— represents actual half-yearly diversity values (iii) or mean half-yearly values over corresponding years (iv)

.... represents actual yearly diversity values (iv)

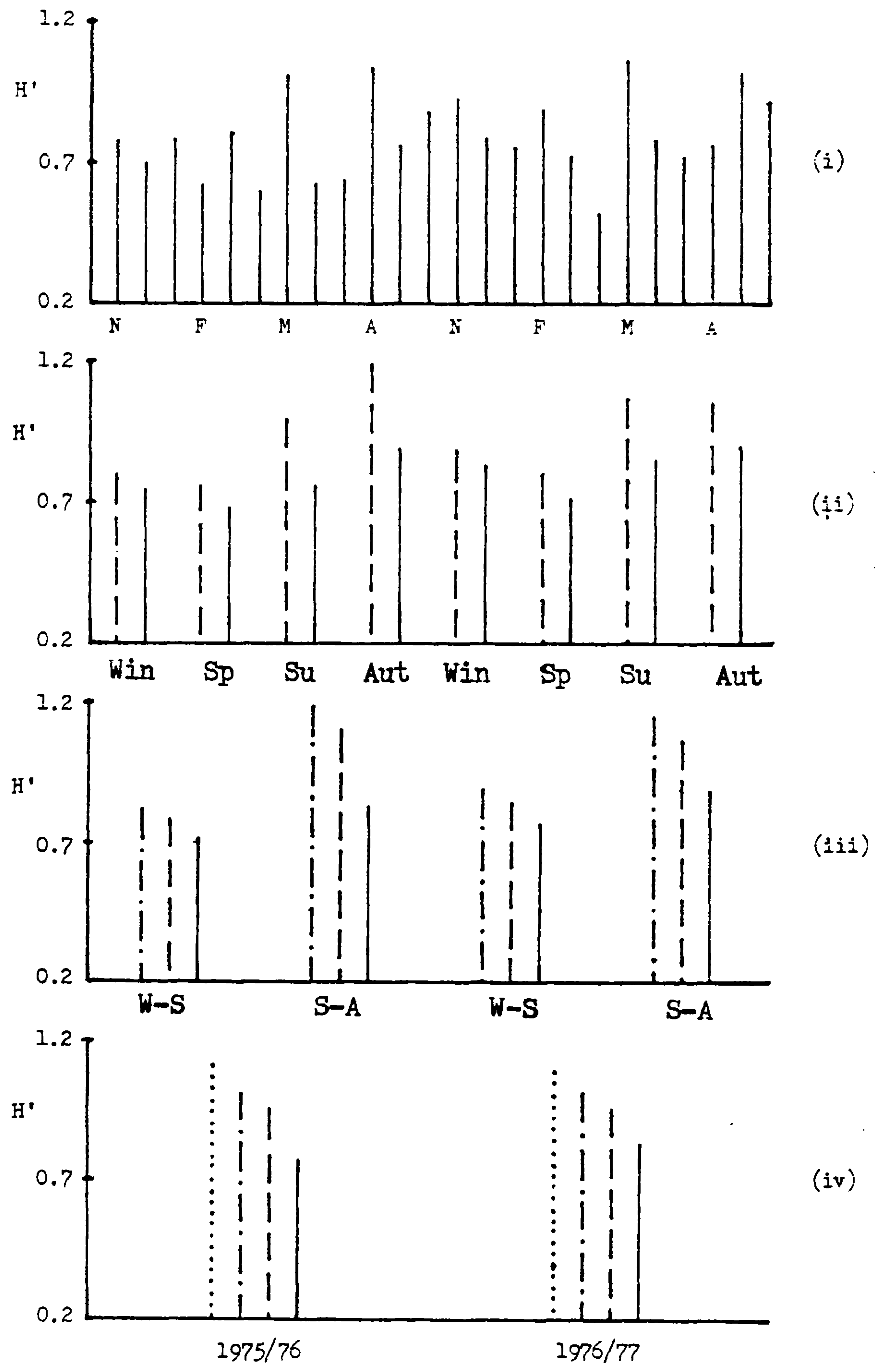


Fig. 5.4 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of H' in Collier's Wood.

unevenness, and the small number of species in the samples, resulted in low values of H'. Differences in the relative abundances of the various species were less marked in the other samples, so that H' of these samples were higher than the April values.

In the May '76 sample, a total of 18 species was recorded. This was the maximum number of species recorded in any monthly sample at Collier's Wood. The evenness of this sample was 0.80. The August '76 sample and the May and September '77 samples contained 17, 15 and 13 species respectively, and the evenness of these samples were 0.84, 0.91 and 0.91 respectively. The large number of species and the evenness with which individuals were distributed among the species in these samples thus accounted for their high values of H' and $\tilde{D}$.

Quarterly Comparisons

In both years, the diversities of the quarterly samples decreased from the first to the second quarter, and increased in the third and fourth quarters, showing trends similar to those found in the monthly samples (Fig. 5.4.ii). In all cases, quarterly diversities calculated from three monthly totals were higher than the mean monthly diversities of the corresponding three months. The differences between the former and latter values were more marked in the third and fourth quarters of each year than in the first and second, and were due to differences in the specific constitution of the various samples. 21 species were trapped in the first quarter of which nine were common to all three monthly samples, three were common to two, and nine were found in only one of the samples. The species which occurred in all three samples were also the numerically most abundant species e.g. Ocalea badia and Oxypoda lividipennis, while those which occurred in only one sample were usually represented by one or two individuals only. In the third quarter, only three species were common to May, June and July. Four species were common to two monthly samples and 20 were found in only one sample. Amalgamation of the three monthly samples to produce a quarterly total thus resulted in a much greater increase in the number of species and in the evenness of their relative abundances in the third sample than in the first. The increase in the quarterly value of H' over its monthly mean value was thus greater in the third quarter than in the first.

Half-yearly comparisons

The half-yearly values of H' reflected trends very similar to those of the quarterly values. The May - October samples of both years were more diverse than those for November - April, and half-yearly diversity values were greater than the relevant means of the monthly and quarterly values. This increase was more marked in the May - October half-year than in the November - April period, and was due to the increased occurrence of the infrequent and less abundant species in the former samples. For example, the May - October 1976 sample contained 36 species, an increase of 23 species over the mean number of species per month for the same period, while the November - April '76 sample contained 23 species, an increase of only 12 species.

The difference between the half-yearly value of H' and the corresponding quarterly means in May - October '76 was weaker than that between the relevant quarterly diversities and their corresponding monthly means. This was because amalgamation of the monthly totals to give quarterly totals resulted in a mean increase of 13 species, while amalgamation of the two quarterly totals to form a half-yearly total resulted in a smaller mean increase, of ten species.

Annual comparisons

The diversities of the annual samples were very similar

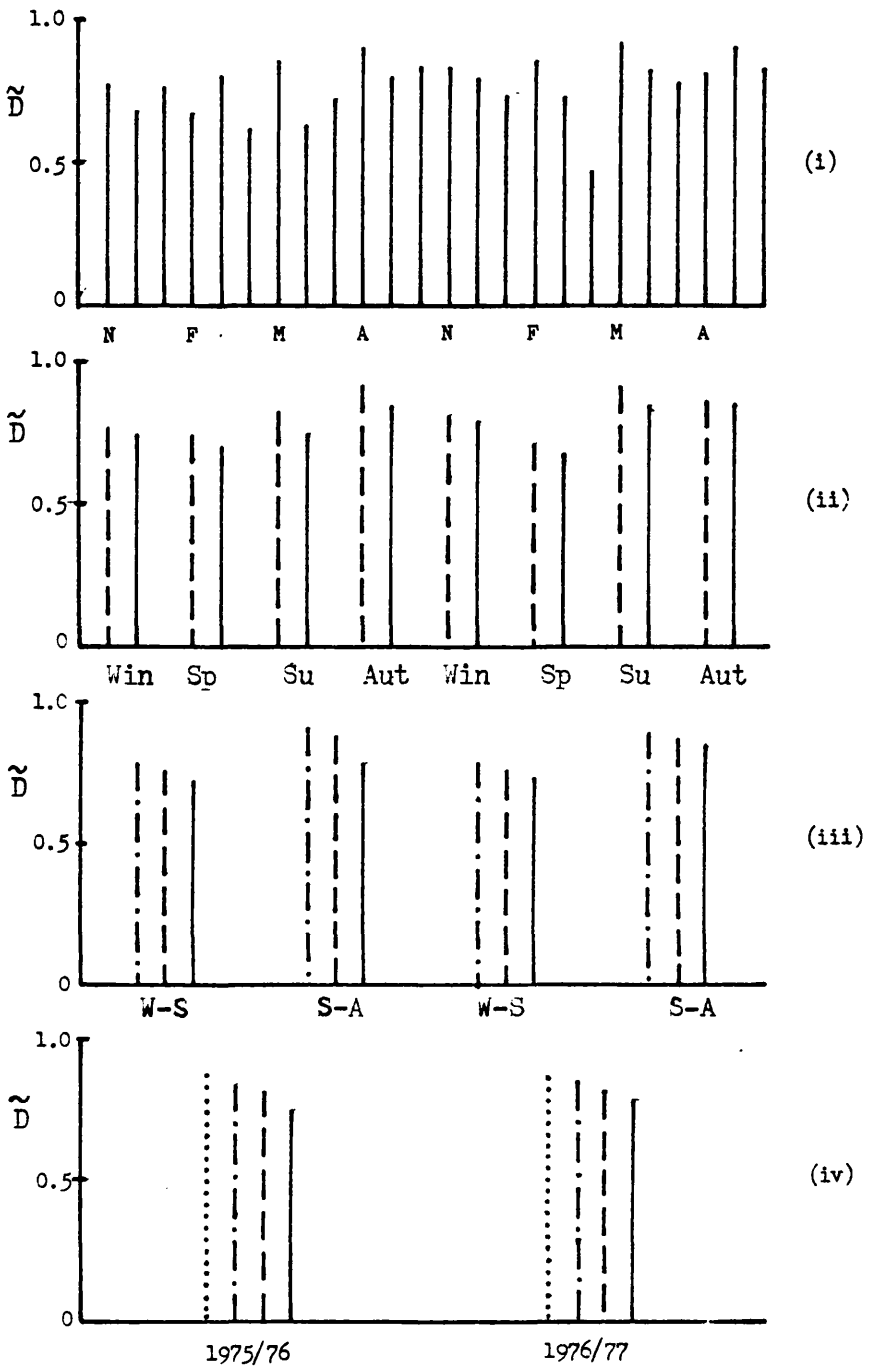


Fig. 5.5 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of $\tilde{D}$ in Collier's Wood.

(Fig. 5.4.iv). The annual diversities calculated from raw data were higher than mean annual values based on half-yearly, quarterly and monthly diversities and showed a progressive decline in that sequence.

Comparison of H' with $\tilde{D}$.

Monthly variations in the value of $\tilde{D}$ (Fig. 5.5.i) were very similar to those of H', although slightly less variable, and ranged from 0.47 - 0.92. Variations in the quarterly, half-yearly and yearly values of $\tilde{D}$ over the study period were also very similar to those of H' (Fig. 5.5.ii - iv).

Temporal variations in the two diversities of the Collier's Wood samples were very similar. They generally decreased from November to April and increased from June to October. The least diverse samples contained few species and A. atrocephalum was represented in very large numbers in these samples so that the distribution of individuals among the species was uneven. The more diverse samples contained a larger number of species with a more even distribution of individuals.

The progressive amalgamation of samples to produce quarterly, half-yearly and annual totals increased the total number of species in the resulting sample thereby increasing the diversity of the sample. The increase in the number of species became less with each successive amalgamation so that the difference between the diversity of the quarterly sample and the mean monthly diversity for the corresponding quarter was more marked than that between the diversity of the annual sample and the corresponding mean half-yearly diversity.

(ii) Other Charnwood Lodge sites

Only the monthly samples from Flat Hill showed general trends during the study (Figs 5.6.i and 5.7.i). There was an initial decrease in H' from December 1975 to February 1976, followed by a marked

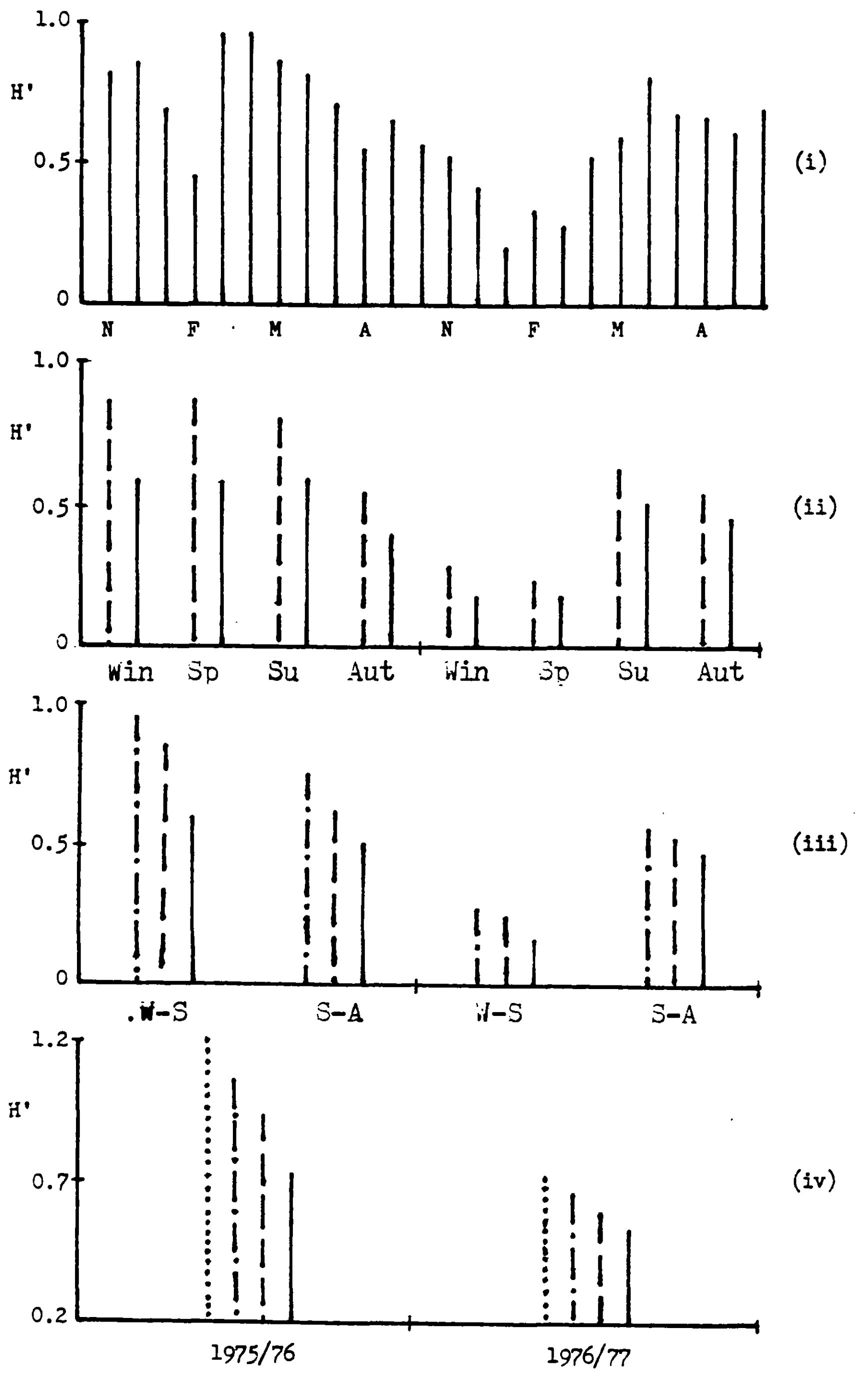


Fig. 5.6 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of H' at Flat Hill.

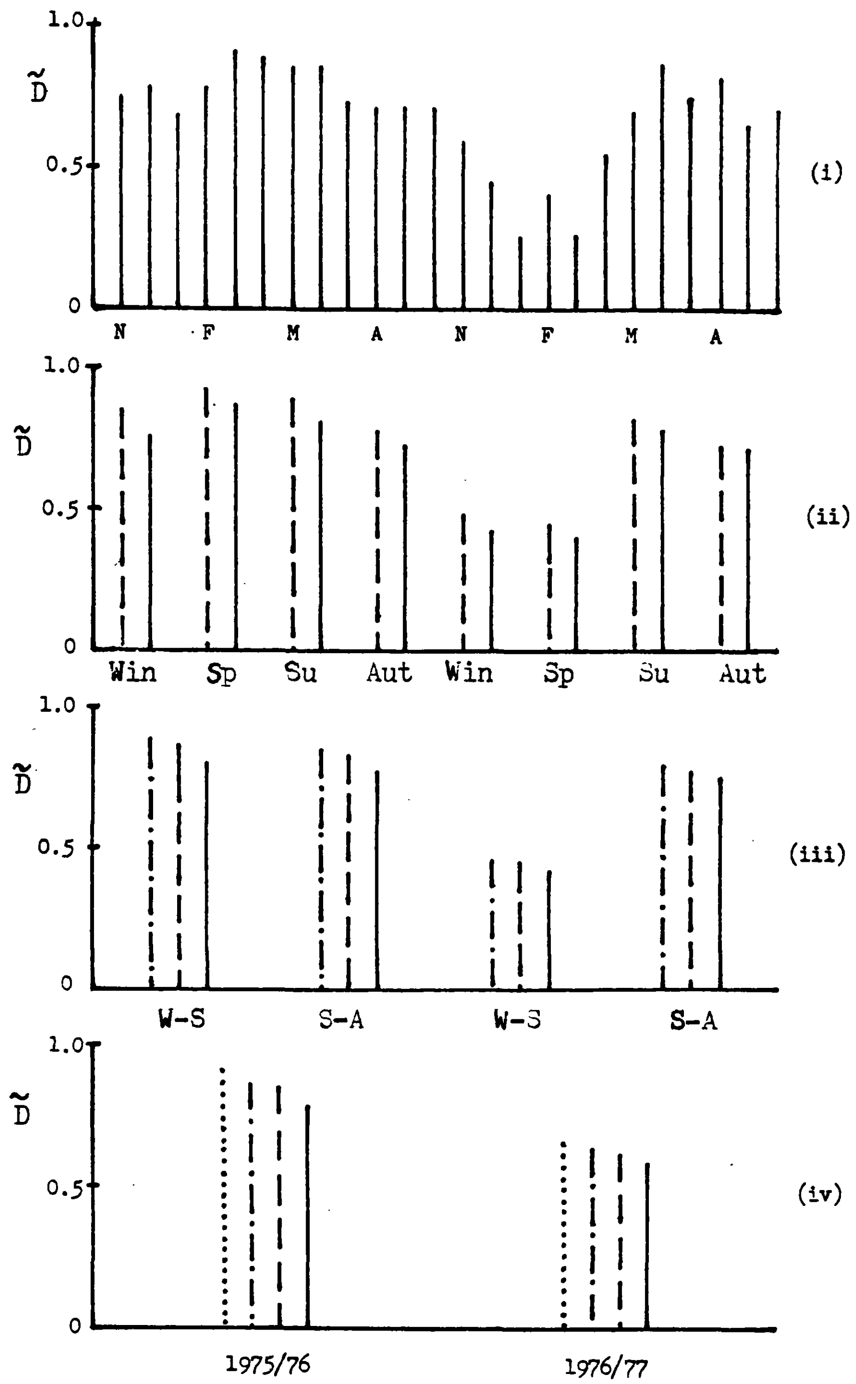


Fig. 5.7 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of $\tilde{D}$ at Flat Hill.

increase in March and April 1976. H' then steadily decreased to a minimum in January '77, after which there was a general increase to a maximum in June 1977.

At the stream site and Timberwood Hill, patterns of variation in the monthly values of H' were dissimilar in the two years of the study (Figs. 5.8.i and 5.10.i). Values of H' fluctuated throughout the study and were generally lower in the second year than in the first. These low values of H' were related to the few species found in these samples, and to the large numbers of Tachyporus hypnorum which resulted in low evenness in these samples. In Timberwood Hill, for example, minimum values of H' occurred in December '76 and January and March '77. The first two samples contained only three species, and the last five, while T. hypnorum was represented by 24, 20 and 41 individuals respectively, and all other species were represented by less than three individuals each.

Temporal variations in the quarterly and half-yearly values of H' and of $\breve{D}$ were similar at Flat Hill, the stream, and Timberwood Hill (Figs. 5.6 - 5.11). Generally, the first three, and the last two quarterly samples, and the first two, and last half-yearly samples, were more diverse than the fourth to sixth quarterly, and the third half-yearly samples, except at Timberwood Hill, where the fourth quarterly sample was more diverse than the third, mainly due to the greater evenness of species abundances in the fourth.

In the third half-yearly samples, the minimal values of H' and $\breve{D}$ were related to the small number of species in the samples, and the unevenness of their relative species abundances. Thus, the third half-yearly sample from Flat Hill contained only 16 species, as compared to 33, 20 and 20 species in the other samples, and T. hypnorum was very

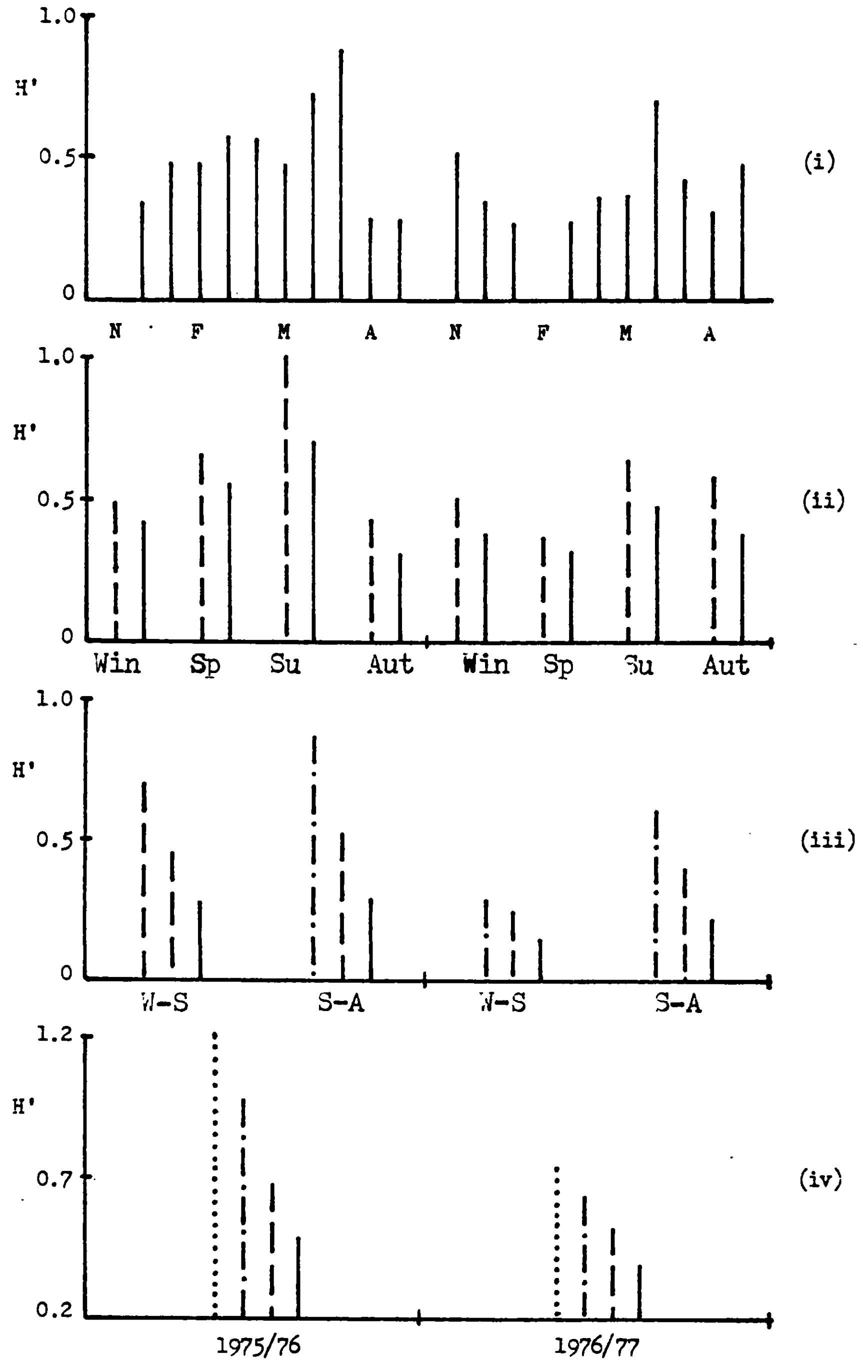


Fig. 5.8 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of H' at the stream site.

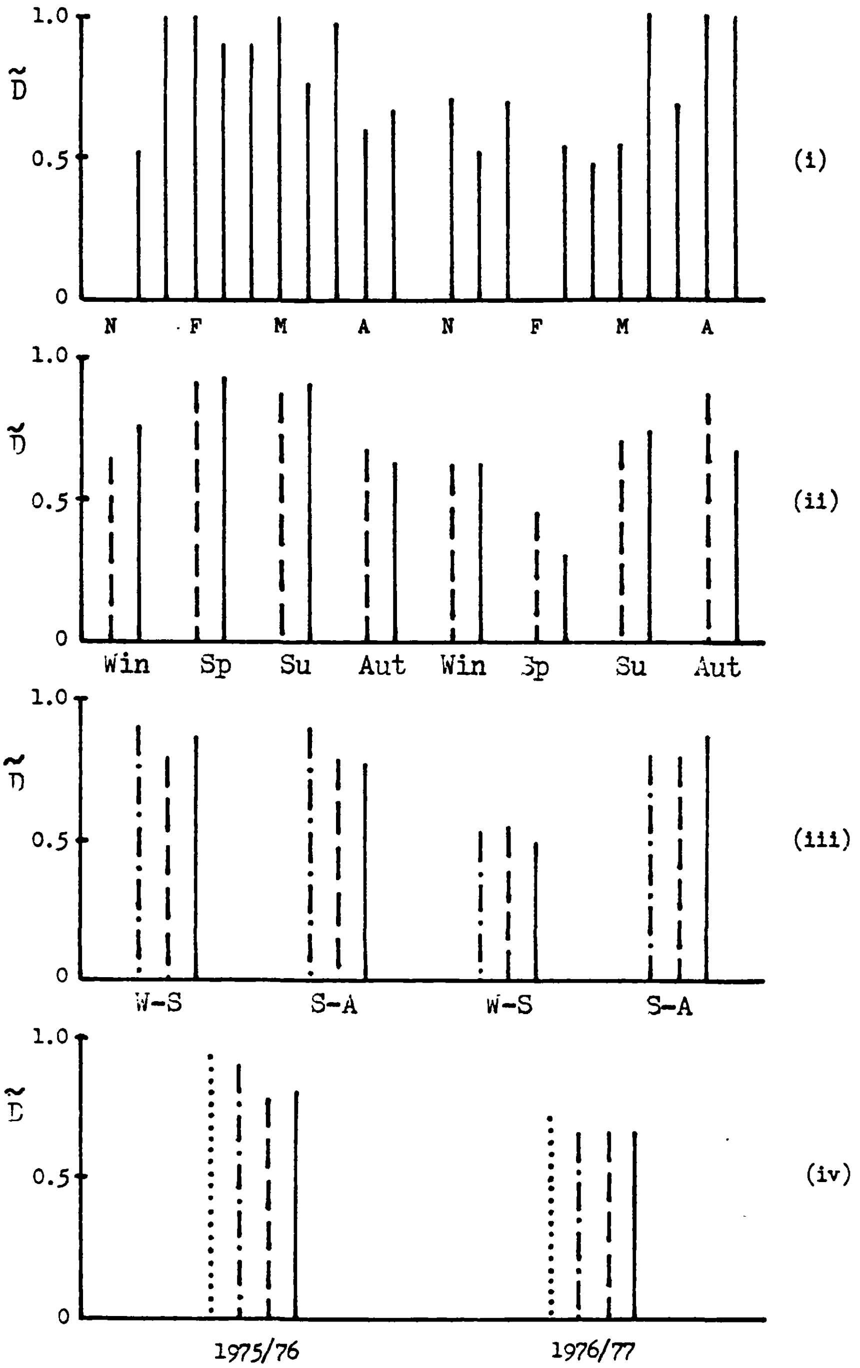


Fig. 5.9 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of $\tilde{D}$ at the stream site.

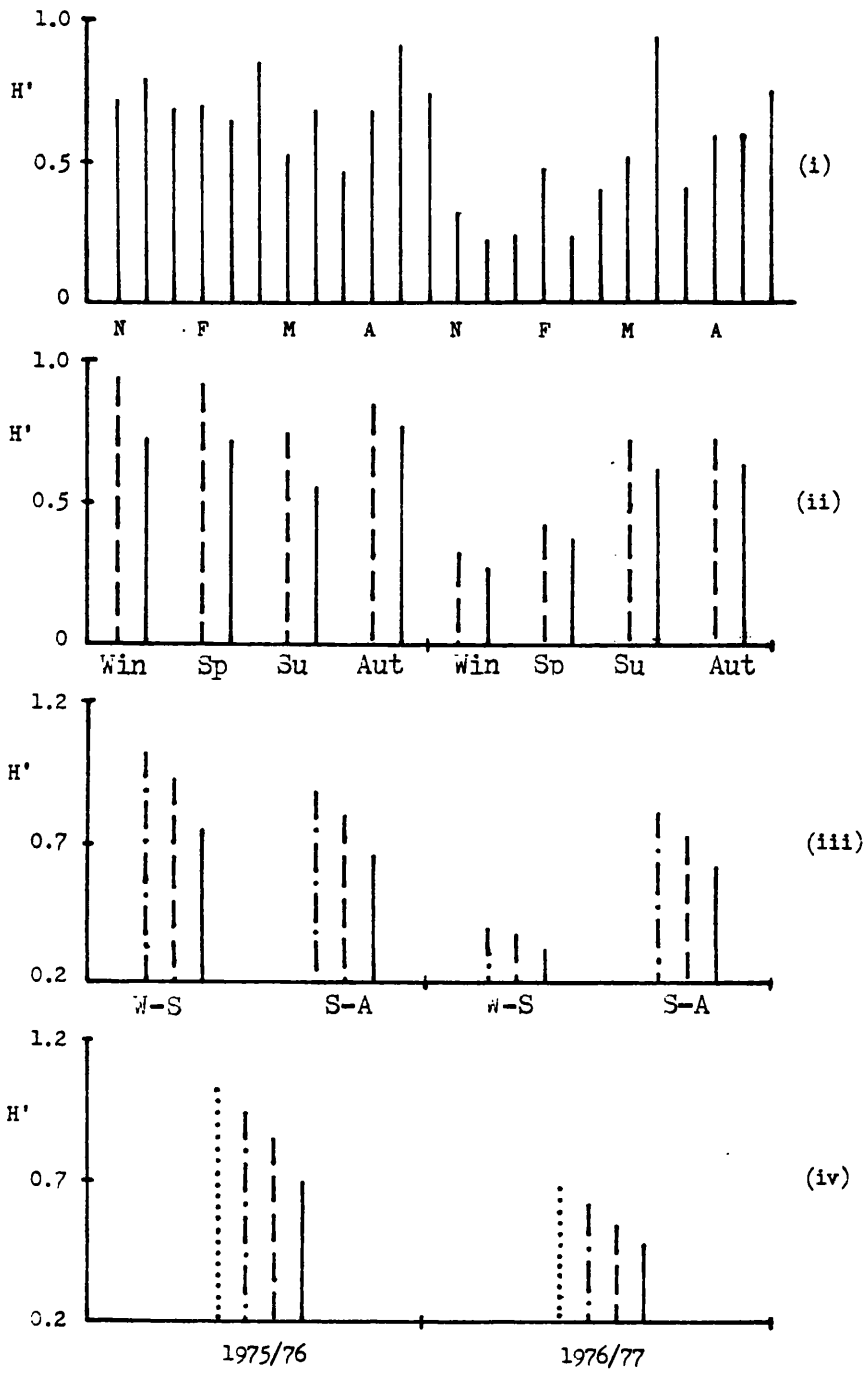


Fig. 5.10 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of H' at Timberwood Hill.

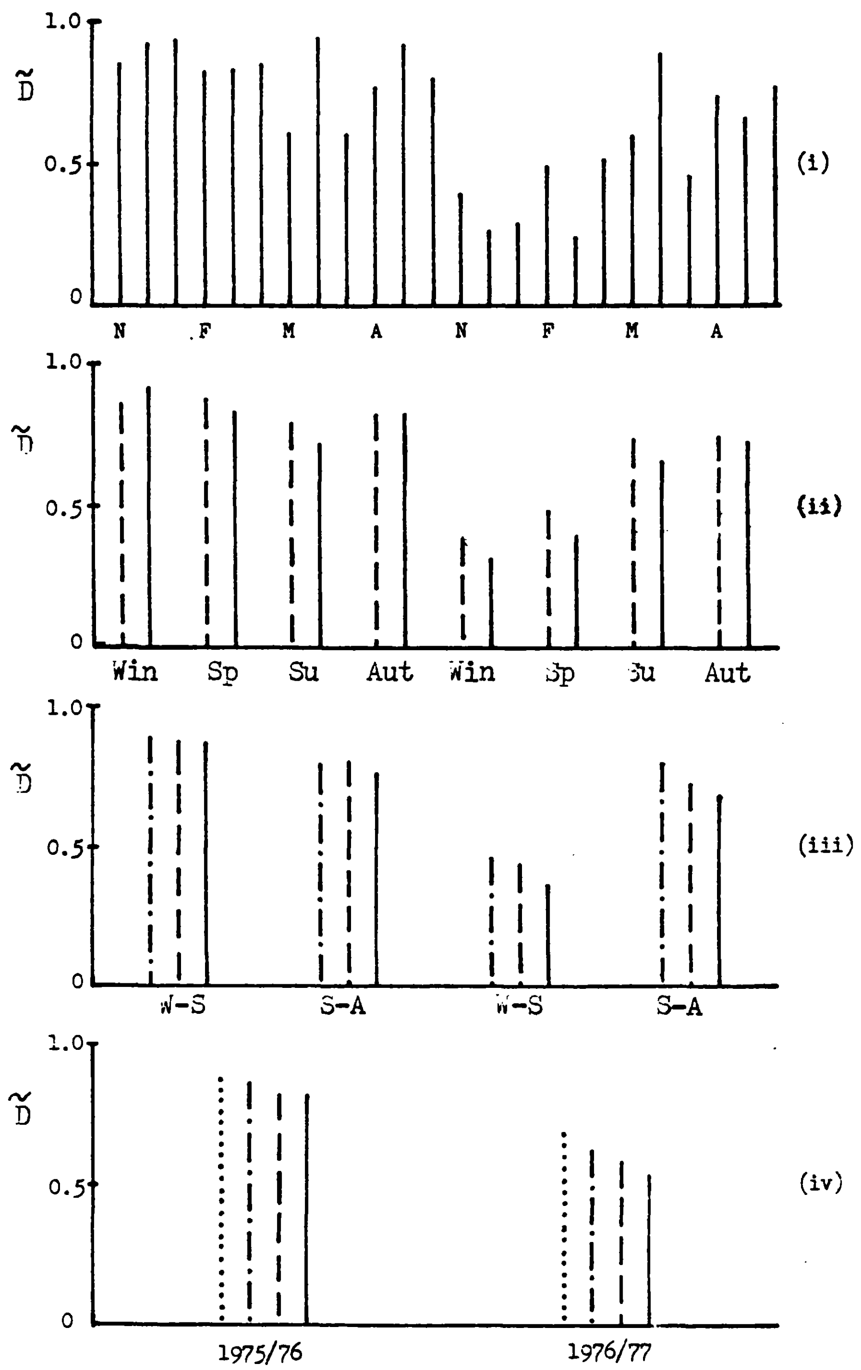


Fig. 5.11 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of $\breve{D}$ at Timberwood Hill.

abundant, with 254 individuals out of a total of 353, resulting in low evenness in this sample ($J' = 0.3949$). The minimal diversities of these third half-yearly samples resulted in lower values of H' and $\tilde{D}$ in the second annual samples, compared to the first.

The progressive amalgamation of monthly samples to form larger samples resulted in samples with values of H' and $\tilde{D}$ which were higher than the mean values for the corresponding lesser periods. This was associated with the increased number of species in the larger samples and increased evenness in the distribution of individuals among the various species. The first quarterly sample from Flat Hill, for example, contained 26 species, an increase of 14 species over the mean monthly number of species for that quarter, and its evenness showed an increase of 0.005 over the mean monthly value. The increase in diversity of the amalgamated samples was more marked when H' was used as a measure of diversity, than when $\tilde{D}$ was used. H' is thus apparently more sensitive than $\tilde{D}$ to changes in the number of species and in the evenness of the distribution of relative species abundances.

At Flat Hill and Timberwood Hill, variations in the monthly values of $\tilde{D}$ were very similar to those of H'. At the stream site, however, variations in the monthly values of $\tilde{D}$ were different from those of H' (Fig. 5.9.i). Six samples had the maximum value of $\tilde{D}$, of 1.0, which corresponded to all species being represented by single individuals, irrespective of the number of species found in the samples. When monthly samples were amalgamated to produce quarterly samples, the value of $\tilde{D}$ decreased from its maximum possible value since not all species were represented by single individuals. The values of $\tilde{D}$ of these quarterly samples were thus lower than the corresponding mean monthly values (Fig. 5.9.ii).

The half-yearly values of $\tilde{D}$ were generally higher than the corresponding mean quarterly values, since amalgamation of quarterly totals to produce half-yearly totals resulted in a further increase in the number of species in the larger samples. In the third half-year of the study, however, amalgamation of the quarterly totals resulted in very large numbers of _T. hypnorum_ in the sample, resulting in a low value of $\tilde{D}$.

The diversities of the annual samples were greater than the mean half-yearly, quarterly and monthly values over the corresponding periods, since amalgamation of the 12 monthly samples resulted in an increase in the number of species in the larger samples.

At the stream site, therefore, the patterns of variation in the diversity of samples varied depending on the index used. This is because samples in which all species are represented by single individuals have the maximum possible value of $\tilde{D}$, of 1.0, irrespective of the number of species in the sample while $H' = \log s = \log N$. Further, the total number of individuals in these samples is generally small, and at this site, is always less than five. Differences in the temporal variations of H' and $\tilde{D}$ were therefore more marked in the smaller ie. monthly samples, than in the larger amalgamated samples.

At Timberwood Plantation, there was no distinct pattern in the variations of the monthly values of H' during the study (Fig. 5.12.i). Values of H' fluctuated initially, and a maximum was attained in May '76, after which H' gradually decreased until December '76. Values of H' thereafter were generally low or minimal (i.e. 0), the minimal values occurring when only one individual was observed in each sample. These low values of H' were associated with the few species occurring in these samples, the mean number of species recorded per sample in the second year of the study being 1.5. In the first year, the number of species per sample was generally higher, averaging five per month, and this resulted

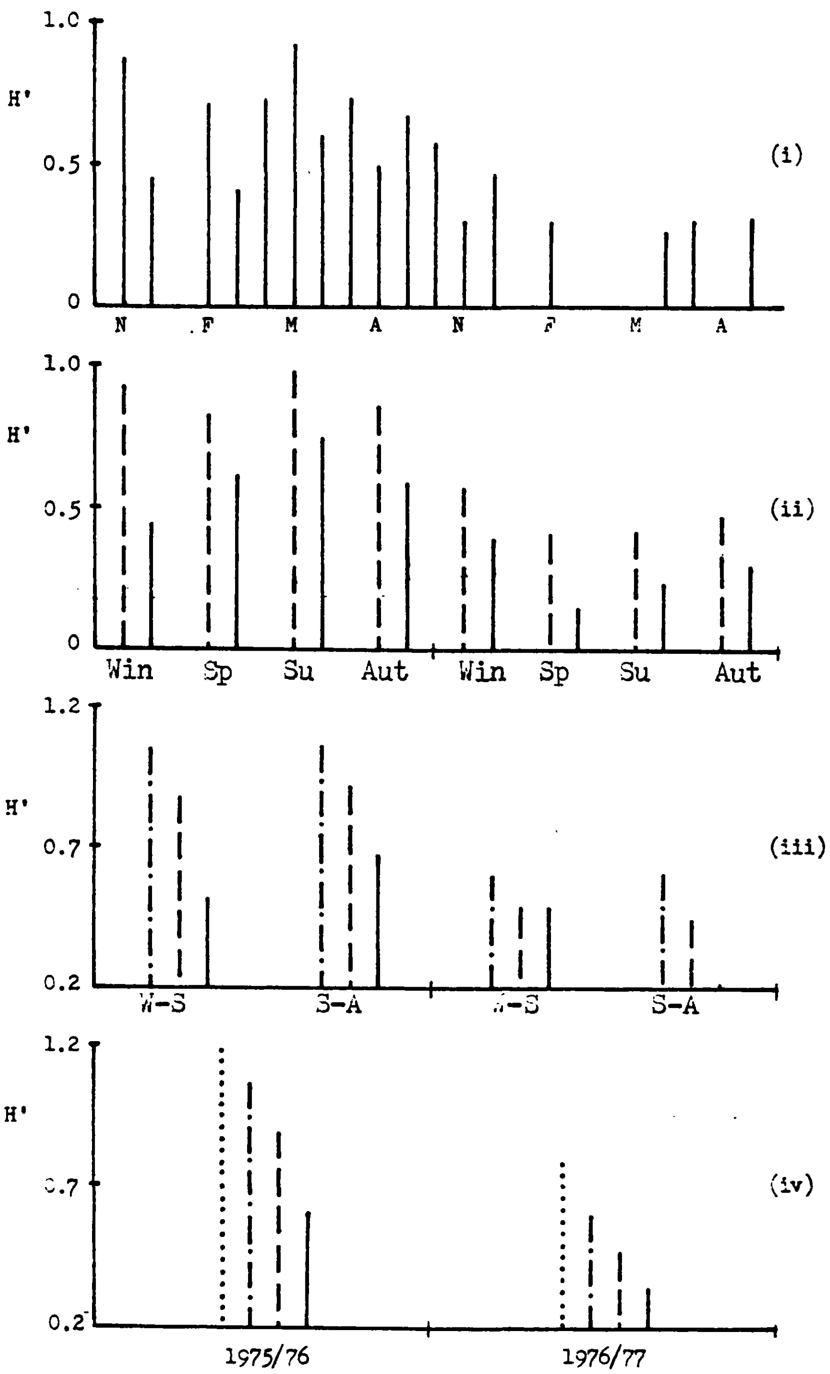


Fig. 5.12 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of H'at Timberwood Plantation.

in higher values of H' in these samples.

The pattern of variations in the values of $\tilde{D}$ were different from those of H' (Fig. 5.13). This was largely due to the different values of H' and $\tilde{D}$ associated with samples containing species represented by single individuals. Six such monthly samples occurred in Timberwood Plantation, and the values of $\tilde{D}$ for these samples were maximal at 1.0, whereas the corresponding values of H' were low.

When such monthly samples were amalgamated to form quarterly samples, there was a general decrease in the value of $\tilde{D}$ from its maximum possible value of 1. Hence, $\tilde{D}$ of these amalgamated quarterly samples were generally less than the corresponding mean monthly values of $\tilde{D}$.

Variations in the half-yearly and annual values of $\tilde{D}$ in the two years of the study were slight. The diversities of the second year samples were high when $\tilde{D}$ was used as a measure of diversity, and low when H' was used. Since the number of species and of individuals in these samples was very low, the diversities of these samples should be low and hence, H' provided a better measure of diversity than $\tilde{D}$.

B. Martinshaw Wood sites

At all the four sites, monthly values of H' and of $\tilde{D}$ fluctuated throughout the study, and no general trends were apparent (Figs. 5.14 - 5.21). At the grass site, however, there was a general decrease in the monthly and quarterly values of H' and $\tilde{D}$ from August '76 to February '77 (Figs. 5.14 and 5.15). These decreasing values were related to decreasing numbers of species in the samples, from an average of six species per month in the first three monthly samples, to two per month in November to January.

At the bracken site, diversities were slightly lower during the first three months than during November to February, when

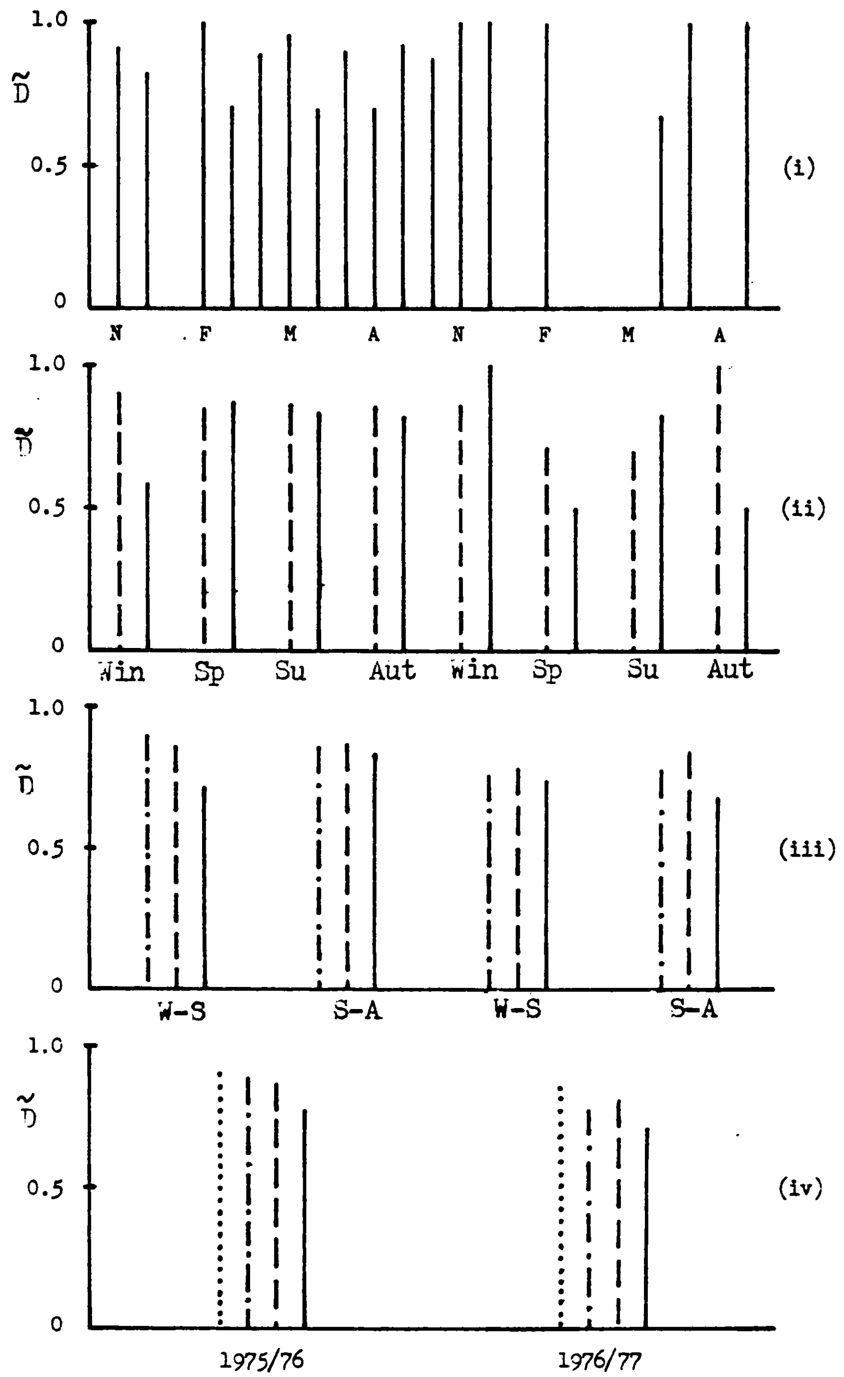


Fig. 5.13 Variations in the (i) monthly (ii) quarterly (iii) half-yearly and (iv) yearly values of $\tilde{D}$ at Timberwood Plantation.

NOTE 2 - In Figs. 5.14 - 5.21 the months corresponding to the various quarters and half-years at Martinshaw Wood are as shown below.

Year	Month	Quarter	Half-year
1976	August		
	September		
	October	Autumn(Aut)	
	November		
	December		
1977	January	Winter(Win)	Autumn-winter(A-W)
	February		
	March		
	April	Spring (Sp)	
	May		
	June		
	July	Summer(Su)	Spring-summer(S-S)
	August		
	September		
	October	Autumn (Aut)	

In these figures,

——— represents actual monthly diversity values (i) or mean monthly values over corresponding quarters (ii), and half-years (iii)

– – – represents actual quarterly diversity values (ii) or mean quarterly values over corresponding half-years (iii)

–·–·– represents actual half-yearly diversity values (iii)

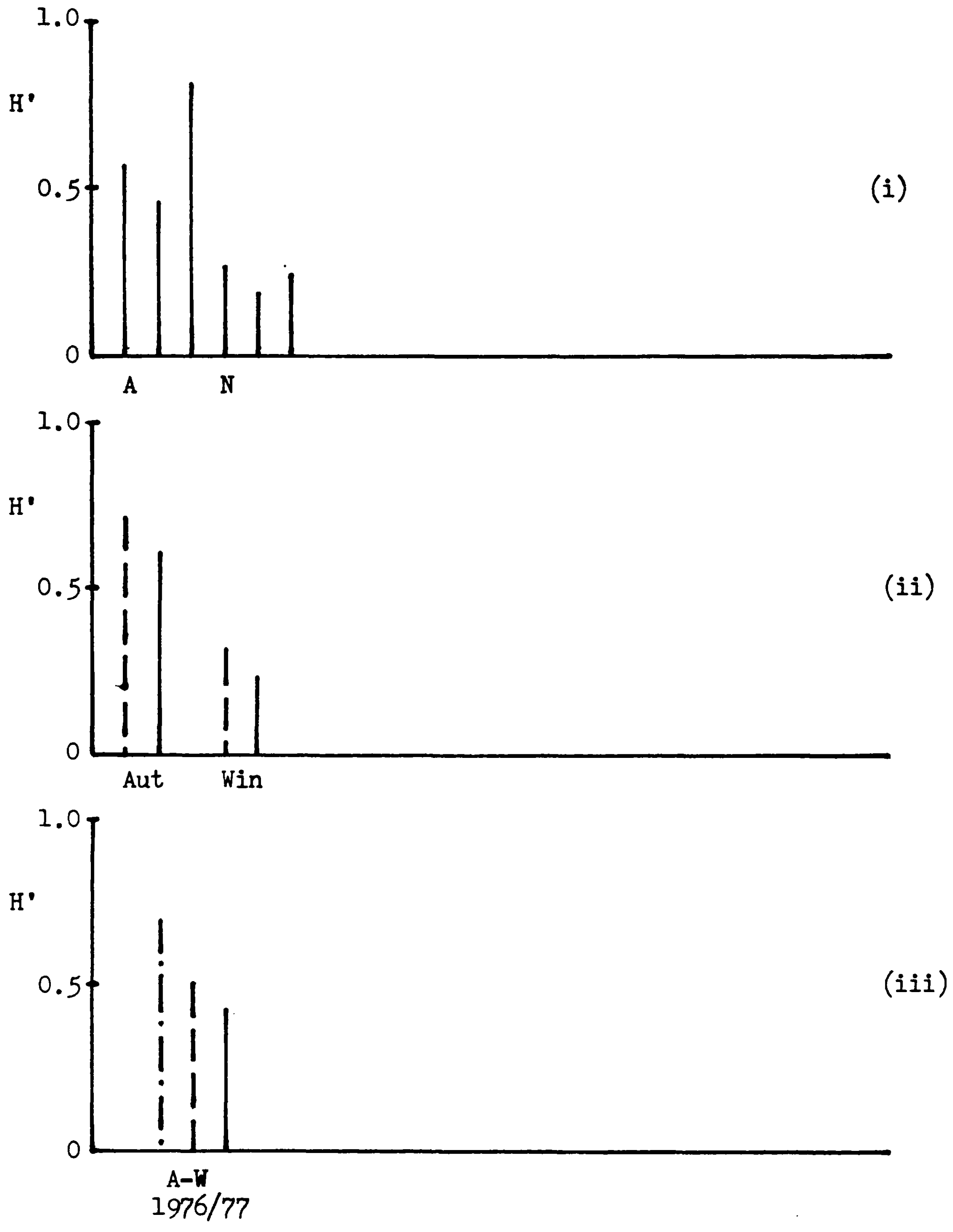


Fig. 5.14 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of H' at the grass site, Martinshaw Wood.

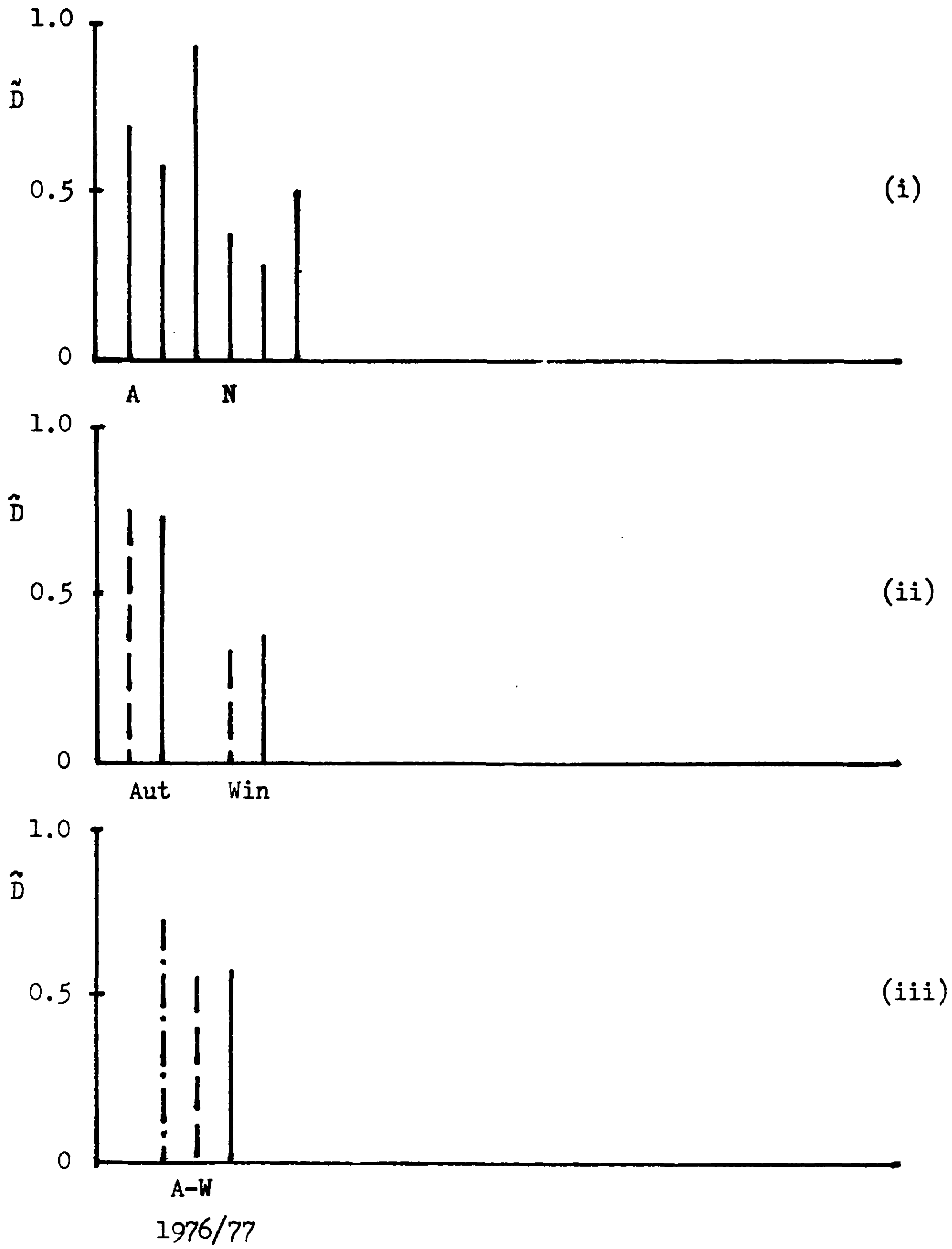


Fig. 5.15 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of $\tilde{D}$ at the grass site, Martinshaw Wood.

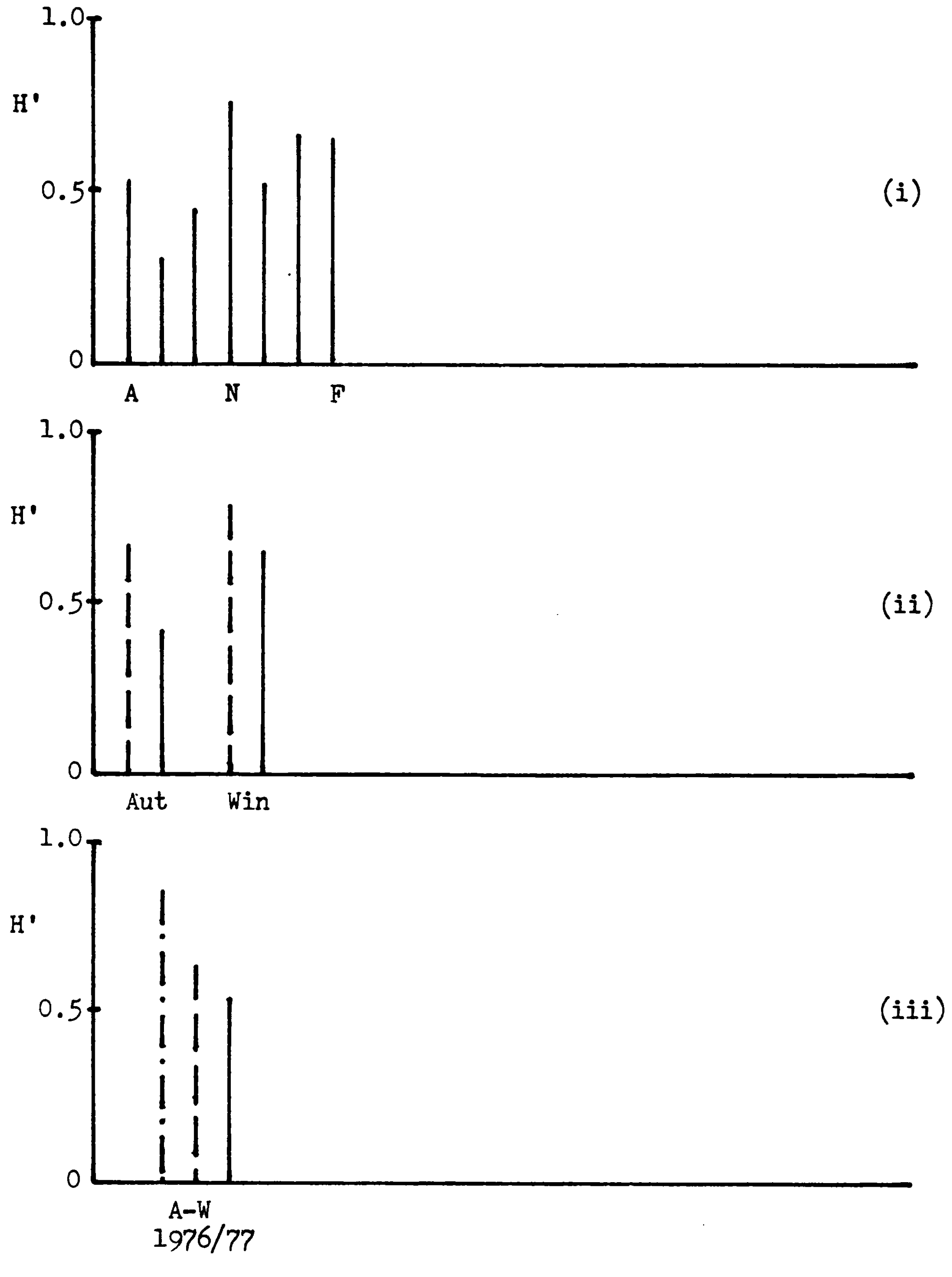


Fig. 5.16 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of H' at the bracken site, Martinshaw Wood.

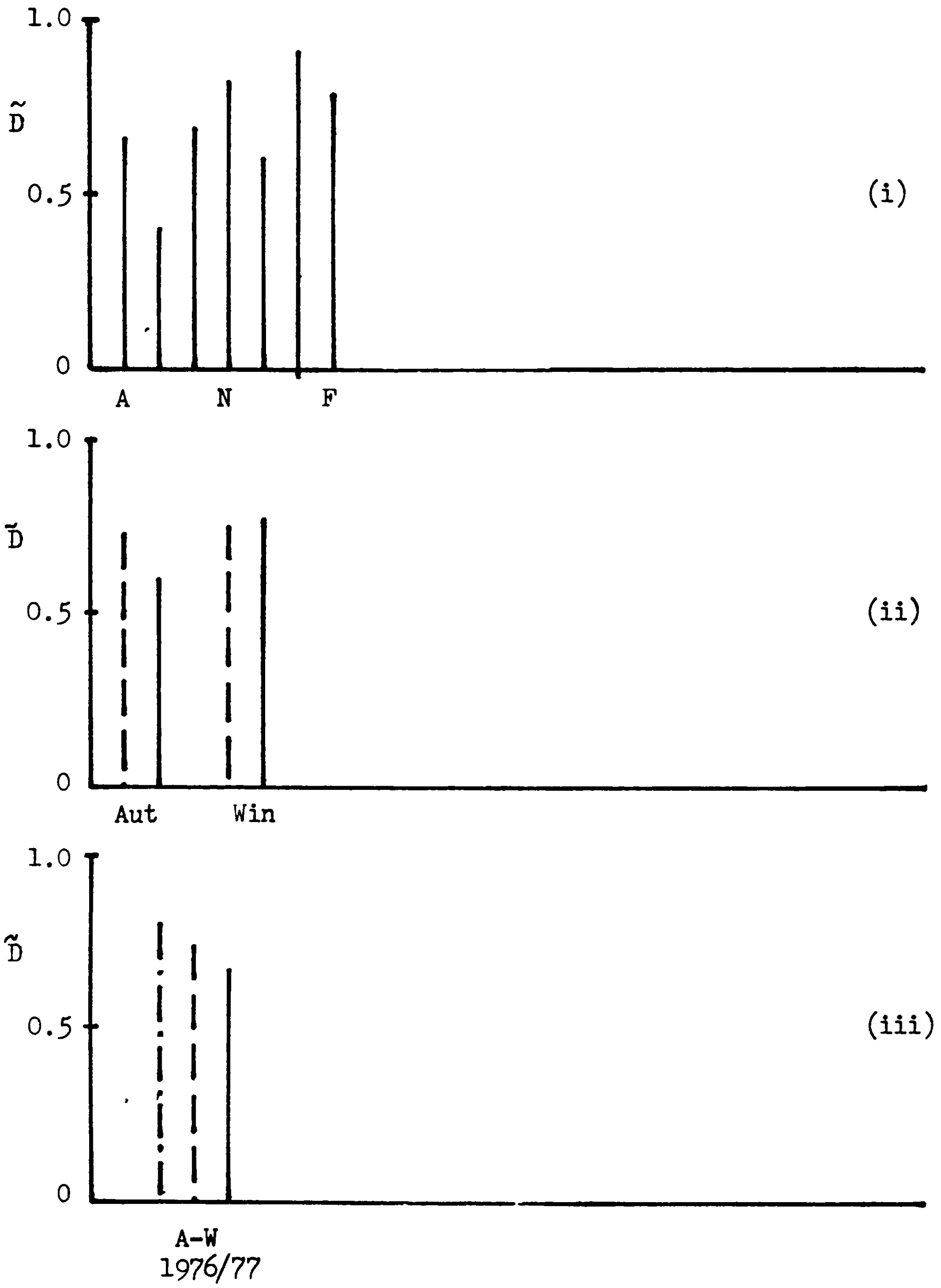


Fig. 5.17 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of $\tilde{D}$ at the bracken site, Martinshaw Wood.

more species occurred in the samples. At the oak site, the fourth quarterly sample was more diverse than the preceding three and showed a marked increase in diversity over the mean monthly diversity for the corresponding period. The May, June and July samples which comprised this sample contained six, two and nine species respectively. Amalgamation of these samples resulted in a thirteen-species quarterly sample, which contained a total of 26 individuals in which the value of J' was 0.9048. This high evenness in the relative species abundances accounted for the high diversity of the fourth quarterly sample.

At the pine site, diversities of the quarterly samples increased from the first to the third and then decreased. Although both first and third samples each contained nine species, the two most abundant species in the first sample, Autalia impressa and Quedius nigriceps, contained 42 and 17 individuals respectively (J' = 0.6565), while the three most abundant species in the third sample comprised four individuals each (J' = 0.9084). Individuals were thus more evenly distributed among the species in the third sample than in the first, resulting in its higher diversity.

5.4 General Pattern of Diversities

In Charnwood Lodge, the rank order of the sites based on their diversities was not consistent from year to year. Thus in 1975/76 the stream site was most diverse, while in 1976/77 Collier's Wood was most diverse, with values close to those for 1975/76, and values of H' and $\tilde{D}$ for all other sites decreased. Comparison of the half-yearly samples from Charnwood Lodge and Martinshaw Wood shows that samples from Collier's Wood and the Martinshaw Wood oak site were the most diverse. Diversities of all other Charnwood Lodge sites were less than those of the other Martinshaw Wood sites, even though Flat Hill and Timberwood Hill had more species than the Martinshaw Wood sites. This was largely

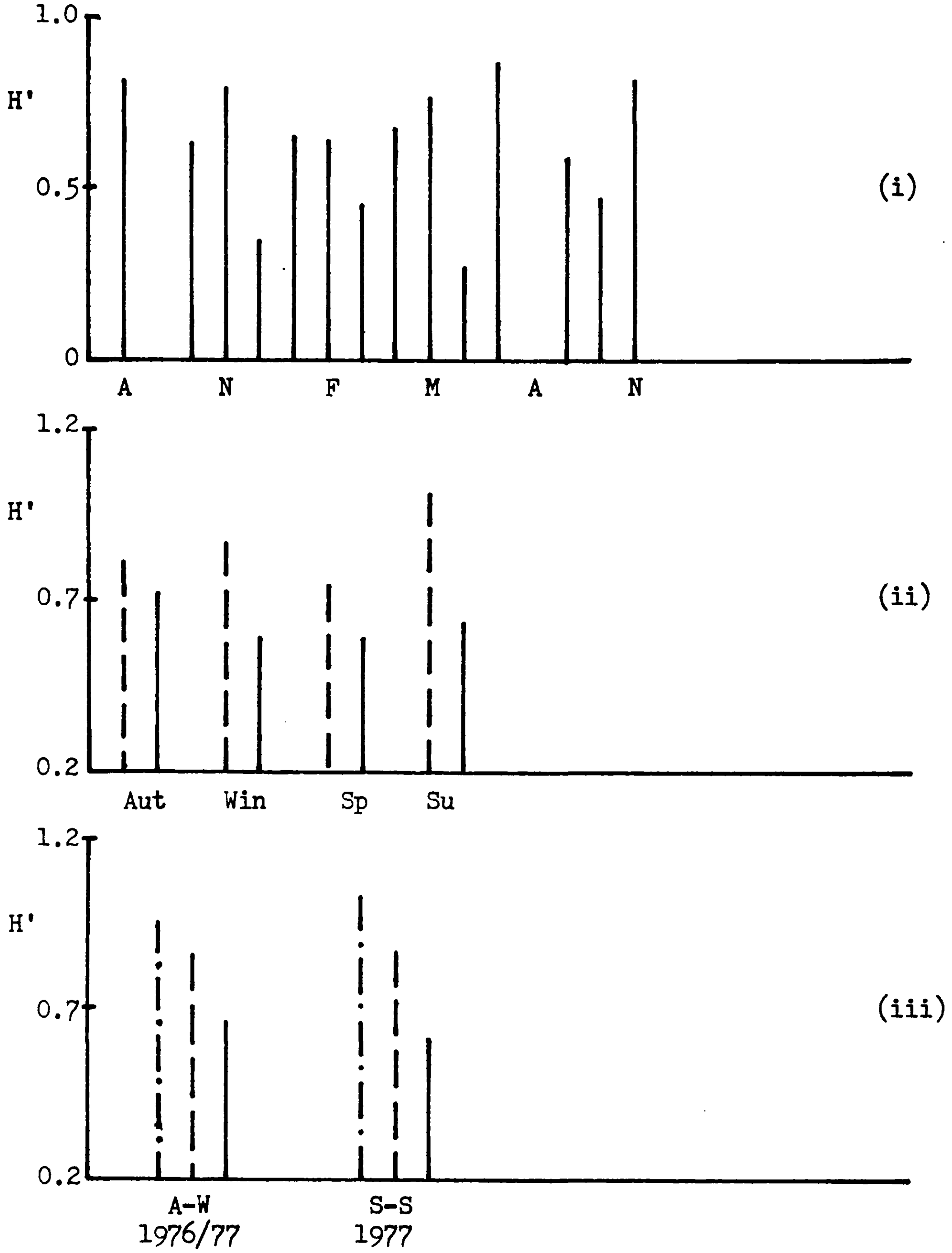


Fig. 5.18 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of H' at the oak site, Martinshaw Wood.

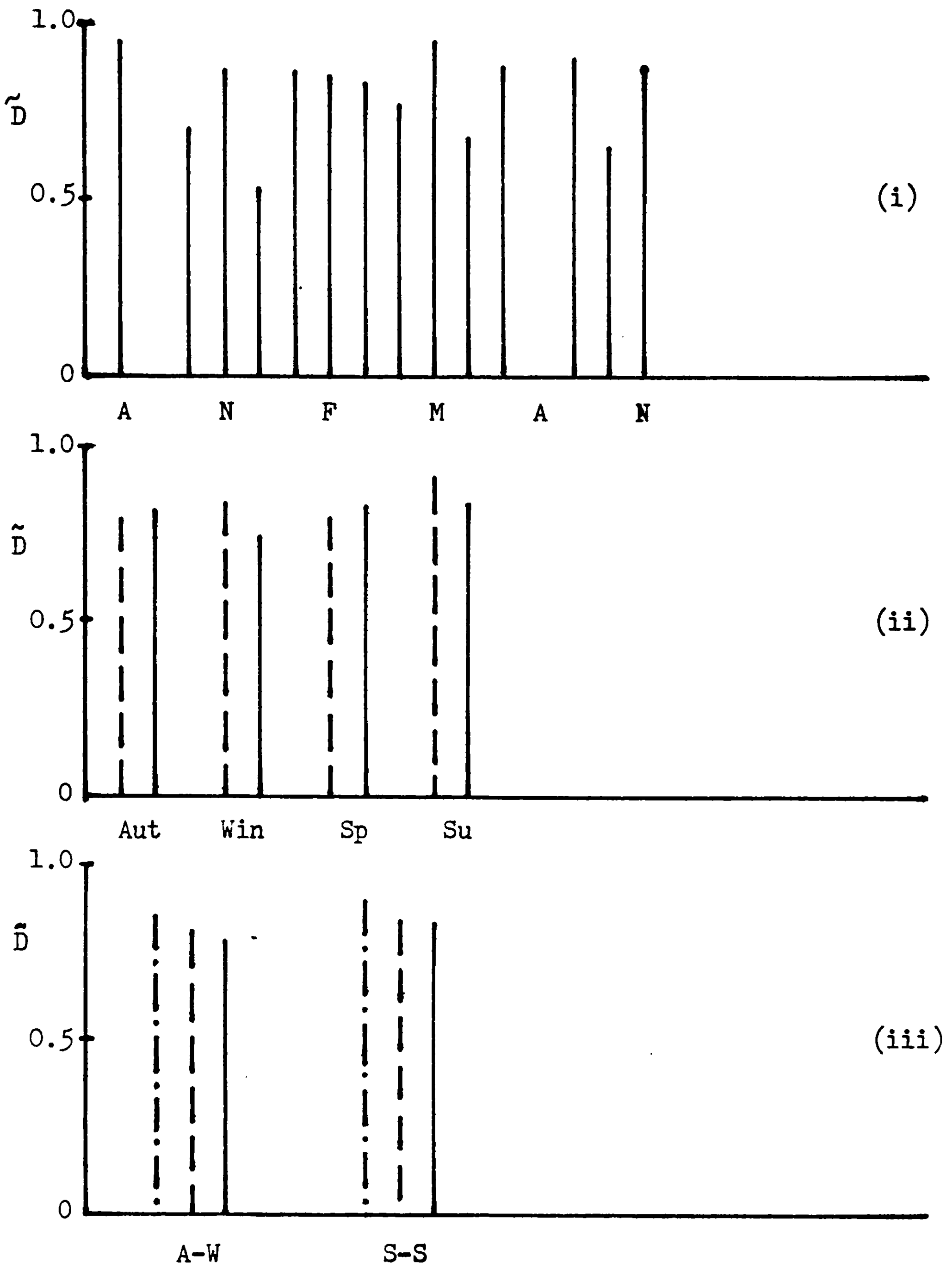


Fig. 5.19 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of $\tilde{D}$ at the oak site, Martinshaw Wood.

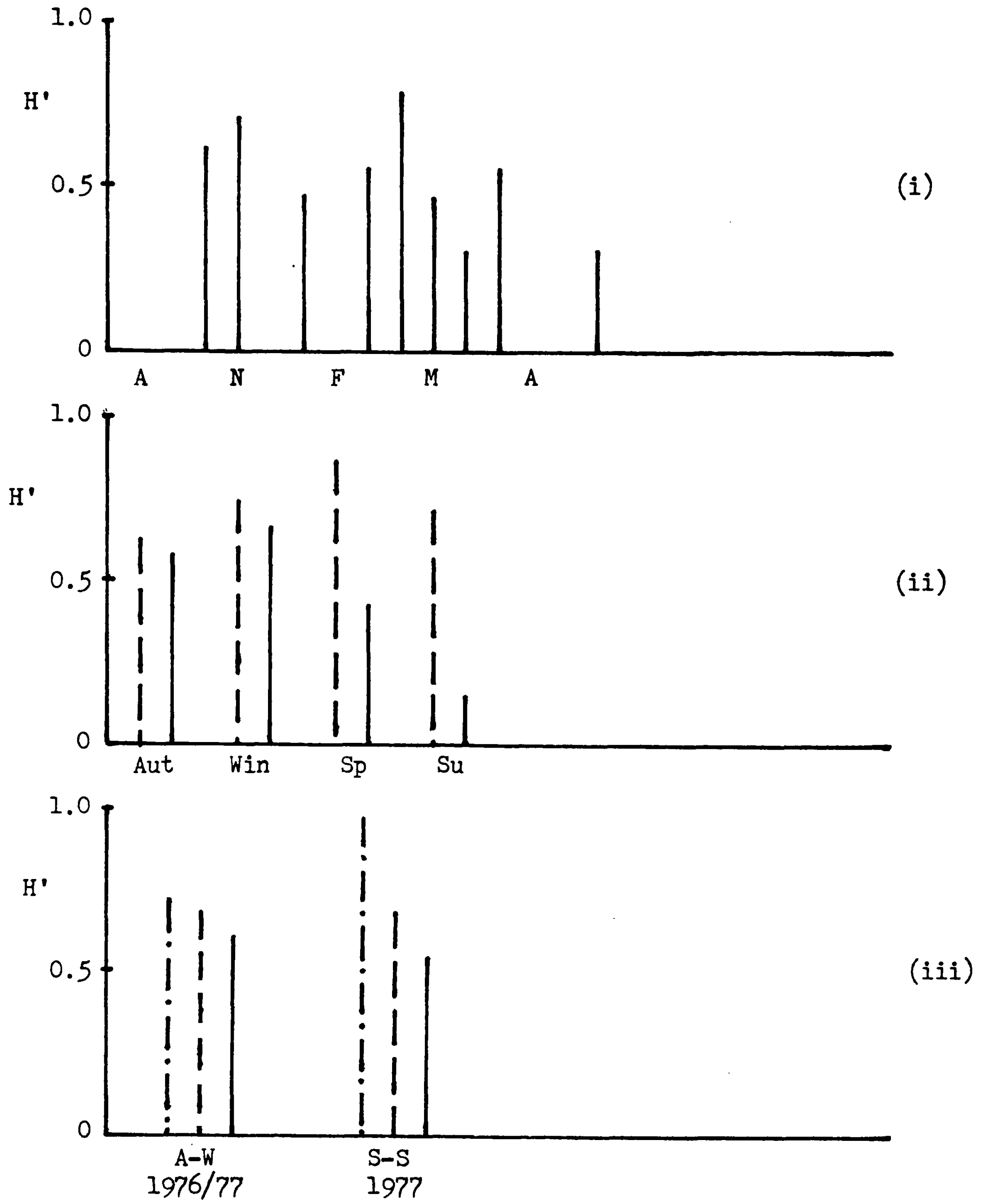


Fig. 5.20 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of H' at the pine site, Martinshaw Wood.

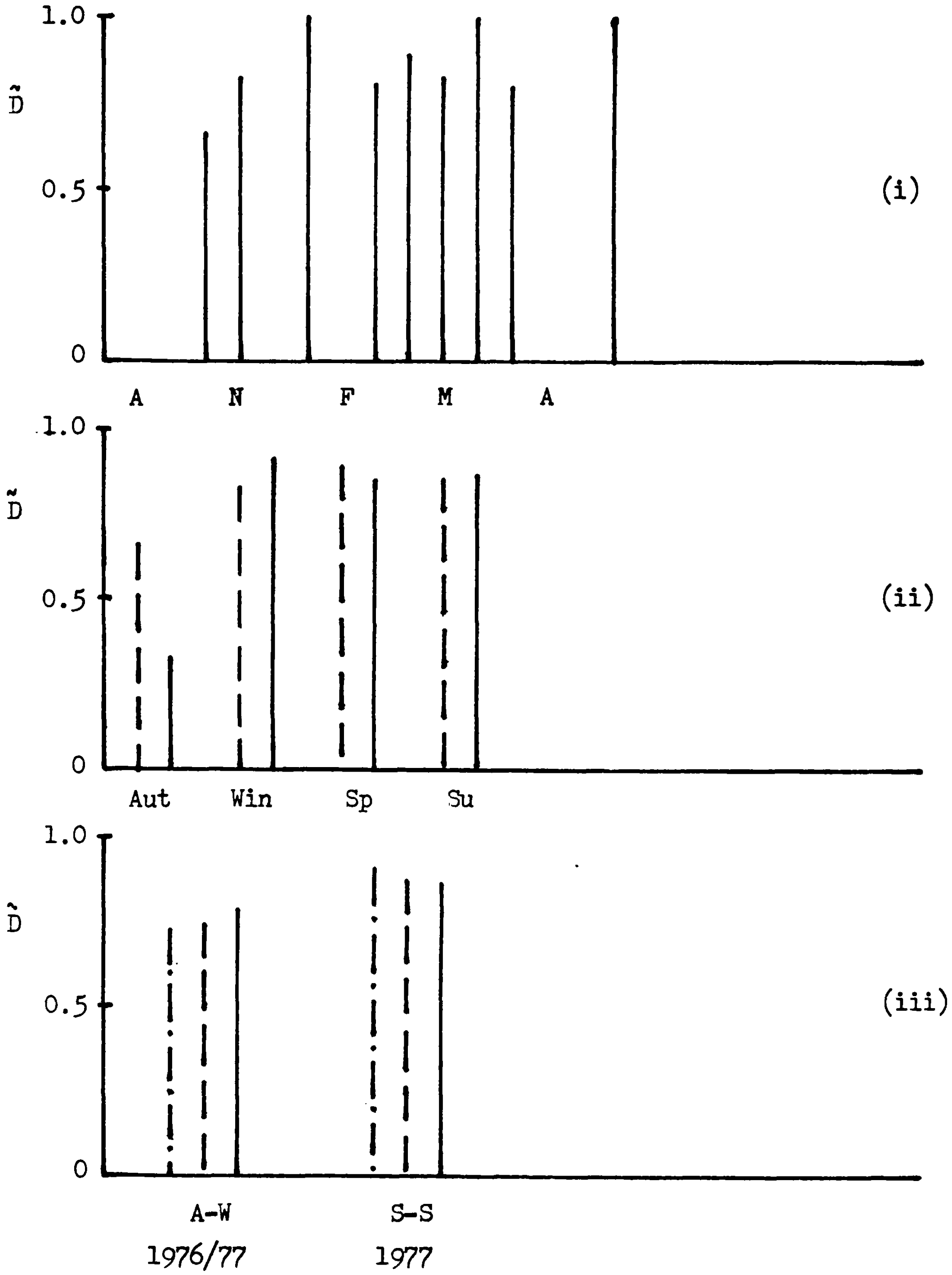


Fig. 5.21 Variations in the (i) monthly (ii) quarterly and (iii) half-yearly values of $\tilde{D}$ at the pine site, Martinshaw Wood.

because of the unevenness of the relative species abundances in the Flat Hill and Timberwood Hill samples, which was related to the large numbers of Tachyporus hypnorum in these samples.

No definite temporal trends in the variation of H' and $\tilde{D}$ were apparent, except at Collier's Wood. Here, the diversity of the samples was approximately equal in both years of the study, and November to April samples were generally less diverse than May to October samples. In all other Charnwood Lodge sites, samples obtained in the second year of the study were less diverse than first year samples. This was generally due to the large numbers of Tachyporus chrysomelinus and T. hypnorum in the second year samples. In the more 'open' sites, i.e. Flat Hill, Timberwood Hill and the stream site, the pattern of variation in the diversities of the quarterly and half-yearly samples was similar, and the diversity of the third half-yearly sample was lower than that of the other three half-years, which had approximately equal diversities. At all these sites, T. hypnorum and T. chrysomelinus were relatively more abundant in the third half-year than in the other samples, resulting in very low diversities in this sample.

Too few samples were obtained from the grass and bracken sites in Martinshaw Wood to show patterns of temporal variation in diversity. At the oak and pine sites, however, there was a slight increase in diversity in the latter half of the study, which was related to the increased evenness of the relative species abundances in these samples.

Amalgamation of monthly samples to produce progressively larger samples generally resulted in progressive increases in the diversity of the samples. Since the numerically more abundant species were usually common to all three monthly samples which were amalgamated to form quarterly samples, the increased number of species resulting from amalgamation of samples was largely due to an increase in the number of rare species. On amalgamation of samples, the value of H' increased relatively more than that of $\tilde{D}$. $\tilde{D}$ is therefore apparently less sensitive to increases in the numbers of rare species in the samples.

The maximum value of $\tilde{D}$, of 1.0, was obtained when all species in a sample were represented by single individuals, irrespective of the number of species in the sample. Since the values of $\tilde{D}$ would be the same whether 2 or 20 species were represented in the samples, H' would provide a better measure of diversity in this instance. Further, since there is a greater likelihood that all species in a sample will be represented by single individuals when the samples are smaller than when they are larger, H' provides the better estimate of diversity in small samples.

At Collier's Wood, Flat Hill and Timberwood Hill, the number of pitfall traps was increased from 6 - 18 in June '76. The diversities of the first eight monthly samples at these sites were therefore based on only six pitfalls. At Collier's Wood, the pattern of variation in the diversity indices was similar in both years, indicating that in Collier's Wood, diversities based on six pitfall trap catches were comparable to those based on 18 pitfalls.

At Flat Hill and Timberwood Hill, the diversities of the first eight samples were generally higher than those of the remaining samples. Since amalgamation of samples at these sites generally results in an increased number of species occurring in the larger samples, and hence, in increased values of diversity, it would be expected that diversity values based on 18 pitfalls would be generally higher than those based on six pitfall traps. Since, however, the reverse appears to be the case in Flat Hill and Timberwood Hill samples, and increasing the number of pitfall traps does not increase the diversity of the monthly samples, the pattern of variation in specific diversity at these sites may be studied as effectively when diversities are based on six pitfalls as when diversities are based on 18 pitfalls.

6. THE STAPHYLINIDAE - SAMPLE COMPARISON

6.1 Introduction

Although indices of diversity may be used for comparisons between samples, they only reflect one intrinsic property of the sample and ignore information on which species are present (and in what numbers). To compare samples in terms of their specific constitution requires first, the selection of a method of measuring similarity, either qualitative or quantitative, and secondly, a means of analysing the resulting matrix of indices of similarity.

6.2 Selection of an Index of Similarity

The qualitative and quantitative comparison of samples containing many species may be effected by the use of various indices of similarity. The range of indices of similarity and different ways of sorting the resulting matrix of indices are both reviewed by Greig-Smith (1964), Williams, Lambert and Lance (1966), Pielou (1969, 1975), Bullock (1971), Whittaker (1973), Wallwork (1976) and Southwood (1978).

Many indices of similarity have been developed for use in plant ecology. Since with many plant species, it is difficult to delimit individuals, the commonest indices are based on the presence or absence of species in the samples being compared. They include Soerensen's Quotient of Similarity, K (Soërensen, 1948, cited in Mountford, 1962), Mountford's Index, I (Mountford, loc. cit.) and χ^2 (Williams and Lambert, 1959).

When quantitative data on the abundance of the various species are available, Pearson's product moment correlation (Macfadyen, 1963), Orloci's Weighted Coefficient of Similarity (Orloci, 1966) and Information Analysis (Williams, Lambert and Lance, 1966; Lloyd, 1972) may be used as indices of similarity. These indices place extreme emphasis on common species with aggregated distributions and are therefore biased against the rarer species, while indices based on presence-absence data do not take into account the relative abundance of species and therefore sacrifice a certain amount of information. Rank correlation coefficients such as Spearman's ρ (Spearman, 1904) and Kendall's τ (Kendall, 1970), however, are intermediate between the two extremes as they take into consideration the relative abundance of all the species. The relative merits of these and other indices of similarity have been discussed in Bullock (1971).

Although both Kendall's τ and Spearman's ρ may be subjected to tests of significance, the latter coefficient has not been used in ecological research. The use of τ is limited to the studies of Bullock (1971) and Leow (1972; 1975), although its use was recommended earlier by Fager (1957).

Bullock (loc. cit.) advocates the use of the τ coefficient in preference to Spearman's ρ since (i) the τ coefficient is normally distributed and (ii) differences in rank are treated arithmetically whereas Spearman's ρ is geometric, so that major differences in rank tend to be overemphasised.

The τ correlation coefficient was therefore selected for use in the present study. A computer program CHTAUM (Program 4 in Appendix II), was written to calculate the similarity between pairs of samples, given the various species abundance matrices obtained from program MATRIX.

A very large number of species in the samples are represented by 0 individuals. These zero values are problematic since a species may be absent from a sample purely by accident or by intention i.e. it is absent, for a variety of reasons, from the habitat from which the sample is taken. A comparison using the total species list would in effect achieve a partial correlation as opposed to a simple correlation. Further, the comparison of pairs of samples containing large numbers of dual absences results in higher τ values than would be the case if such dual absences were excluded. An IF statement was therefore included in program CHTAUM to exclude dual absences, thereby providing more realistic estimates of the similarity between samples.

6.3 Choice of Sorting Techniques

Once the similarity between pairs of samples has been calculated, it is essential to sort these indices to determine whether the various samples form distinct groups. Two basic sorting techniques are available, namely classification and ordination.

Classification is basically a hierarchical technique in which samples are sorted into successively smaller or larger groups depending on their greater or lesser level of similarity. Classification may be divisive i.e. the total collection of samples is divided and re-divided into successively smaller groups, or agglomerative i.e. individual samples are combined and re-combined to form successively larger groups. Classificatory techniques may also be monothetic i.e. groupings may be based on the presence or absence of a single feature, such as the possession of a particular species, or polythetic i.e. groupings are based on the overall similarity between sample units.

Four basic methods of classification are therefore potentially possible, but of these, agglomerative monothetic methods are difficult to conceive and it is hard to see how they would operate; Williams, Lambert and Lance (1966) consider that they 'cannot exist except in a trivial sense'. Gower (1967) considers divisive polythetic methods such as that of Edwards and Cavalli-Sforza (1965) unsuitable for application to ecological problems because of the lengthy computations involved. As a result, only divisive monothetic and agglomerative polythetic techniques are feasible for use in ecological research. Virtually the only divisive monothetic technique which has been described is association analysis (Williams and Lambert, 1959; 1960) while a variety of agglomerative polythetic techniques exist. These include centroid sorting and nearest neighbour sorting (Williams, Lambert and Lance, 1966) and mean index sorting (Mountford, 1962).

Pielou (1966) prefers polythetic methods to monothetic ones since all the species are taken into account whereas monothetic methods are wasteful of information, although admittedly, the simpler polythetic techniques also suffer this disadvantage. Further, monothetic techniques may result in uninformative subdivisions based on unimportant attributes (Greig-Smith, 1964). Two agglomerative polythetic methods of classification were therefore selected for sorting the indices - namely, nearest neighbour sorting (Williams, Lambert and Lance, 1966) and mean index sorting (Mountford, 1962). The former technique represents one of the simplest agglomerative polythetic methods since no recalculation of indices is involved as the analysis proceeds. Mean index sorting is comparatively more complicated, requiring the recalculation of indices as the analysis proceeds and thereby increasing the utilisation of available information.

In nearest neighbour sorting, the matrix of similarity indices is examined, and the highest index in this matrix is selected. The two samples contributing to this index are combined to form a single group. The next highest index is then selected. If neither of the samples forming this index is already in the existing group, the members of this pair are combined to form a new group. If one of the members of the pair is already in the existing group, the other member is added to the group. The third highest index in the matrix is then selected and the sorting process continues in a similar way except that if both members of the pair concerned already belong to different groups, the relevant groups are fused while if both members of the pair are already in the same group, the index is ignored. The analysis continues until all the samples have been fused into a single group (cf. Fig. 6.2).

In mean index sorting, the triangular matrix of similarity coefficients between pairs of samples is examined, and the pair of samples corresponding to the highest value in this matrix is combined to form a single group. The indices of similarity between this newly formed group and each of the other samples is recalculated using the general formula

$$I(A_1, A_2 \ldots\ldots A_m ; B_1, B_2 \ldots\ldots B_n) = \frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} I(A_i B_j)$$

where I is the similarity between group A comprising m samples and group B comprising n samples, using values obtained from the original similarity matrix. The entries for those samples which occur in the new group in the original similarity matrix are then discarded, and the reduced table of indices relating the new group to the rest of the original samples, is examined. The highest index in this reduced table is selected, and the procedure repeated. This process is continued until the similarity matrix has been reduced to a single value (cf. Fig. 6.1).

A computer was used to sort the large number of τ matrices under investigation. A package 'Genstat' program, HIER (Program 5 in Appendix II) was selected for this purpose. In this program five methods of clustering are available, specified by the option CM. Nearest neighbour sorting (referred to as single linkage cluster analysis in the program) is specified by the option CM = 1, while mean index sorting (referred to as centroid cluster analysis in the program), is specified by the option CM = 3. The lower triangular matrix of τ values is used in this program. However, τ values may range from -1 to +1. Since calculations are much simplified when all values are positive, the values were modified to (τ + 1)/2 as recommended by Bullock (1971), and expressed as percentages to fulfill the requirements of the Genstat program. The resulting classifications are presented as dendrograms exactly as they emerged from the computer to avoid subjective bias in regrouping the samples.

Classificatory techniques assume that groupings of samples are hierarchically related. Ordinatory techniques make no such assumptions and are therefore preferable in this respect. In ordination, species or samples are plotted with reference to a number of independent axes (Orloci, 1966; Pielou, 1969; Bullock, 1971). Ordinatory techniques include the oblique axes method of Bray and Curtis (1957), the perpendicular axes technique of Orloci (1966) and principal component analysis (e.g. Austin and Orloci, 1966).

Simple ordination techniques such as those of Bray and Curtis (1957) and Orloci (1966) use the least similar samples as reference points for the ordination axes. Since the reference axes need not neccessarily lie in the direction of maximal variation the results obtained may not have any ecological meaning. In principal component analysis, uncorrelated axes are fitted to a swarm of points in a hyper-space in such a manner that the first axis extracts maximum variation, the second axis is orthogonal to the first and extracts the maximum residual variation, and each subsequent axis is orthogonal to the preceding ones and extracts the maximum remaining variation. This is a purely mathematical operation, and does not make any basic assumptions about the data as do the oblique axes and perpendicular axes ordination techniques. Principal component analysis was therefore selected in preference to the other ordination techniques for sorting the τ indices of similarity between the various samples in this study. A package SPSS program, PCA (Program 6 in Appendix II) was used for the principal component analysis. For this program, lower triangular matrices of modified τ values (with the elements of the leading diagonal set to unity) resulting from program CHTAUM were converted into standard SPSS format using program TAU (Program 7 in Appendix II).

In program PCA, the eigenvalues or latent roots of the modified τ matrix show how much of the variation is extracted by each orthogonal axis. The percentage of the total variation extracted by each successive eigenvalue and the corresponding cumulative percentages were calculated. Since in the majority of analyses $> 60\%$ of the total variation in the samples had been extracted by the first four axes, subsequent analyses were limited to these axes. The positions of the various samples in relation to these axes, taken two at a time, i.e. their eigenvectors, were calculated and then plotted.

6.4 Application of Similarity Indices and Sorting Techniques to staphylinid data

Initially, the 24 monthly samples from each of the five Charnwood Lodge sites were compared separately. The results of nearest neighbour and mean index sorting and principal component analysis were examined to discover whether the samples may be grouped according to a pattern. Samples were summed to give three monthly totals for each species in each site (cf. Table 5.1), resulting in eight quarterly totals per site. The forty quarterly samples from the five sites were held together in an 87 x 40 sequential matrix, and then compared to determine how samples were grouped, and then, to attempt to explain the sample groupings. The half-yearly and yearly samples were also studied in a similar way.

For comparative purposes, data from the four sites in

Martinshaw Wood were treated in a similar way, firstly to determine the factors affecting the grouping of monthly samples in individual study sites and then to study the factors affecting the grouping of quarterly and half-yearly samples.

However, for Martinshaw Wood, only two quarterly totals from each of the grass and bracken sites and four quarterly totals from each of the woodland sites were available for comparison. Conclusions drawn from such a limited number of sample comparisons may not be valid. Hence, to further investigate the factors which determine the occurrence of Staphylinidae in pitfall traps, the quarterly matrices from Charnwood Lodge and Martinshaw Wood were amalgamated to increase the number of comparisons possible between samples. Since a total of 91 staphylinid species were obtained from these study areas, a 91 x 52 matrix is needed for the comparison of samples from both these study areas (Table 5.1).

6.4.1 Charnwood Lodge - Site by Site Comparisons

(i) Collier's Wood

Classification

Two distinct groups result at the 30% level from mean index sorting (Fig. 6.1), one consisting mainly of the October to April samples and the May '76 sample (1 - 7, 12 - 18 and 24) and the other of May to September samples. Within each of these groups, samples obtained in the first year of the study tend to be grouped together as are those obtained in the second year. The May - June samples of the second year of the study (samples 19 and 20) are more alike than those of the first year (samples 7 and 8).

As in mean index sorting, nearest neighbour sorting (Fig.6.2) shows that the October to April samples are more similar to each other than samples obtained from May to September. Although nearest neighbour

__NOTE 1__ :- In Figs. 6.1 - 6.12, the numbers correspond to monthly Charnwood Lodge samples as follows:-

Number	Sample	Symbol	Number	Sample	Symbol
1	Nov '75	○ (Winter)	13	Nov '76	● (Winter)
2	Dec		14	Dec	
3	Jan '76		15	Jan '77	
4	Feb	□ (Spring)	16	Feb	■ (Spring)
5	Mar		17	Mar	
6	Apr		18	Apr	
7	May	△ (Summer)	19	May	▲ (Summer)
8	Jun		20	Jun	
9	Jul		21	Jul	
10	Aug	◠ (Autumn)	22	Aug	◓ (Autumn)
11	Sept		23	Sept	
12	Oct		24	Oct	

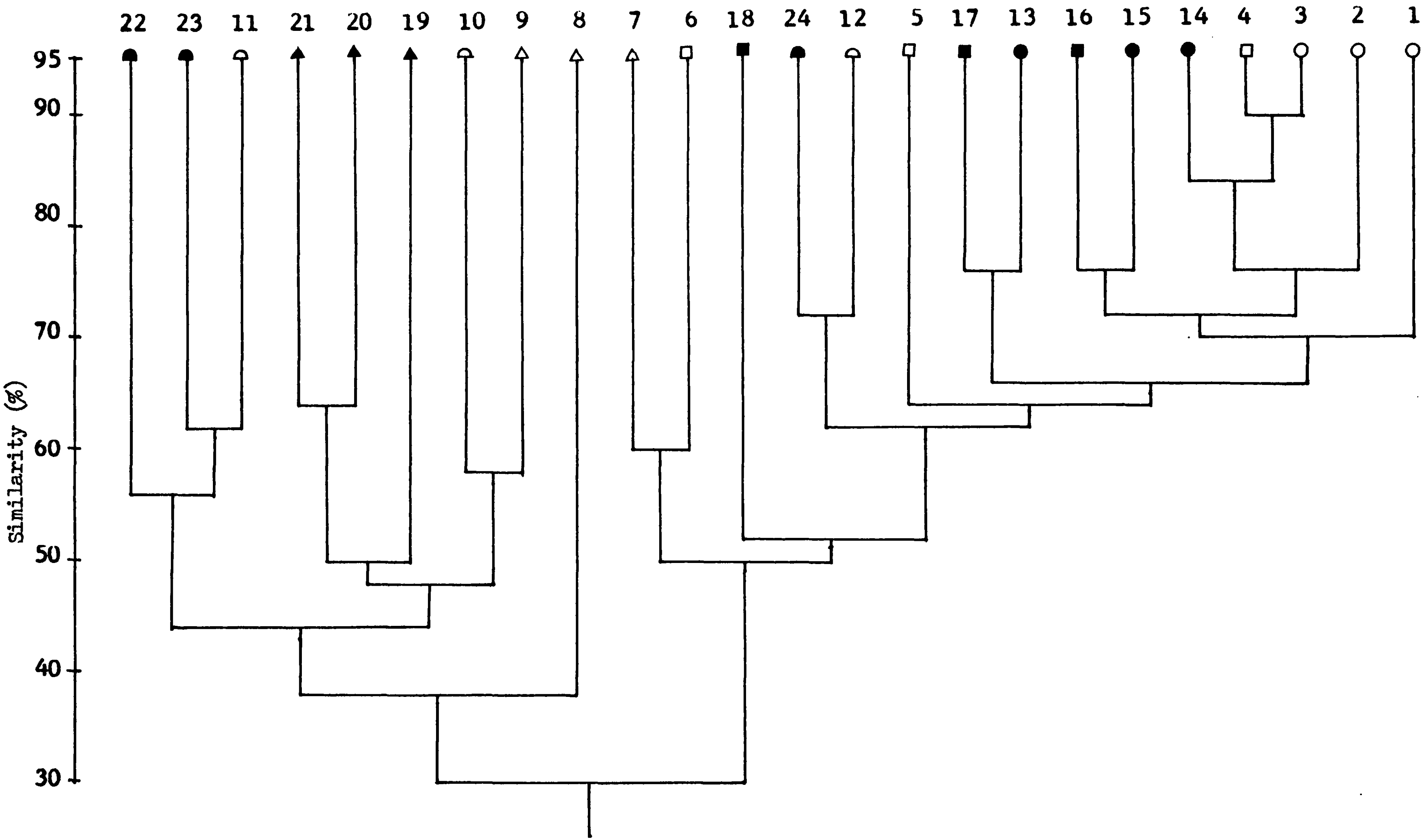


Fig. 6.1 Dendrogram resulting from mean index sorting of 24 monthly samples from Collier's Wood.

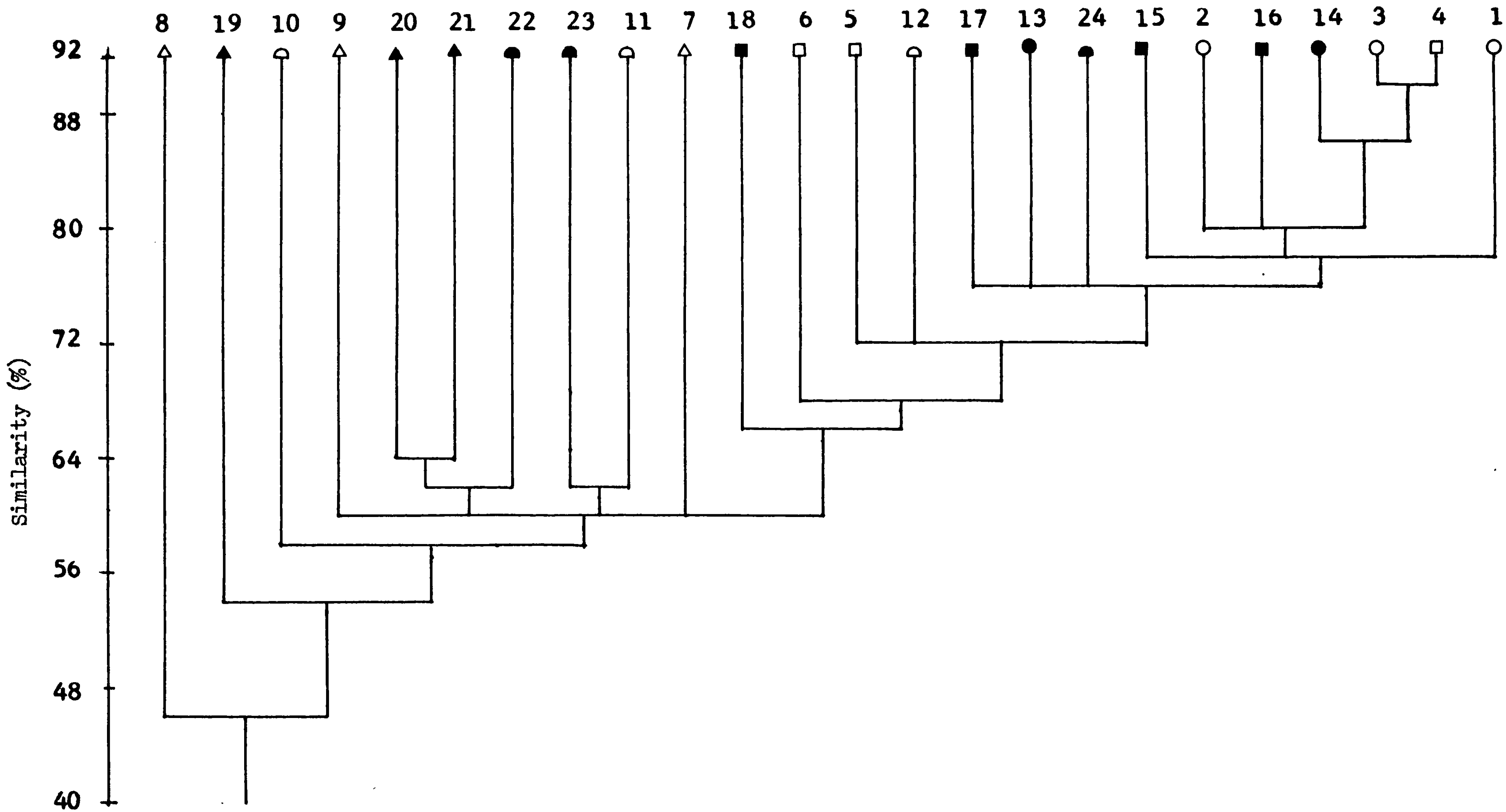
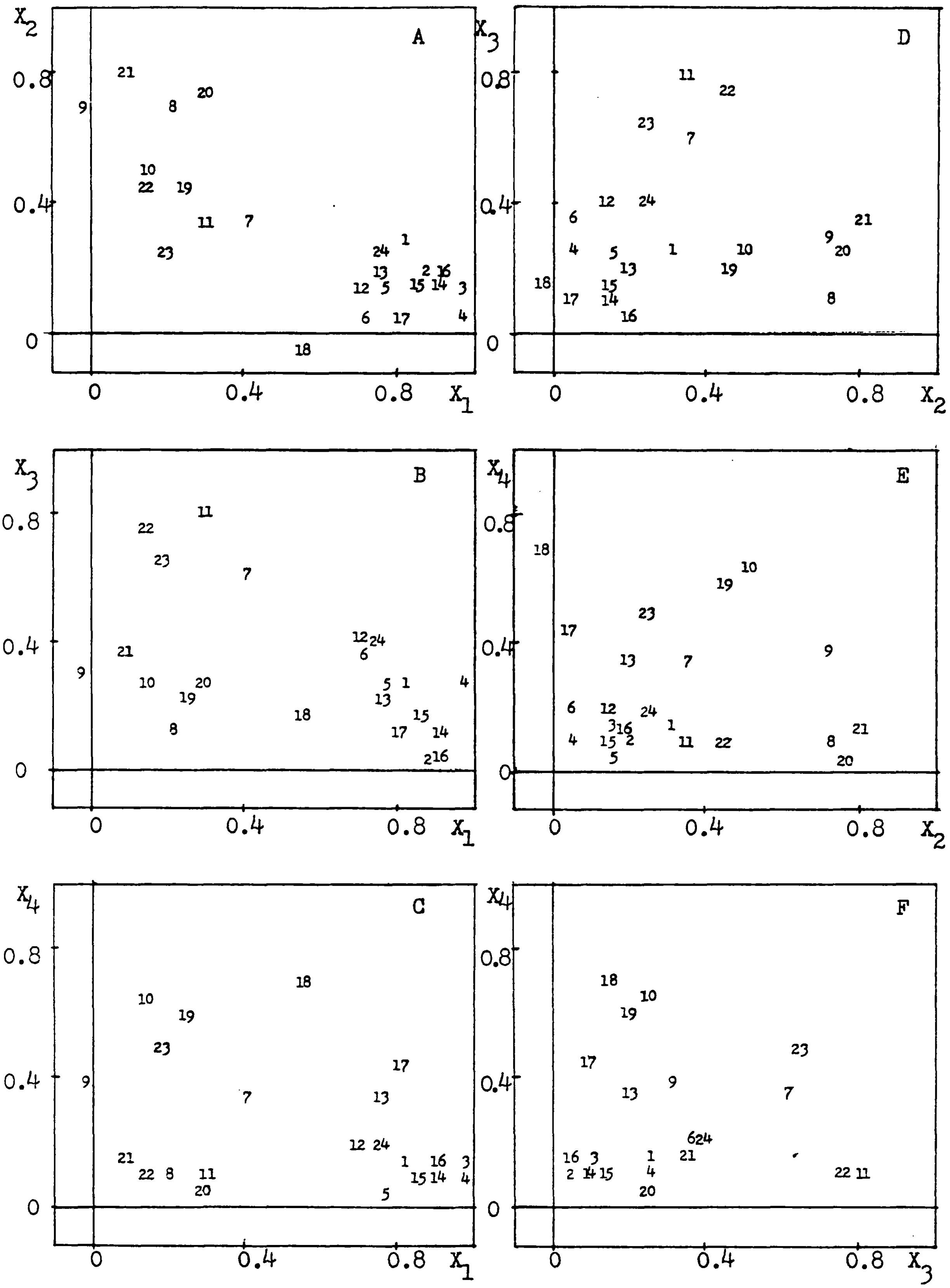


Fig. 6.2 Dendrogram resulting from nearest neighbour sorting of 24 monthly samples from Collier's Wood.

Fig. 6.3 Plots of the first four axes of the principal component analysis of 24 monthly samples from Collier's Wood.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
B	3	14
C	2	15
	6	12
D	2	16
	3	14
E	14	5
F	5	4
	8	14
	12	24


A
B
C
D
E
F
X1
X2
X3
X4
0
0.4
0.8

third axes and the second and third axes result in the separation of the May - September samples into two groups - one consisting of May '76, September '76, August and September '77 samples (7, 11, 22, 23) and the other of June - August '76, and May - July '77 samples (8 - 10, 19 - 21). A similar, but less clear-cut grouping of the May to September samples is achieved by plotting axes 3 and 4. In this plot, samples 7, 11, 22 and 23 are separated from the rest of the samples, but the remaining samples (8 - 10 and 19 - 21) are more closely grouped with the October to April samples.

Discussion

Comparison of the classificatory techniques with principal component analysis shows that both techniques separate the October to April samples from the May - September samples. This grouping of samples reflects the temporal variation in the abundance of the numerically more abundant species - *Micropeplus staphylinoides*, *Anthobium atrocephalum*, *A. unicolor*, *Omalium italicum*, *Othius punctulatus*, *Ocalea badia* and *Oxypoda lividipennis* as well as the less abundant species e.g. *Othius myrmecophilus*, which occurred in pitfall traps in Collier's Wood from around October to April or May while *Philonthus decorus* and *Tachinus signatus* occurred more commonly from May to September.

The general grouping of first year samples, and of second year samples, which is more evident in the dendrograms than in the plots of principal component analysis is possibly due to *Anthobium* spp. being trapped less abundantly in the first year than in the second, while *O. badia* and *O. lividipennis* were more abundant in the first year than in the second. The greater similarity of samples 19 and 20 as opposed to samples 7 and 8, which is evident in Fig. 6.1, is possibly because the catches of *M. staphylinoides*, *A. atrocephalum*, *P. decorus* and *Mycetoporus lepidus* were less variable in '77 than in '76.

The June and July samples are more effectively separated from the rest of the May to September samples by principal component analysis than by classificatory techniques. Examination of the raw data suggests that the grouping of June - July samples (8, 9, 20 and 21) by principal component analysis may be due to the relatively small number of species in these samples as compared to samples taken in other months, as well as the peak numbers of P. decorus and T. signatus trapped in these months.

(ii) Flat Hill

Classification

As a result of mean index sorting (Fig. 6.4), two groups may be distinguished at the 46% level of similarity - one group consists mainly of the November to April samples (samples 4 - 6, 8, 13 - 18) but also includes a June '76 sample, while the other consists mainly of the June - October samples although a May '77 sample (19), is also included. A further small group joins at the 30% level, comprising the November to January and May samples (1 - 3 and 7) of the first year of study.

Nearest neighbour sorting (Fig. 6.5) results in two distinct groups at the 68% level of similarity - the larger group consisting of January to April samples (4, 14 - 17) as well as August - November samples (10, 12, 13, 23) and a May (19) sample, while the smaller consists of July to September samples (9, 11, 21, 22). Below 68%, samples are added on one by one so that the resultant dendrogram shows less clear cut groupings of samples than that resulting from mean index sorting.

Although nearest neighbour sorting was applied to other similarity matrices, it generally resulted in the formation of a single large group in which smaller groups of samples were not clear-cut because samples were often added on one by one. The results of nearest neighbour

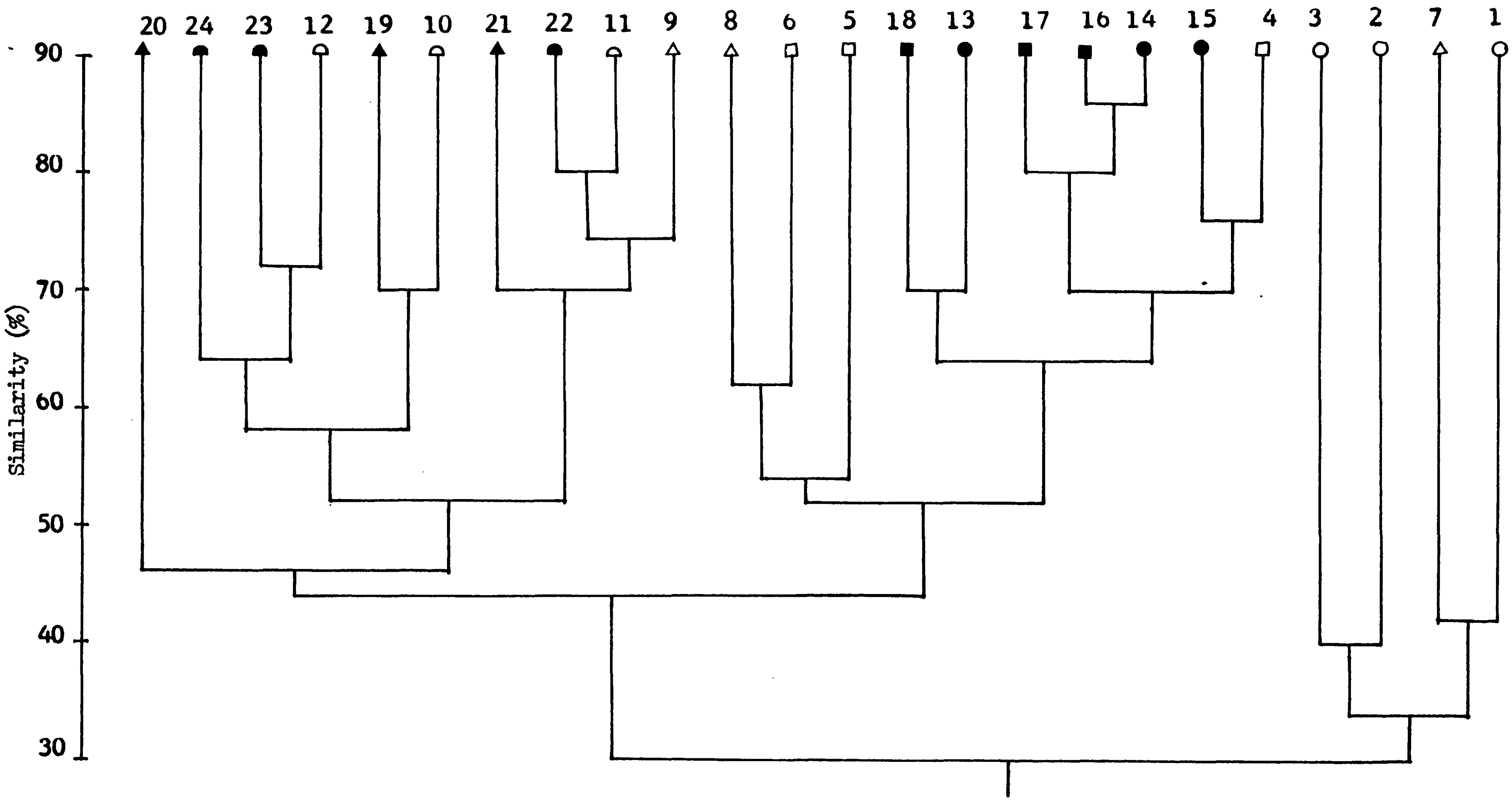


Fig. 6.4 Dendrogram resulting from mean index sorting of 24 monthly samples from Flat Hill.

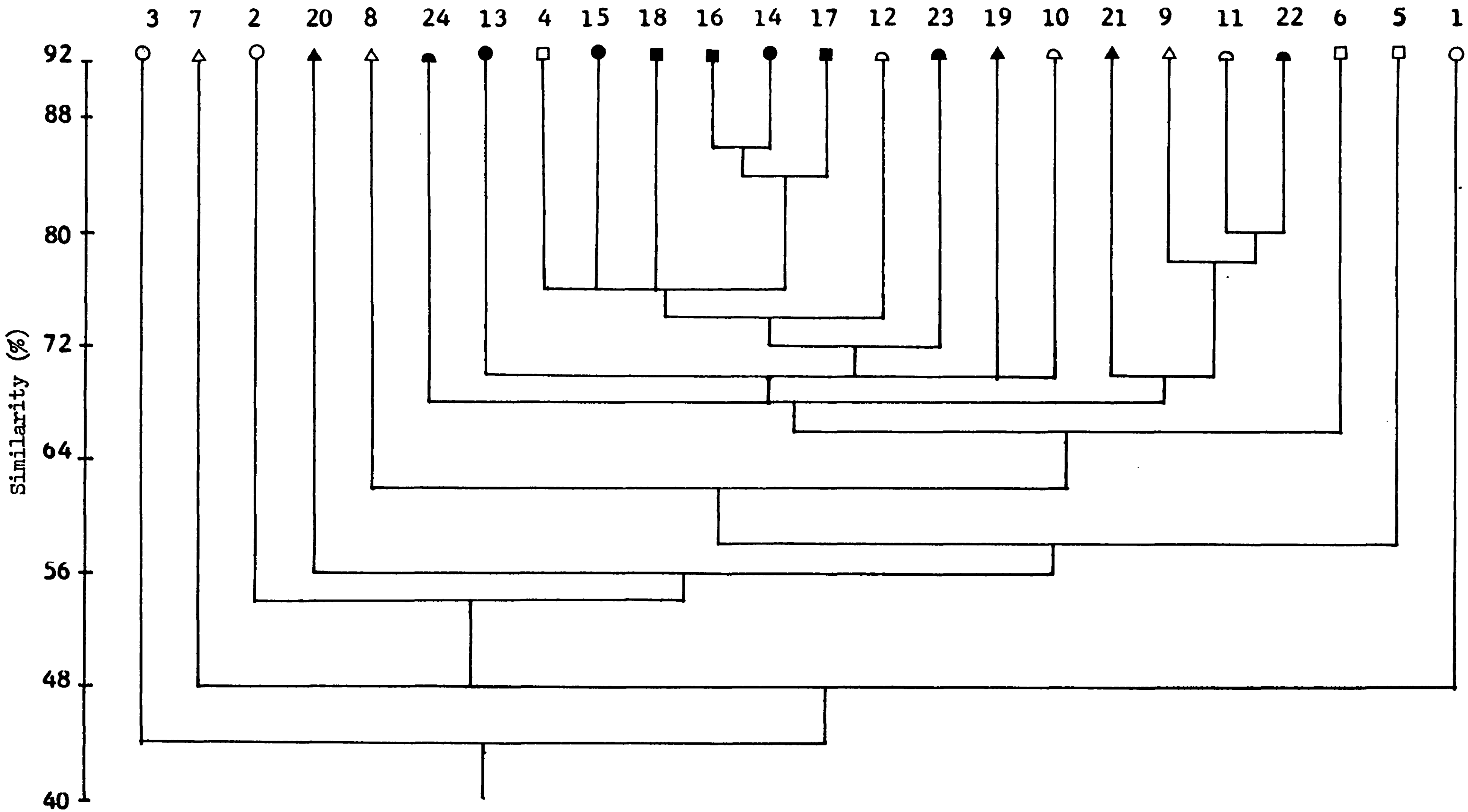


Fig. 6.5 Dendrogram resulting from nearest neighbour sorting of 24 monthly samples from Flat Hill.

sorting are therefore not discussed for other similarity matrices.

Ordination

The first four eigenvalues account for 70% of the variation in the samples (Table 6.2).

Table 6.2 First four eigenvalues from principal component analysis of γ matrix of 24 monthly samples from Flat Hill and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	11.65693	48.6	48.6
2	2.52084	10.5	59.1
3	1.48409	6.2	65.3
4	1.14333	4.8	70.0

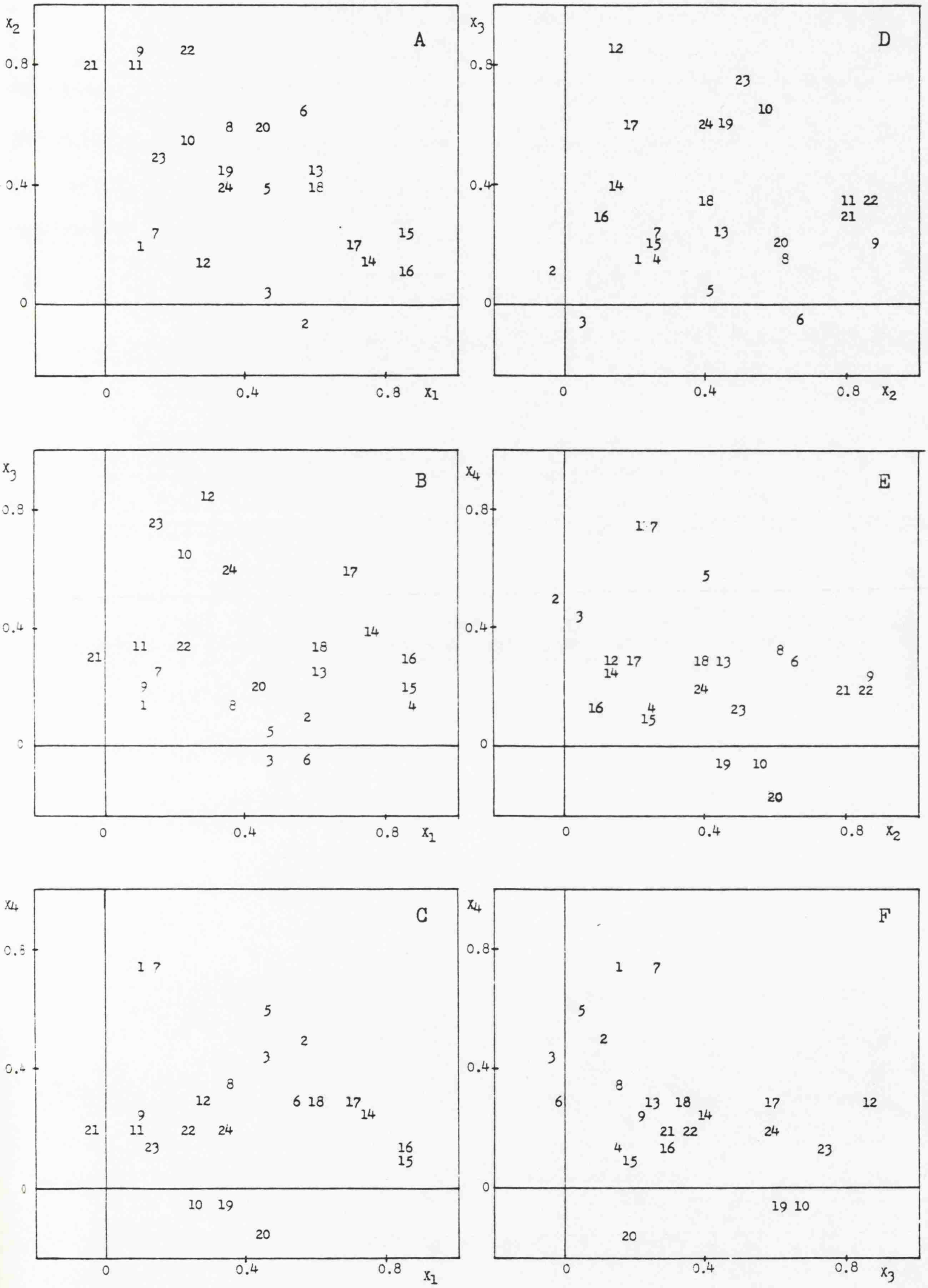
A plot of axes 1 and 2 (Fig.6.6) results in the separation of December '75 to March '76 and October '76 to April '77 samples (2 - 5 and 12 - 18 respectively) from the November '75, April to September '76 and May to October '77 samples (samples 1, 6 - 11, 19 - 24) along a line bisecting the angle between the axes. In general, the November to April samples (2 - 6, 13 - 18) have more positive values along axis 1, although the separation of these samples from the other samples is not very distinct.

In the plot of axes 1 and 3, samples 19 and 24 (May and October '77) are very closely paired. These samples are also closely grouped with samples 10 and 12 since they all assume high values along axis 3. The effect of this axis is thus to separate these August to October samples, and the May '77 sample, from the rest of the May to September samples. This effect is also evident in the plot of axes 3 and 4.

Fig. 6.6 Plots of the first four axes of the principal component analysis of 24 monthly samples from Flat Hill.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A	4	15
B	19	24
C	4	15
	13	18
E	11	21
F	11	22


A
x_2
x_1
0.8
0.4
0
21 9 11 22 6 8 20 10 23 19 24 5 13 18 7 1 17 14 15 16 12 3 2
B
x_3
x_1
12 23 10 24 17 14 11 22 18 21 7 13 16 9 20 15 1 8 4 2 5 3 6
C
x_4
x_1
1 7 5 2 3 8 12 6 18 17 14 9 21 11 22 24 23 16 15 10 19 20
D
x_3
x_2
12 23 10 17 24 19 14 18 11 22 16 21 7 13 15 20 1 4 9 8 2 5 3 6
E
x_4
x_2
1 7 5 2 3 8 12 17 18 13 6 14 9 24 21 22 16 4 23 15 19 10 20
F
x_4
x_3
1 7 5 2 3 8 6 13 18 17 12 14 9 21 22 24 4 16 23 15 19 10 20

The plots of axes 2 and 3 and 2 and 4 result in the grouping of samples 8, 9, 11, 20 - 22 (June to September samples) which take high positive values along axis 2. This group of samples is separated from a loose grouping of November to March samples (samples 1 - 5, 14 - 17) which take low positive values along axis 2, by a group comprising samples 10, 13, 18, 19, 23 and 24, which take intermediate values along this axis.

The various plots of the principal component analysis also result in the constant close pairings of samples 1 and 7 (November and May), 13 and 18 (November and April) and 19 and 24 (May and October).

Discussion

The absence of a temporal pattern in the results of mean index sorting and principal component analysis may be explained on examination of the species list. Temporal variations in the captures of the various species on Flat Hill are not very clear-cut e.g. peak numbers of *Philonthus* spp. and *Drusilla canaliculata* occur in the summer months, from May - July, but lesser numbers of these species are also captured at various intervals throughout the year. Similarly, the majority of captures of *Staphylinus aeneocephalus* and *Quedius curtipennis* and especially of *Xantholinus linearis* occur from November to March but a few isolated individuals are also captured during the summer months.

Further, captures of *Sepedophilus nigripennis*, *Tachyporus chrysomelinus* and *T. hypnorum* extend throughout the year, especially during the last one and a half years of the study. Two peaks in the abundance of both *T. chrysomelinus* and *T. hypnorum* occur, one from August/ September to November/December, the other from March - May. This may explain the grouping together of samples 1 and 7, 13 and 18, and 19 and 24.

The close grouping of samples 9, 11, 21 and 22 along axis 2 of the principal component analysis and in the dendrogram resulting from mean index sorting, may be explained by the relatively low numbers of T. chrysomelinus, and T. hypnorum in these samples, as well as by the presence in them of Drusilla canaliculata.

(iii) Stream

Only 28 of the 87 staphylinid species recorded in Charnwood Lodge are represented in the pitfall trap catches from the stream site. The majority of these appear intermittently throughout the year as single individuals, so that the monthly matrix of abundances contains a very large number of zero values. Further, no Staphylinidae are found in the pitfall traps in samples 1 (November '75) and 12 (October '76). These factors contribute to the large number of perfect positive correlations (modified τ values 100%) e.g. those between samples 10 and 16, 10 and 18, 13 and 16, 14 and 16 and 16 and 17, and perfect negative correlations (modified τ values 0%) e.g. those between samples 3 and 7, 4 and 7, 22 and 24, as well as pairs of samples with zero τ values (modified τ values 50%) e.g. 1 and 12 with the rest of the samples. Comparisons of samples 1 and 12, in which the Staphylinidae are absent, with the rest of the samples, result in indeterminate values of τ which appear as $\tau = 0$. These values must be distinguished from the zero τ values which result from the comparison of samples containing individuals, but which show no correlation at all.

Classification

Mean index sorting results in two groups of samples at the 20% level of similarity - one group consisting mainly of November - April samples (2 - 6, 10, 13 - 19), the other of June - October samples (1, 7 - 9, 11, 12, 20 - 24) though November and May samples are represented in each grouping (Fig. 6.7).

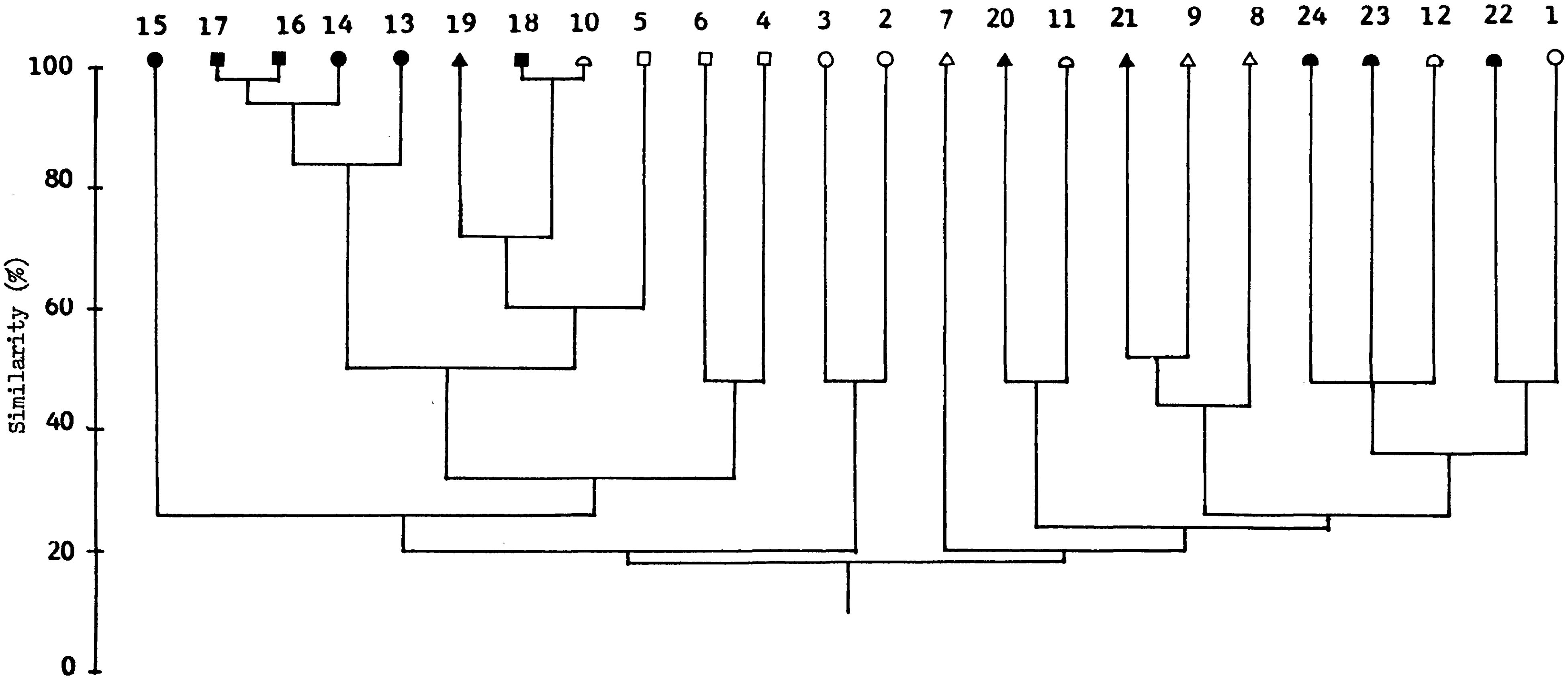


Fig. 6.7 Dendrogram resulting from mean index sorting of 24 monthly samples from the stream site.

Each of these two major groups consist of smaller groups. The largest group within the general November - April grouping includes samples from November to May of the second year of the study, and the March and August '76 samples, while the largest group within the June to October grouping includes the August to October samples (1, 12, 22 - 24).

Within each major grouping, monthly samples are grouped according to a temporal pattern. Samples obtained from a particular month are generally grouped with samples from the same month in the following year, or with samples taken in consecutive months e.g. the June '76, and July '76 and '77 samples are grouped together.

Ordination

62% of the variation in the samples is accounted for by the first four eigenvalues of the principal component analysis (Table 6.3).

Table 6.3 First four eigenvalues from principal component analysis of γ matrix of 24 monthly samples from the stream site and percentage of variation extracted by each axis.

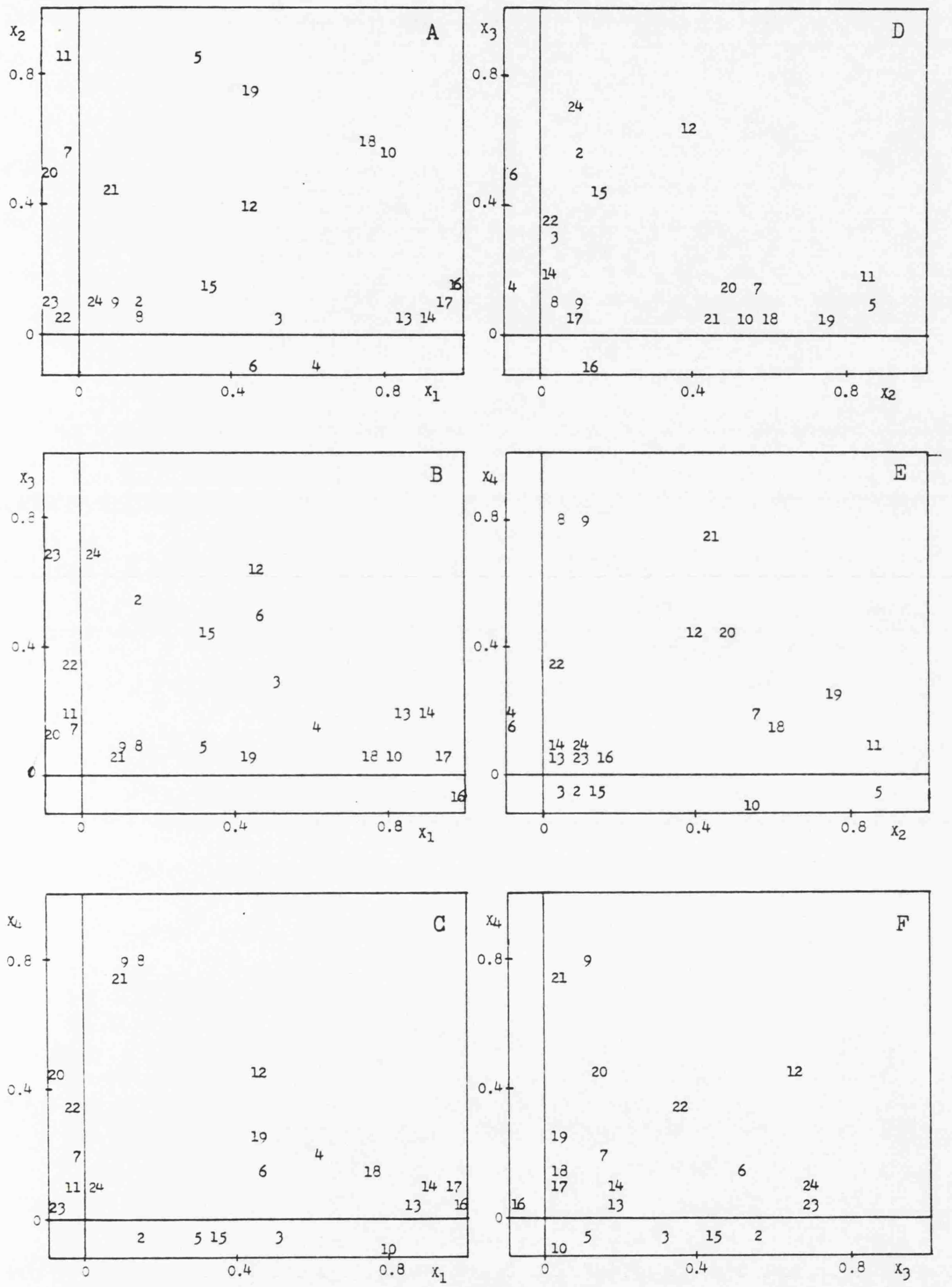
Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	8.18970	34.1	34.1
2	3.16537	13.2	47.3
3	2.10722	8.8	56.1
4	1.43272	6.0	62.1

In plots of the various axes (Fig.6.8), samples taken from consecutive months and samples taken from the same month in different years generally appear together. Samples 8 and 9, for example, consistently appear together in all the plots. Samples taken from March to August (4, 5, 7 - 11, 17 - 21) generally take low positive values along axis 3, while November

Fig. 6.8 Plots of the first four axes of the principal component analysis of 24 monthly samples from the stream site.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A	1	12
B	1	12
C	1	12
D	1	12
	13	14
	23	24
E	1	12
F	1	12
	4	7
	8	9
	11	14



A
x_2
x_1
B
x_3
x_1
C
x_4
x_1
D
x_3
x_2
E
x_4
x_2
F
x_4
x_3
0
0.4
0.8

to January samples, as well as the April '76 and August to October '77 samples (2, 3, 6, 13 - 15, 22 - 24) take higher positive values along this axis. Only the plot of axes 2 and 4 results in a very close grouping of samples. October to February (2, 3, 13 - 16, 21 - 24) samples are clustered together near the origin, while the rest of the samples are more scattered. Samples 10 (August) and 18 (April) also consistently appear close together in the various plots.

Discussion

The high degree of similarity between samples 13 to 18, which is evident in both the dendrogram and in the plots of principal component analysis is due largely to the presence of Xantholinus linearis and Tachyporus hypnorum in these samples. The similarity between samples 10 and 18 may be explained by the presence of higher numbers of T. hypnorum relative to T. chrysomelinus in these samples.

(iv) Timberwood Hill

Classification

Mean index sorting results in three distinct groups of samples at the 40% level of similarity (Fig. 6.9). The largest group consists of November to May samples (1, 4 - 7, 10, 12 - 19) as well as the October '76 (12) and June '77 (20) samples. The second major group generally consists of June - October samples (8, 9, 11, 21 - 24), while the smallest group consists of samples 2 and 3 (December '75 and January '76). Within the largest group, samples 7, 10, 12 - 14, 17 - 20 are separated from smaller groups of samples 15 and 16, and 1, 5, and 6.

Ordination

The first four eigenvalues of the principal component analysis of the τ matrix account for 71% of the variation in the samples (Table 6.4).

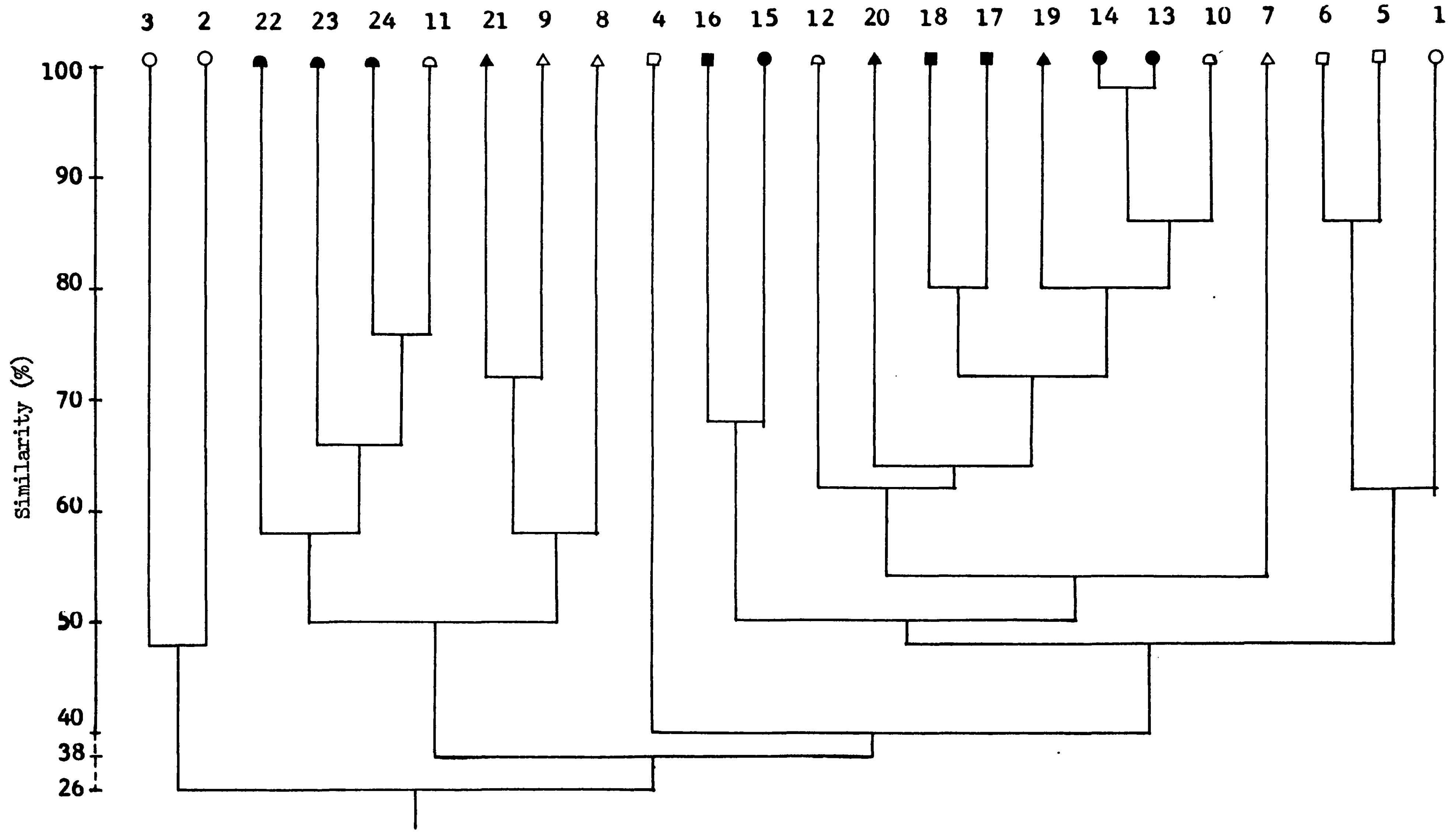


Fig. 6.9 Dendrogram resulting from mean index sorting of 24 monthly samples from Timberwood Hill.

Table 6.4 First four eigenvalues from principal component analysis of τ matrix of 24 monthly samples from Timberwood Hill and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	11.66059	48.6	48.6
2	2.73343	11.4	60.0
3	1.60996	6.7	66.7
4	1.14193	4.8	71.4

Axis 1 generally separates samples 7, 10, 12 - 14 and 17 - 20 from the remaining samples (Fig. 6.10). There is a general separation of May - October samples (8 - 11, 19 - 24) from November - April samples along axis 2, since the former samples assume higher values along this axis. The November '75 to April '76 samples (1 - 3, 5 and 6) are further separated from the rest of the November to April samples along axis 4, since they take higher values along this axis. The plot of axes 2 and 4 thus results in three distinct groups of samples, a group containing the November '75 to April '76 samples, another containing the rest of the November to April samples, and a third of samples 9 - 11, and 19 - 24. Axis 3 separates samples 4, 15 and 16 from the rest of the samples.

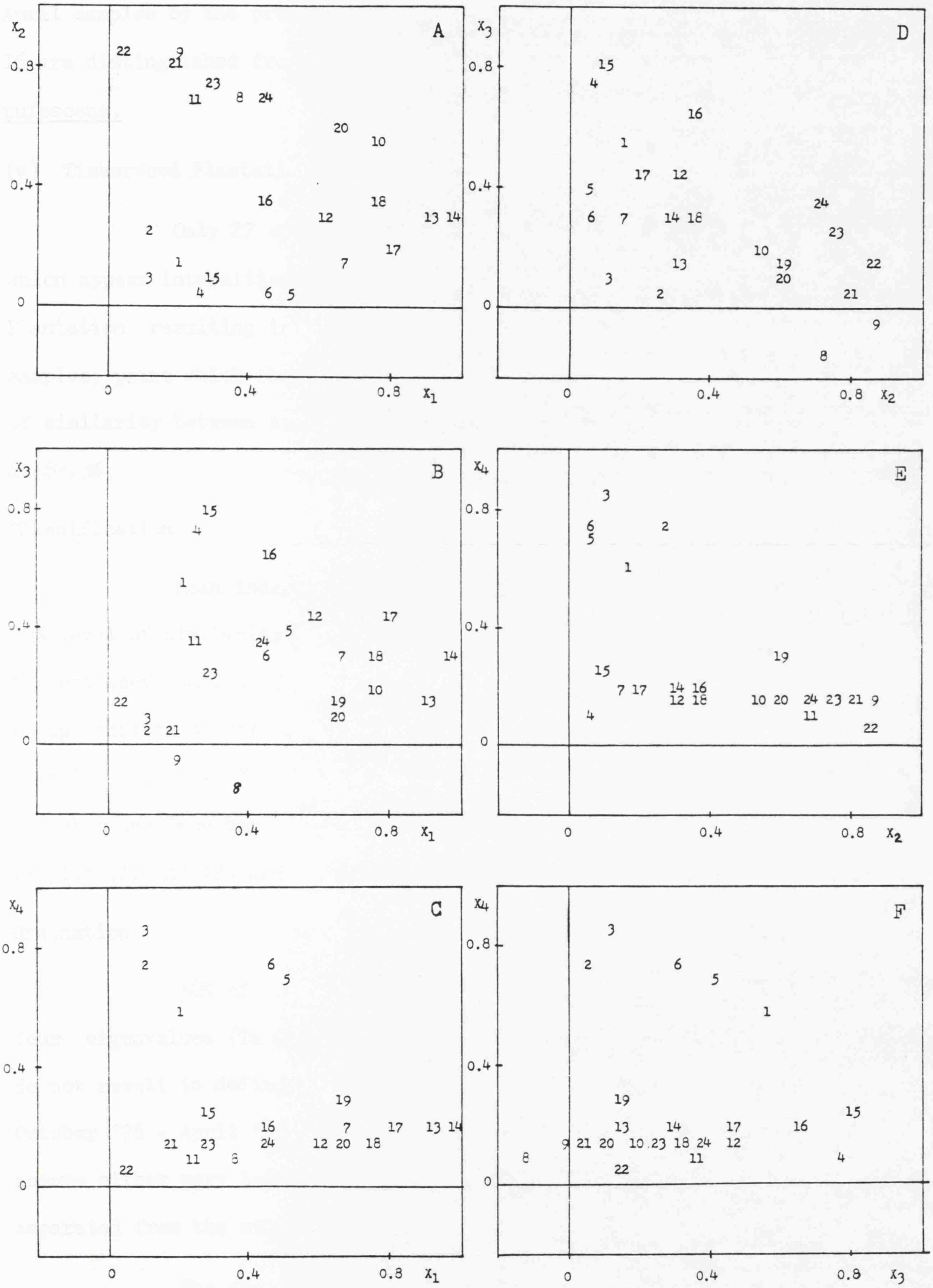
Discussion

The separation of samples 7, 10, 12 - 14 and 17 - 20 from the rest of the samples by axis 1 of the principal component analysis, and in the dendrogram, is largely due to the presence of large numbers of *Tachyporus chrysomelinus* and *T. hypnorum* in these samples. *Dinaraea angustula*, *Drusilla canaliculata*, *Stenus impressus* and other Aleocharinae distinguish the May - October samples from the November to April samples.

Fig. 6.10 Plots of the first four axes of the principal component analysis of 24 monthly samples from Timberwood Hill.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A	19	20
C	4	11
	9	21
	10	18
D	11	24
E	8	11
	13	14
F	7	14



A
x_1
x_2
B
x_1
x_3
C
x_1
x_4
D
x_2
x_3
E
x_2
x_4
F
x_3
x_4
0
0.4
0.8

Samples 1 - 3, 5 and 6 are distinguished from the rest of the November to April samples by the presence of Olophrum piceum, while samples 4, 15 and 16 are distinguished from the others by the presence of Mycetoporus rufescens.

(v) Timberwood Plantation

Only 27 species, the majority of which are single individuals which appear intermittently, are found in the samples from Timberwood Plantation resulting in a large number of negatively correlated pairs of samples, pairs which show no correlation at all, and a generally low level of similarity between samples. Samples 6 and 20 are the most similar, at 87.3%.

Classification

Mean index sorting results in five groups of samples at the 30% level of similarity (Fig. 6.11). The largest group consists of March to September samples (5 - 8, 10, 19 - 21 and 23). The second largest group consists of six samples, taken from November '76 to October '77 (samples 13, 15 - 17, 22 and 24). The three smaller groups consist of November and December samples (1, 2 and 14), September and October samples (11 and 12) and January '76 and April '77 samples (3 and 18).

Ordination

58% of the variation in the samples is extracted by the first four eigenvalues (Table 6.5). Plots of the first four axes (Fig. 6.12) do not result in definite groupings of samples although the January '76, October '76 - April '77 and October '77 samples (3, 12 - 18 and 24) assume either very low or negative values along axis 1 and are thus separated from the other samples.

The absence of a definite grouping of samples according to

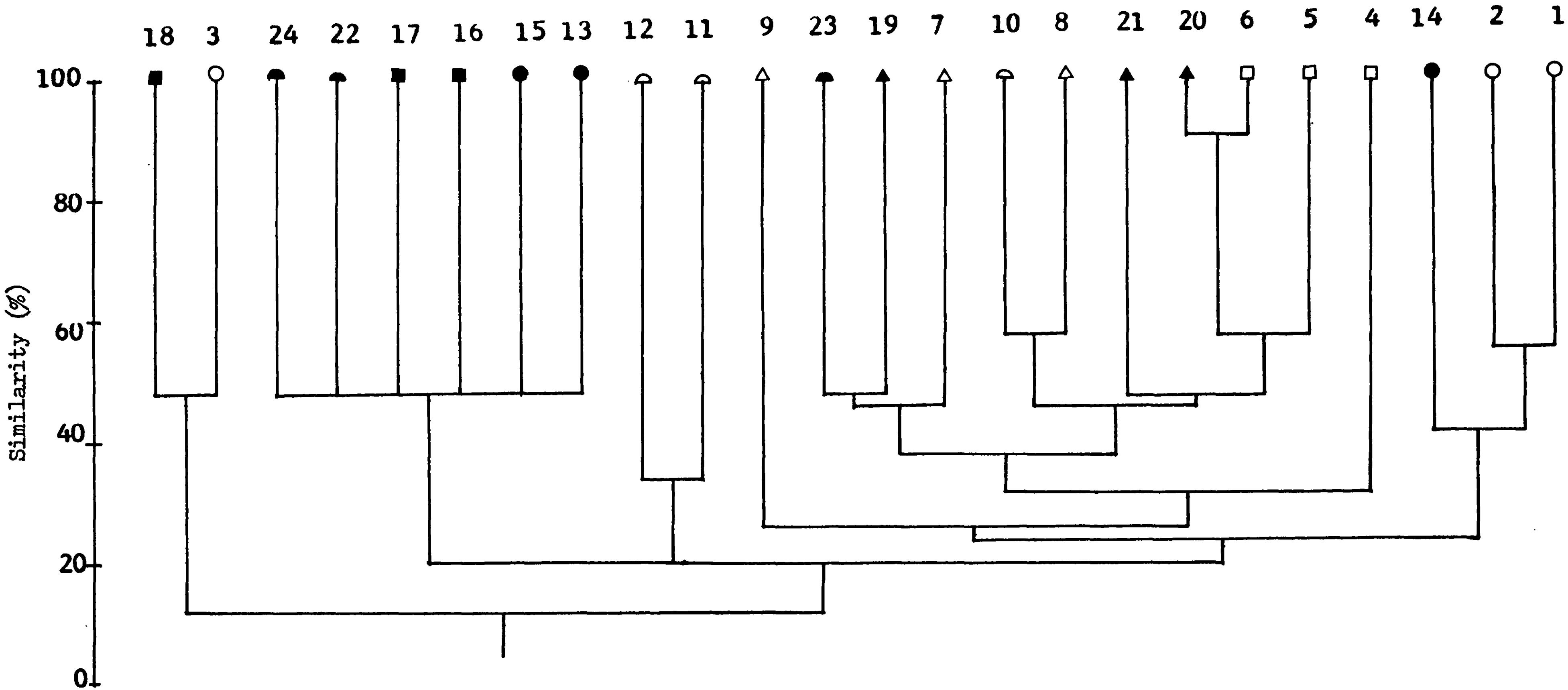


Fig. 6.11 Dendrogram resulting from mean index sorting of 24 monthly samples from Timberwood Plantation.

Fig. 6.12 Plots of the first four axes of the principal component analysis of 24 monthly samples from Timberwood Plantation.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A,B,E	3	18
	8	10
	13	16
	15	24
	17	24
	19	22
C,F	3	18
	13	16
	15	24
	17	24
	19	22
D	3	18
	6	14
	8	10
	13	16
	15	24
	17	24
	19	22

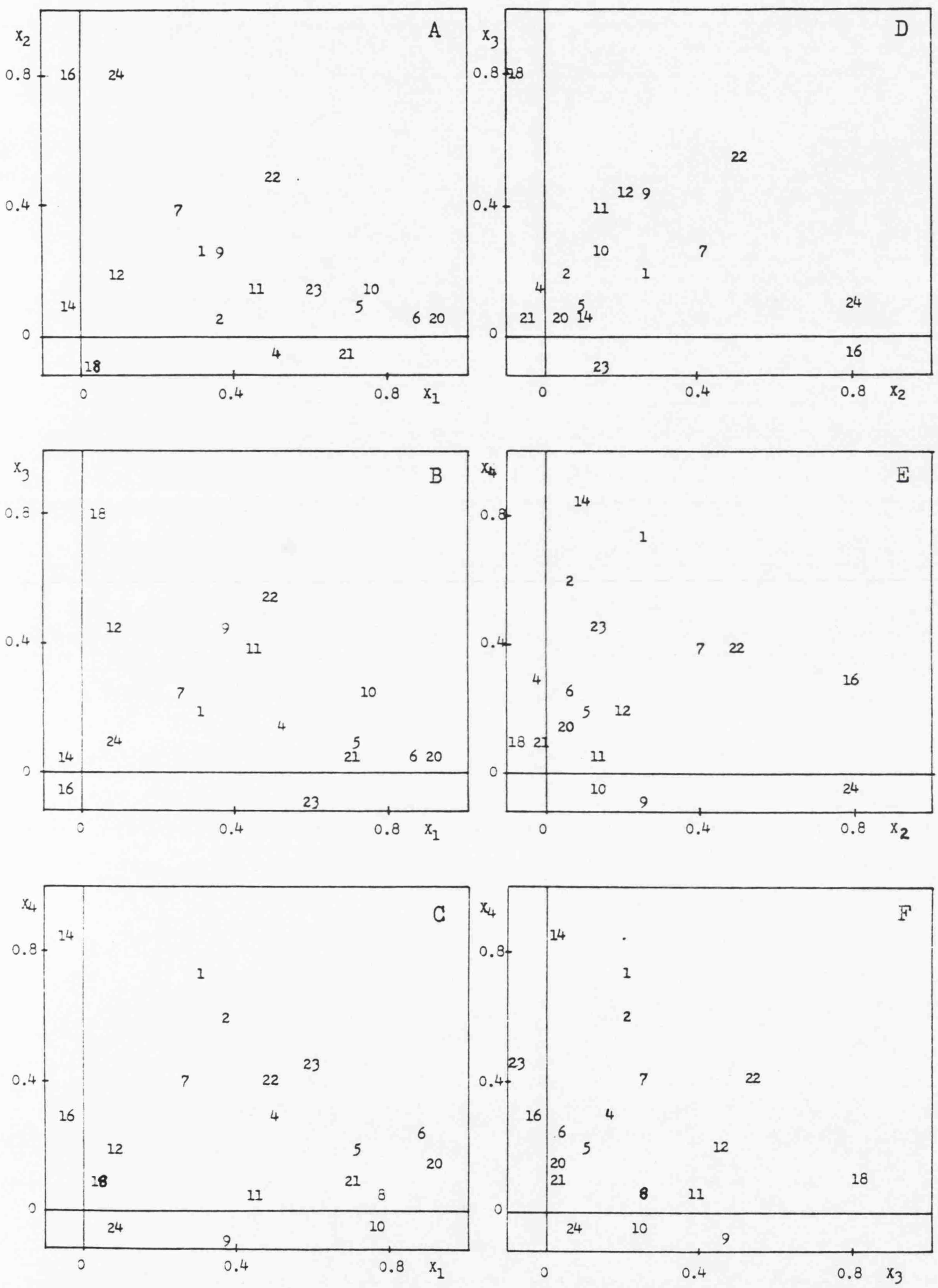

A
x_2
x_1
0
0.4
0.8
16 24 22 7 1 9 12 11 23 10 14 5 2 6 20 4 21 18
D
x_3
x_2
18 22 12 9 11 10 7 2 1 4 5 24 21 20 14 16 23
B
x_3
x_1
18 22 12 9 11 7 10 1 4 24 5 14 21 6 20 16 23
E
x_4
x_2
14 1 2 23 7 22 4 16 6 5 12 20 18 21 11 10 24 9
C
x_4
x_1
14 1 2 23 7 22 16 4 6 12 5 20 18 21 11 8 24 10 9
F
x_4
x_3
14 1 2 23 7 22 16 4 6 5 12 20 21 18 8 11 24 10 9

Table 6.5 First four eigenvalues from principal component analysis of γ matrix of 24 monthly samples from Timberwood Plantation and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	7.53831	31.4	31.4
2	3.00774	12.5	43.9
3	1.81425	7.6	51.5
4	1.60934	6.7	58.2

a temporal sequence, especially in the principal component analysis, is due to the presence of the various species in pitfall traps at irregular intervals throughout the year, while samples 3, 12 - 18 and 24 are distinguished from the rest by the absence of other Aleocharinae and the presence of few other species compared to the other samples.

6.4.2 Charnwood Lodge Site Comparisons

When staphylinid captures are summed to produce quarterly, half-yearly and yearly totals (cf. Table 5.1), and the totals from all the five Charnwood Lodge sites are compared, they should provide information on the grouping of samples i.e. whether habitat type or temporal factors affect the formation of sample groups. To simplify discussion, samples from the first quarter i.e. November to January samples are designated as winter samples, February to April samples as spring samples, May to July samples as summer samples and August to October samples as autumn samples. Samples from the first half-year of the study (November to April) are designated winter-spring samples while those from the second half-year are designated summer-autumn samples. These temporal groupings of samples are listed in Table 6.6.

Table 6.6 Classification of monthly samples from Charnwood Lodge sites.

Samples	Months	Seasonal Group
1 - 3, 13 - 15	November - January	Winter
4 - 6, 16 - 18	February - April	Spring
7 - 9, 19 - 21	May - July	Summer
10 - 12, 22 - 24	August - October	Autumn
1 - 6, 13 - 18	November to April	Winter - spring
7 - 12, 19 - 24	May - October	Summer - autumn

Classification

Mean index sorting of the quarterly, half-yearly and annual samples results in the separation of woodland samples from samples from the more open sites (Figs. 6.13, 6.14, 6.15). In the woodland group resulting from the quarterly comparisons, all the Collier's Wood samples are very similar to each other and the winter and spring samples from this site show the highest level of similarity. Half of the Timberwood Plantation samples, i.e. the first winter sample, and the winter, spring and summer samples of the second year, are grouped with the Collier's Wood samples while the remaining samples appear more similar to samples from the more open sites.

When the half-yearly samples are compared, the relationships between samples taken from different sites differ in some respects from those resulting from the quarterly comparisons. The woodland group resulting from the comparisons of half-yearly samples thus consists of all the Collier's Wood and Timberwood Plantation samples, which are generally grouped according to a temporal pattern. Three winter-spring samples (1, 3 and 19 in Fig. 6.14) are grouped together, two from Collier's Wood and

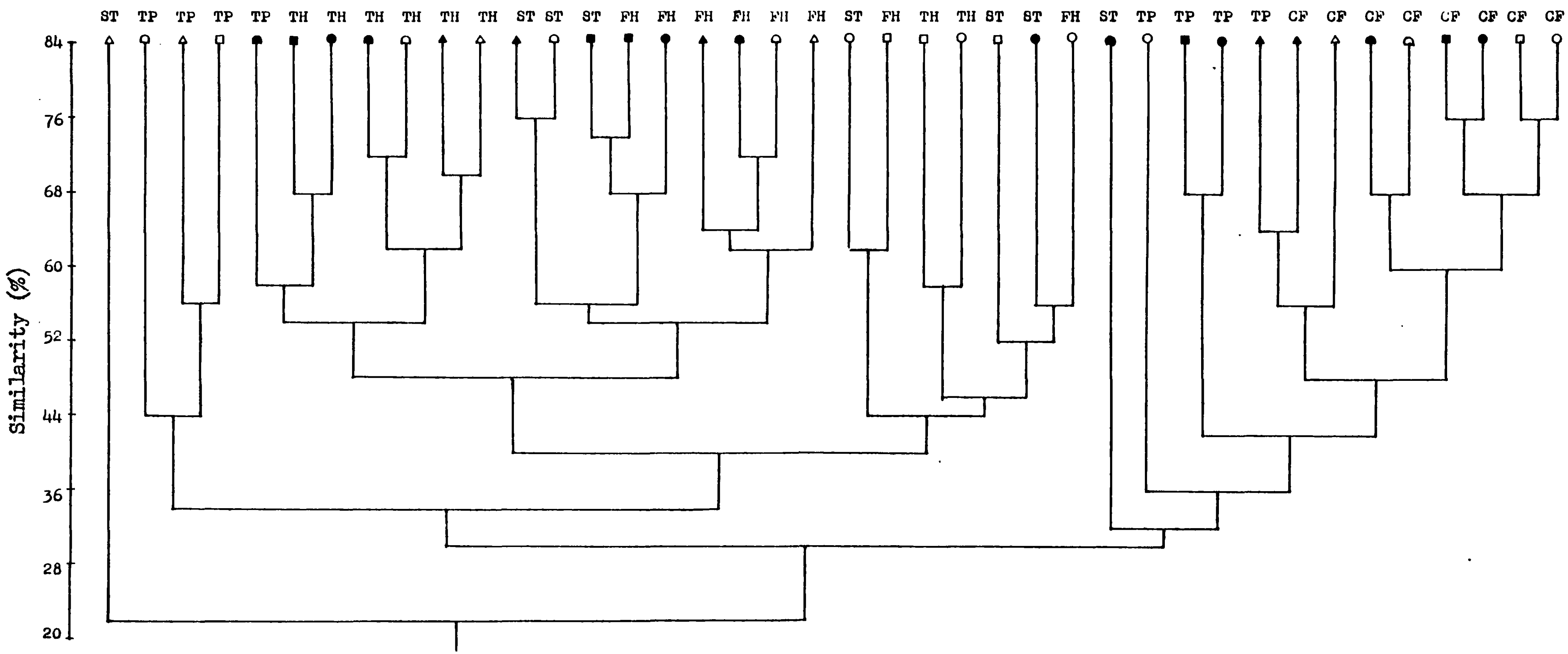


Fig. 6.13 Dendrogram resulting from mean index sorting of 40 quarterly samples from Charnwood Lodge sites.

CF - Collier's Wood FH - Flat Hill ST - stream TH - Timberwood Hill TP - Timberwood Plantation

○ - winter sample □ - spring sample △ - summer sample ⌂ - autumn sample of first year

Shaded symbols represent second year samples

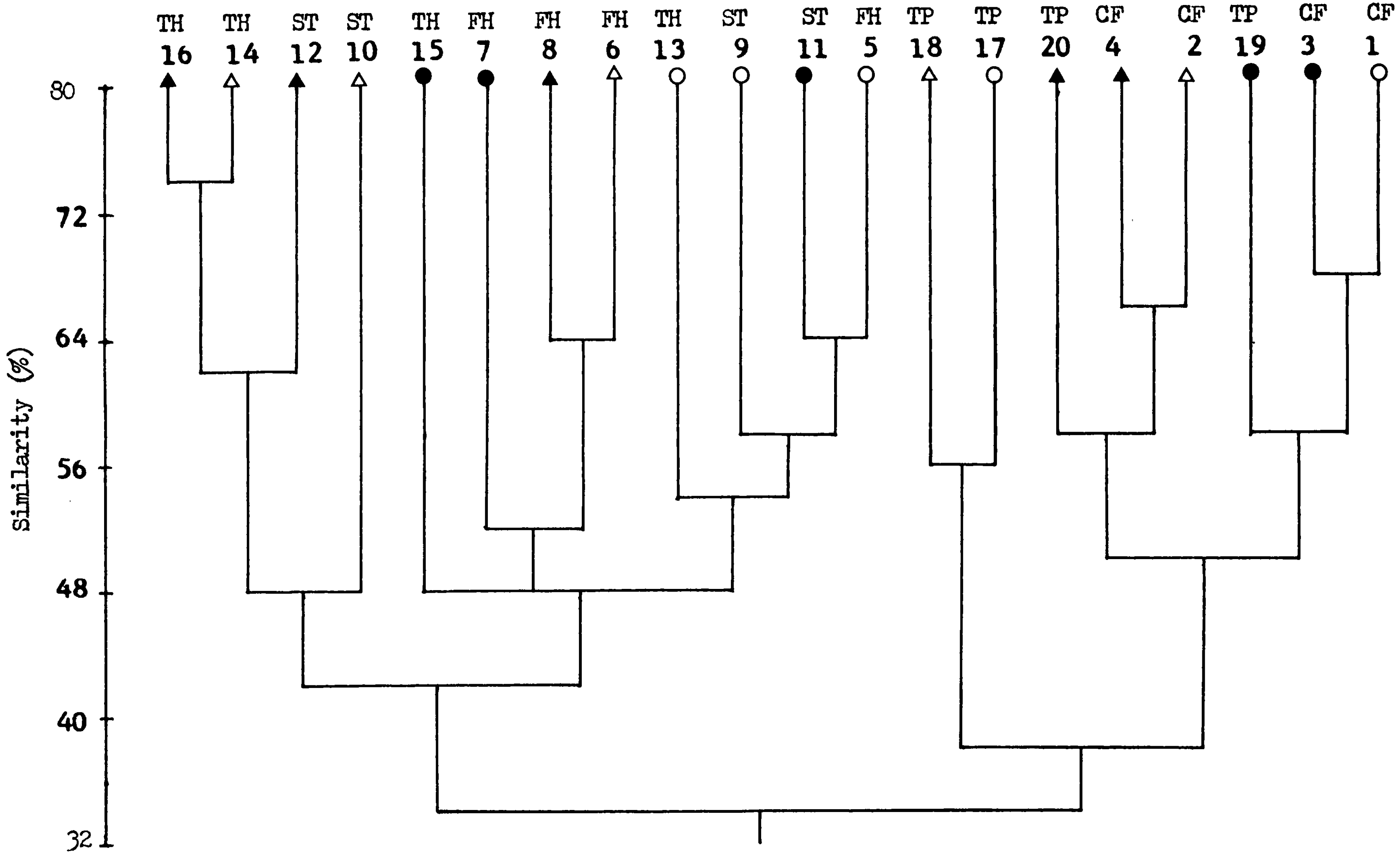


Fig. 6.14 Dendrogram resulting from mean index sorting of 20 half-yearly samples from Charnwood Lodge sites.

○ - winter-spring sample of first year

△ - summer-autumn sample of first year

Shaded symbols represent second year samples.

one from Timberwood Plantation, while two summer-autumn samples (2 and 4) from Collier's Wood and another from Timberwood Plantation (20) form another group. The first two half-yearly samples from Timberwood Plantation form a separate group since the corresponding quarterly samples are more similar to samples from the open sites.

In the comparison of annual samples (Fig. 6.15), the second year samples from Collier's Wood and Timberwood Plantation are more similar than samples taken from different years in the same site.

In the quarterly comparisons, the group of mainly open site samples consists of three smaller groups (Fig. 6.13). The largest of these comprises two groups, one of mainly summer and autumn samples from Timberwood Hill and an autumn sample from Timberwood Plantation, and the other of mainly summer and autumn Flat Hill samples and three stream samples. The second group consists of winter and spring samples of the first year of the study from Flat Hill and Timberwood Hill and three winter and spring samples from the stream site, while the smallest group consists of the first year spring, summer and autumn samples from Timberwood Plantation. Thus, there is a general grouping of summer and autumn Timberwood Hill samples, and another of Flat Hill samples. Winter and spring samples from both these sites form another grouping, while samples taken from the stream site are more similar to Flat Hill samples in both these groupings. At both Timberwood Hill and Flat Hill, summer and autumn samples are more similar than winter and spring samples. The relationships between the group of quarterly winter and spring samples from Flat Hill, Timberwood Hill and the stream remain generally unaltered in the half-yearly comparisons (Fig. 6.14), so that a group consisting of winter-spring samples from these sites (samples 5, 9, 11 and 13 in Fig. 6.14) results. However, the relationships between the other samples are altered so that the summer-autumn samples from the stream are grouped with similar samples from Timberwood Hill, and another group, consisting of only Flat Hill samples, is formed.

In the comparison of annual open site samples, greater similarities are found within sites than between catches from the same year in different sites. Thus, the two samples from Flat Hill (3 and 4 in Fig. 6.15) are grouped together, as are those from the stream (5 and 6) and those from Timberwood Hill (7 and 8).

Ordination

The principal component analyses of quarterly, half-yearly and annual samples result in the distinct separation of woodland samples from open site samples.

In the quarterly comparisons, the first four eigenvalues extract 60% of the variation in the samples (Table 6.7). The plot of

Table 6.7 First four eigenvalues from principal component analysis of τ matrix of 40 quarterly samples from Charnwood Lodge, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	16.14168	40.4	40.4
2	3.72162	9.3	49.7
3	2.39653	6.0	55.6
4	1.66343	4.2	59.8

axes 1 and 2 (Fig. 6.16) shows a distinct group of woodland samples (1 - 8, 33 - 39), and a larger group of open site samples. The latter group may be further subdivided into a group of winter and spring samples (9, 10, 13, 14, 17, 18, 21, 22, 25 and 26) and another consisting mainly of summer and autumn samples (11, 12, 15, 16, 20, 23, 27 - 29, 31

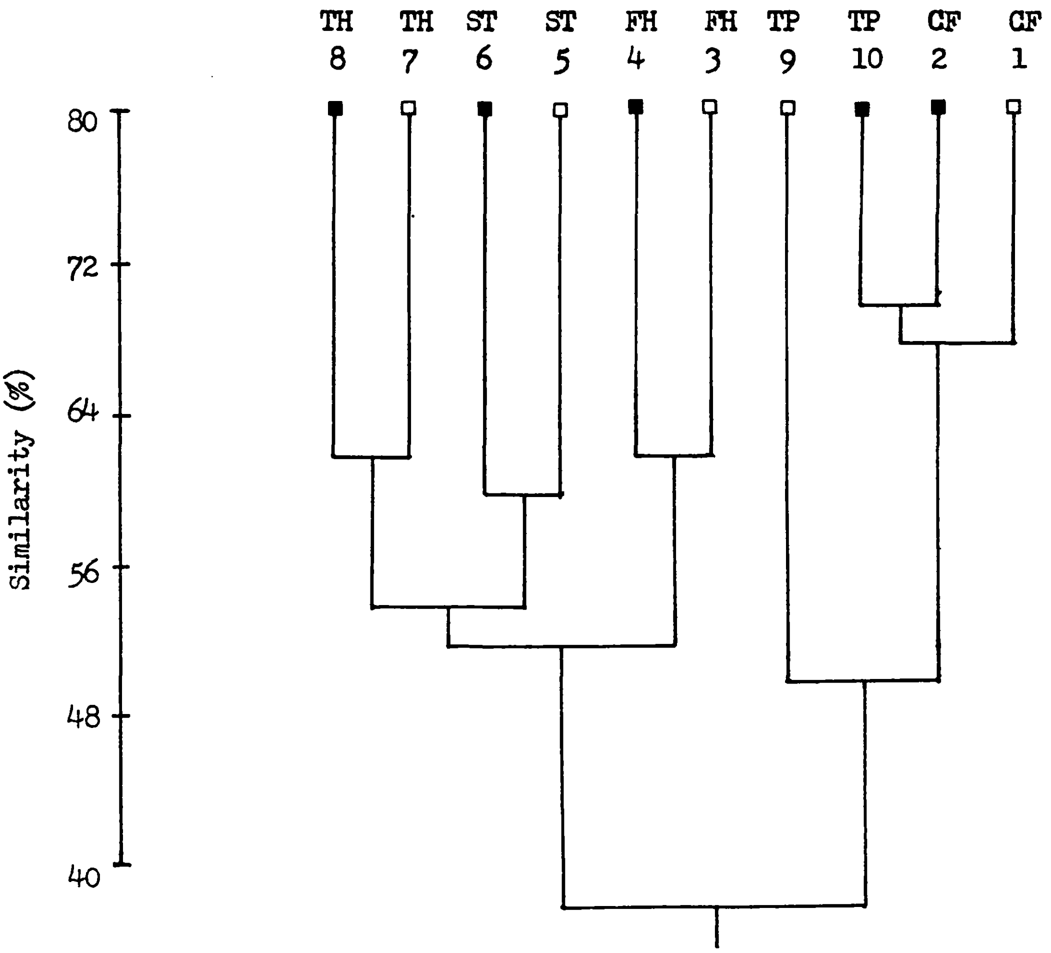


Fig. 6.15 Dendrogram resulting from mean index sorting of 10 yearly samples from Charnwood Lodge sites.

Samples	Site	Site abbreviation
1,2	Collier's Wood	CF
3,4	Flat Hill	FH
5,6	Stream	ST
7,8	Timberwood Hill	TH
9,10	Timberwood Plantation	TP

□ represent first year samples

■ represent second year samples

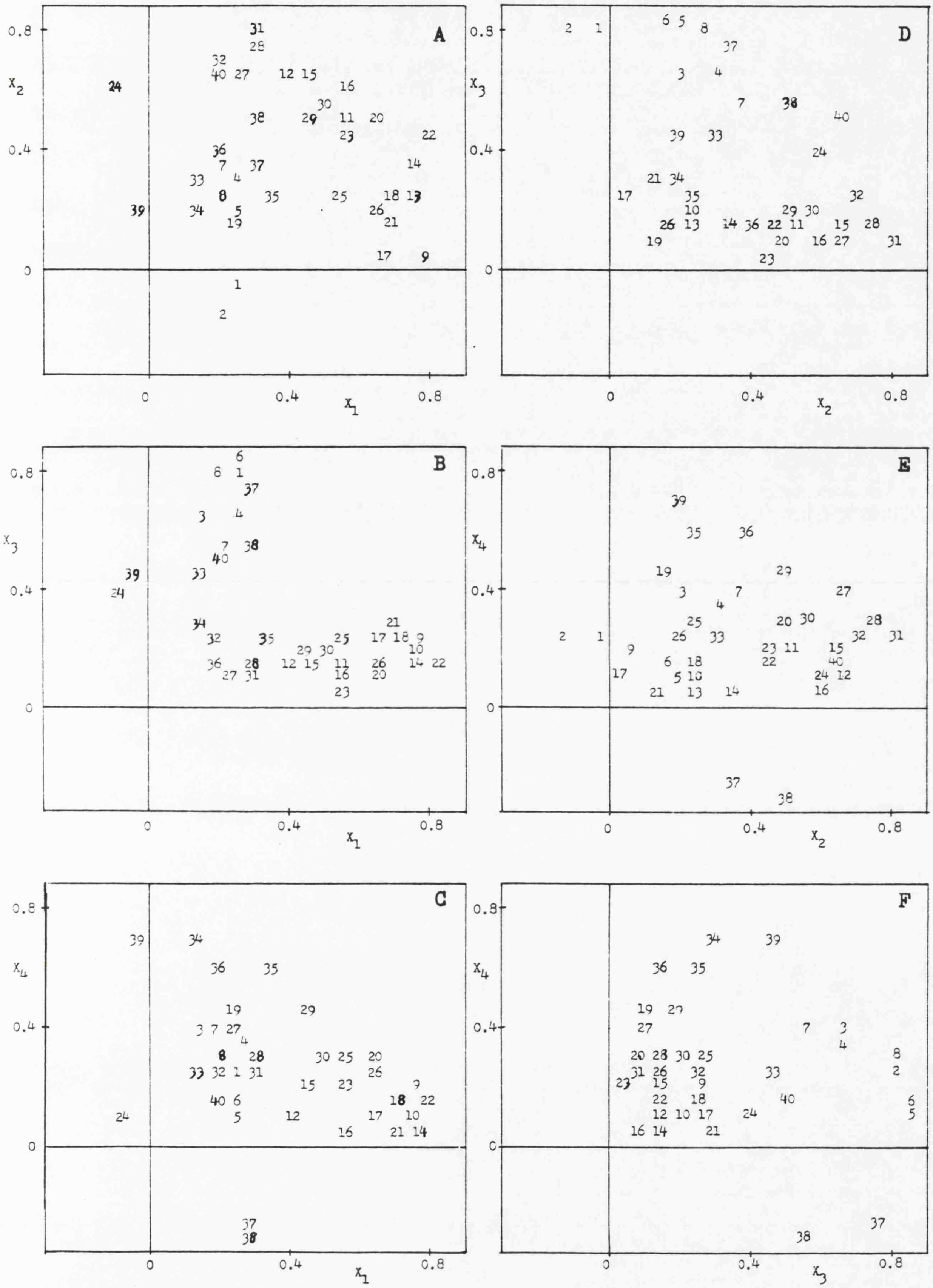
Fig. 6.16 Plots of the first four axes of the principal component analysis of 40 quarterly samples from Charnwood Lodge sites.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A	3	34
	6	19
	10	13
B	2	8
	5	6
	13	22
	19	27
C	2	33
	11	23
	13	14
D	9	17
	12	15
	18, 25	35
E	8	25
	34	39
F	1	2
	11	15
	13	14

In these plots, the numbers correspond to samples as follows:-

Sites	CF	FH	ST	TH	TP	Quarter	
	1	9	17	25	33	winter	(Nov '75 - Jan '76)
	2	10	18	26	34	spring	(Feb '76 - Apr '76)
	3	11	19	27	35	summer	(May '76 - Jul '76)
	4	12	20	28	36	autumn	(Aug '76 - Oct '76)
	5	13	21	29	37	winter	(Nov '76 - Jan '77)
	6	14	22	30	38	spring	(Feb '77 - Apr '77)
	7	15	23	31	39	summer	(May '77 - Jul '77)
	8	16	24	32	40	autumn	(Aug '77 - Oct '77)


A
B
C
D
E
F
x_1
x_2
x_3
x_4
0
0.4
0.8

and 32). Plots of axes 1 and 3, 2 and 3, and 3 and 4 also result in the separation of woodland from open site samples, with the woodland samples taking higher positive values along axis 3, although samples 34 - 36 from Timberwood Plantation are more closely grouped with the open site samples. In these plots the open site samples are very closely grouped together, while the woodland samples are more spaced. Within the open site group, the winter and spring samples are separated from the summer and autumn samples along axis 1 since the former samples assume greater values along this axis. The plots of axes 2 and 4 result in the grouping, irrespective of site, of winter and spring samples close to the origin. Within each of the seasonal groupings in the various plots, samples taken from the same site are generally grouped together. In the plot of axes 2 and 4, for example, samples 10, 13, 14 and 16 from Flat Hill are grouped together, as are samples 27 - 32 from Timberwood Hill. The stream samples are generally grouped more closely with the Flat Hill samples than with the Timberwood Hill samples.

The first four eigenvalues together account for 66% of the variation in the half-yearly samples (Table 6.8). Woodland samples are

Table 6.8 First four eigenvalues from principal component analysis of γ matrix of 20 half-yearly samples from Charnwood Lodge, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	8.97601	44.9	44.9
2	2.02145	10.1	55.0
3	1.29426	6.5	61.5
4	0.93882	4.7	66.2

generally separated from open site samples since they assume higher values along axis 1 (Fig. 6.17). A plot of axes 2 and 3 groups the woodland samples close to the origin. Within the woodland group, samples taken from Collier's Wood (samples 1 - 4) are generally more closely grouped together than are samples from Timberwood Plantation. Within the open site group of samples, the identity of each site is less evident, although in the plot of axes 1 and 4, a group of Flat Hill samples (5 - 8) is separated by two stream samples (9 and 12) from another of Timberwood Hill samples (13 - 16).

Groupings according to a temporal pattern are less evident than groupings according to habitat although the values for the summer-autumn samples from open sites are higher along axis 2 and in the plot of axes 2 and 3, the summer-autumn samples from all the sites are separated from the winter-spring samples along the line bisecting these axes.

The first four eigenvalues extract 78% of the variation in the annual samples from the five sites (Table 6.9). Plots of the first

Table 6.9 First four eigenvalues from principal component analysis of γ matrix of 10 annual samples from Charnwood Lodge, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	5.23479	52.3	52.3
2	1.32124	13.2	65.6
3	0.64952	6.5	72.1
4	0.58324	5.8	77.9

four axes show the general separation of woodland from open site samples (Fig. 6.18). The two Collier's Wood samples (1 and 2) and the second year sample (10) from Timberwood Plantation, are consistently grouped together

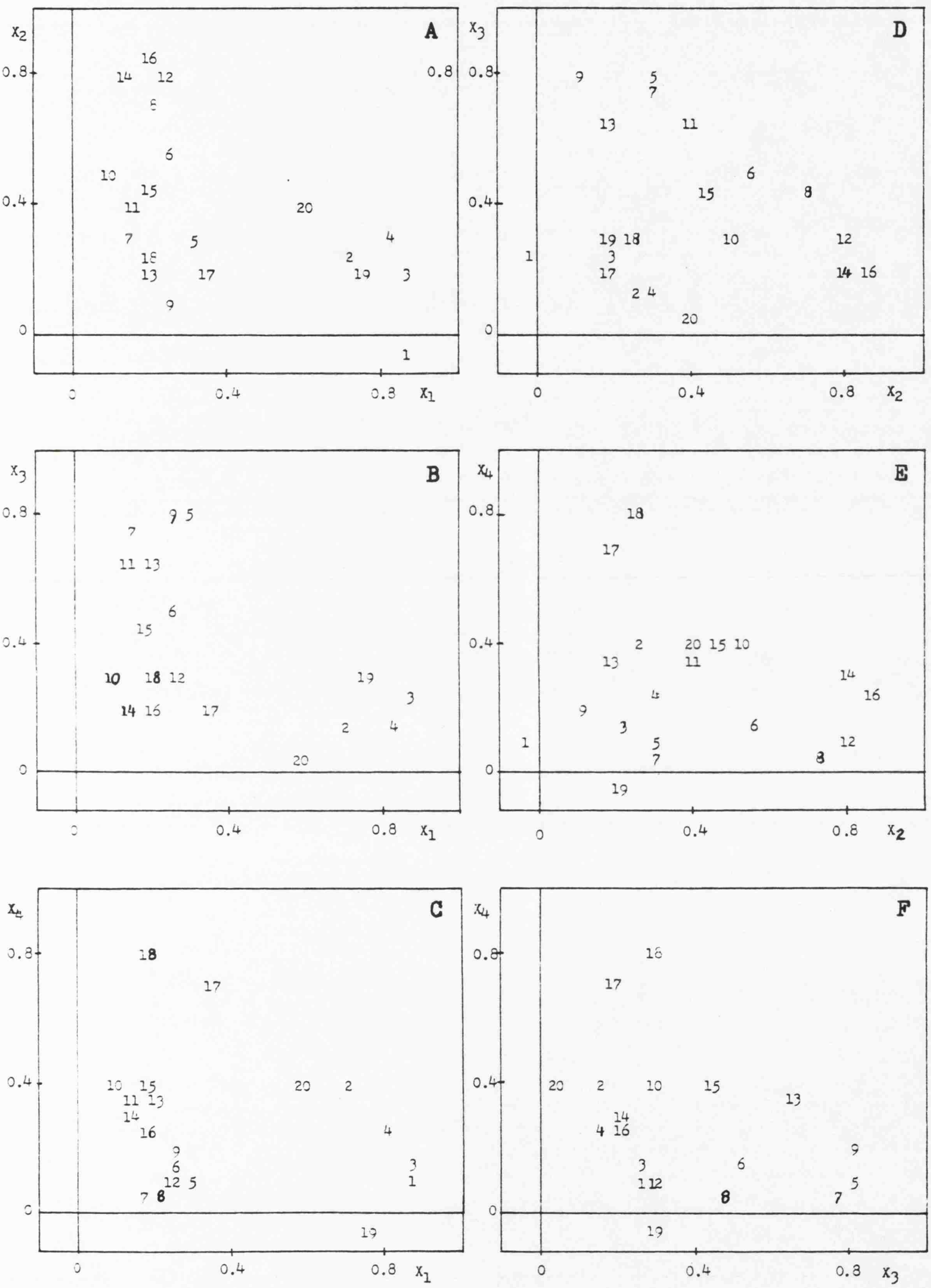
Fig. 6.17 Plots of the first four axes of the principal component analysis of 20 half-yearly samples from Charnwood Lodge sites.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
B	1	3
	8	15
F	11	13

In these plots, the numbers correspond to samples as follows:-

Number	Site	Half-year
1	Collier's Wood	winter-spring (Nov '75 - Apr '76)
2		summer-autumn (May '76 - Oct '76)
3		winter-spring (Nov '76 - Apr '77)
4		summer-autumn (May '77 - Oct '77)
5	Flat Hill	winter-spring (Nov '75 - Apr '76)
6		summer-autumn (May '76 - Oct '76)
7		winter-spring (Nov '76 - Apr '77)
8		summer-autumn (May '77 - Oct '77)
9	Stream	winter -spring (Nov '75 - Apr '76)
10		summer-autumn (May '76 - Oct '76)
11		winter-spring (Nov '76 - Apr '77)
12		summer-autumn (May '77 - Oct '77)
13	Timberwood Hill	winter-spring (Nov '75 - Apr '76)
14		summer-autumn (May '76 - Oct '76)
15		winter-spring (Nov '76 - Apr '77)
16		summer-autumn (May '77 - Oct '77)
17	Timberwood	winter-spring (Nov '75 - Apr '76)
18	Plantation	summer-autumn (May '76 - Oct '76)
19		winter-spring (Nov '76 - Apr '77)
20		summer-autumn (May '77 - Oct '77)



A
B
C
D
E
F

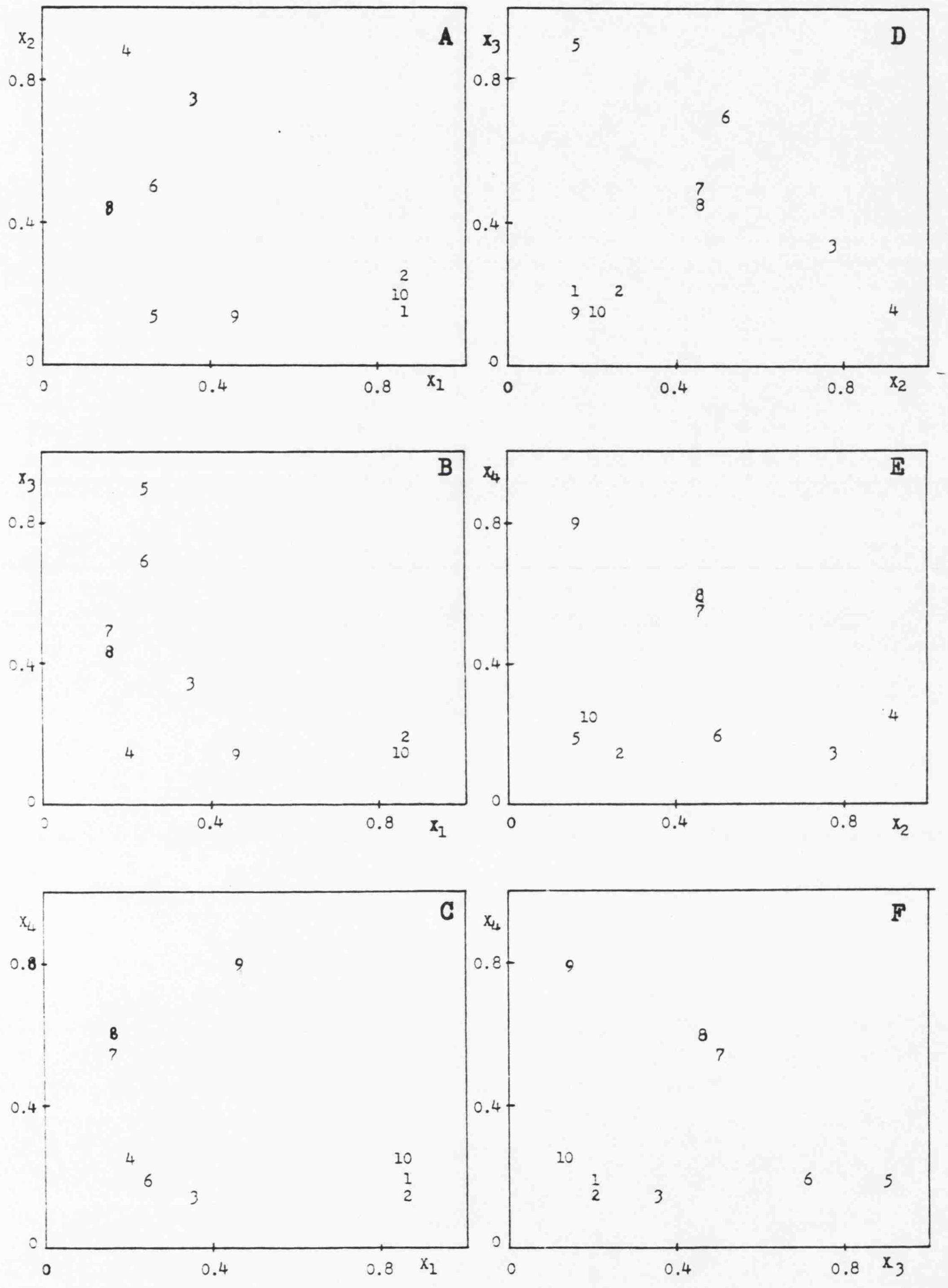
Fig. 6.18 Plots of the first four axes of the principal component analysis of 10 yearly samples from Charnwood Lodge sites.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A	7	8
B	1	2
C	5	6
E	1	5
F	4	10

In these plots, the numbers correspond to samples as follows:-

Number	Site	Year
1	Collier's Wood	Nov '75 - Oct '76
2		Nov '76 - Oct '77
3	Flat Hill	Nov '75 - Oct '76
4		Nov '76 - Oct '77
5	Stream	Nov '75 - Oct '76
6		Nov '76 - Oct '77
7	Timberwood Hill	Nov '75 - Oct '76
8		Nov '76 - Oct '77
9	Timberwood Plantation	Nov '75 - Oct '76
10		Nov '76 - Oct '77


A
x_2
x_1
B
x_3
x_1
C
x_4
x_1
D
x_3
x_2
E
x_4
x_2
F
x_4
x_3
0
0.4
0.8

and assume high values along axis 1 and low values along axes 2, 3 and 4. The plot of axes 2 and 3 thus results in the distinct grouping of woodland samples close to the origin, with samples 1 and 2 from Collier's Wood assuming higher values along axis 3.

The open site samples are less closely grouped than the woodland samples. Samples 7 and 8 from Timberwood Hill are consistently closely grouped, and samples from Flat Hill (3 and 4) though less closely grouped, generally appear together, as do those from the stream (5 and 6).

Discussion

Both mean index sorting and principal component analysis result in the separation of woodland samples from samples from open sites. This separation is most distinct in the comparison of half-yearly and annual samples. In the quarterly sample comparisons, both techniques result in the grouping of the first year spring, summer and autumn samples from Timberwood Plantation with the open site samples.

The grouping of quarterly samples from the open sites according to a temporal pattern is less evident in the plots of principal component analysis than in the dendrogram. However, both techniques result in the grouping of quarterly summer and autumn stream samples with those from Flat Hill. The relationships between these quarterly open site samples are slightly altered in the half-yearly comparisons, so that the summer-autumn stream samples appear more similar to those from Timberwood Hill.

Woodland samples are distinguished from open site samples by the presence of <u>Proteinus brachypterus</u>, <u>Oxypoda lividipennis</u> and <u>O. umbrata</u>, and by the lower numbers of <u>Tachyporus chrysomelinus</u> and <u>T. hypnorum</u> in these samples as compared to the open site samples. The distinct grouping of the Collier's Wood samples is due to the presence, in large numbers, of <u>Micropeplus staphylinoides</u>, <u>Anthobium atrocephalum</u>,

A. unicolor, Omalium italicum, Tachinus signatus, and Ocalea badia. Quarterly samples 34, 35 and 36 from Timberwood Plantation are grouped with the open site samples because of the presence of Tachyporus chrysomelinus in these samples.

Open site samples are distinguished by the presence of Olophrum piceum, Xantholinus linearis, Mycetoporus rufescens, T. chrysomelinus and T. hypnorum. Flat Hill samples are distinguished from the rest of the open site samples by the presence of Staphylinus aeneocephalus and Sepedophilus nigripennis, while the presence of Dinaraea angustula distinguishes Timberwood Hill samples from the rest, and the absence of Stenus impressus, Philonthus cognatus and Drusilla canaliculata distinguishes the stream samples from the rest. Similarities between samples 27 to 32 from Timberwood Hill, 20, 22 and 23 from the stream and 11 to 16 from Flat Hill are due to the higher numbers of T. chrysomelinus and T. hypnorum in these samples relative to the other samples from these sites.

6.4.3 Martinshaw Wood Comparisons

For comparative purposes, the samples obtained from Martinshaw Wood were subjected to the same classificatory and ordinatory techniques to determine whether samples are grouped according to habitat type or according to temporal effects.

In the grass and bracken sites, sample comparisons are of limited value for the study of patterns in specific constitution because of the small number of samples involved. At both these sites, however, mean index sorting results in the general grouping of consecutive samples (Figs. 6.19 and 6.20) and in the bracken site, samples 1 - 4 (August - November '76) are grouped separately from samples 5 - 8 (December '76 - March '77).

<u>NOTE 2</u> :- In Figs. 6.19 - 6.26, the numbers correspond to monthly Martinshaw Wood samples as follows:-

Number	Sample	Symbol
1	Aug '76	⌓ (autumn)
2	Sept	
3	Oct	
4	Nov	● (winter)
5	Dec '76	
6	Jan '77	
7	Feb	■ (spring)
8	Mar	
9	Apr	
10	May	▲ (summer)
11	Jun	
12	Jul	
13	Aug	◓ (autumn)
14	Sept	
15	Oct	
16	Nov '77	○ (winter)

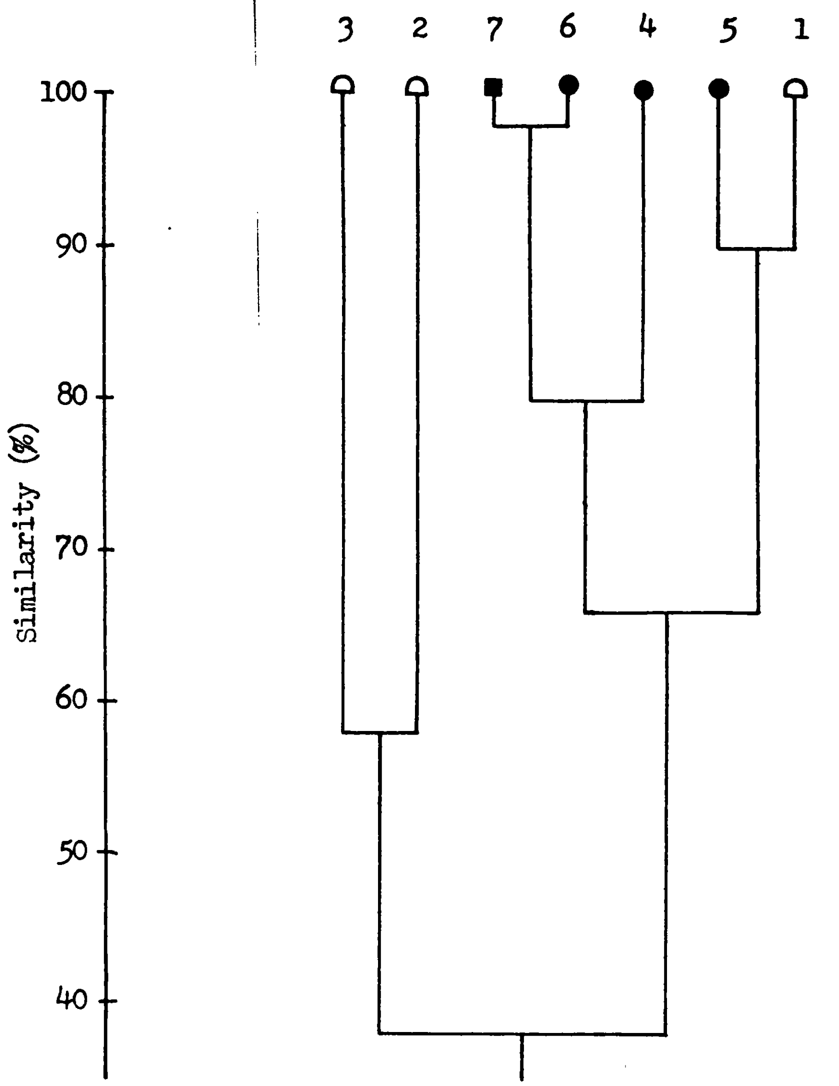


Fig. 6.19 Dendrogram resulting from mean index sorting of 7 monthly samples from the Martinshaw grass site.

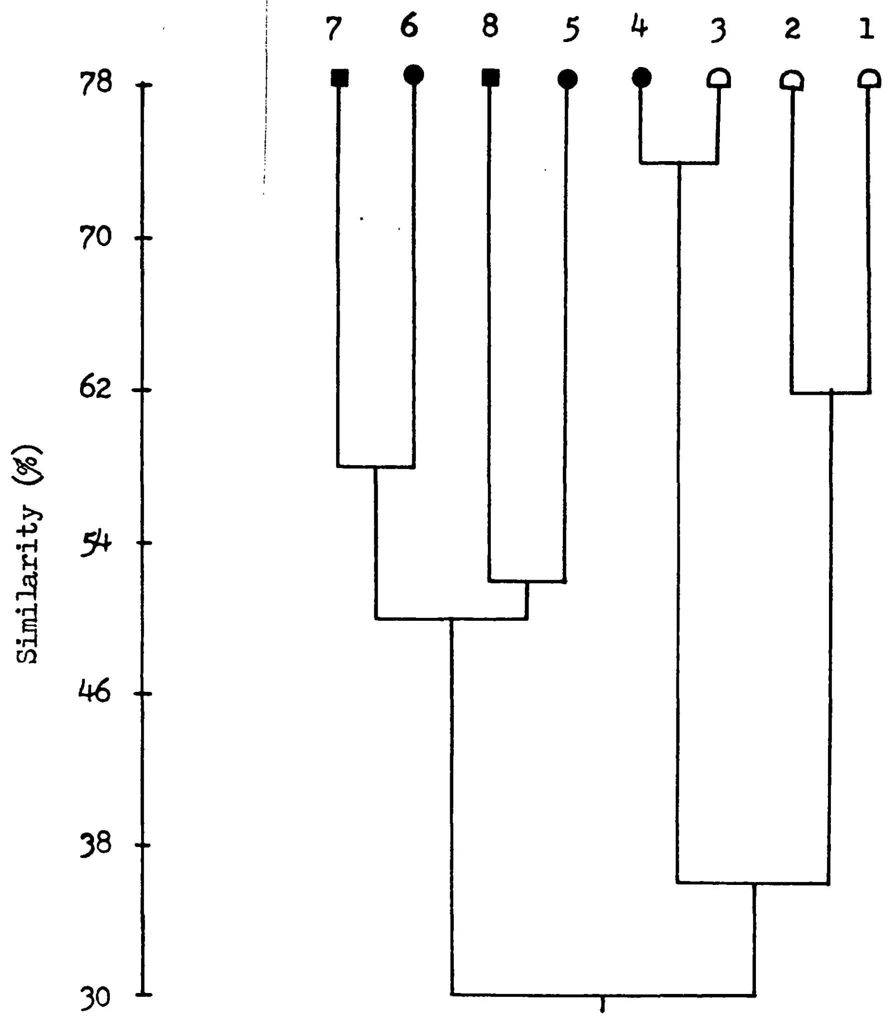


Fig. 6.20 Dendrogram resulting from mean index sorting of 8 monthly samples from the Martinshaw bracken site.

The first four eigenvalues extract 99% and 84% of the variation in the grass and bracken samples respectively (Tables 6.10 and 6.11 respectively). Principal component analysis results in the general

Table 6.10 First four eigenvalues from principal component analysis of r matrix of 7 monthly samples from Martinshaw grass site, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	4.63138	66.2	66.2
2	1.26440	18.1	84.2
3	0.58288	8.3	92.6
4	0.41667	6.0	98.5

Table 6.11 First four eigenvalues from principal component analysis of r matrix of 8 monthly samples from Martinshaw bracken site, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	3.82744	47.8	47.8
2	1.39275	17.4	65.3
3	0.96016	12.0	77.3
4	0.54755	6.8	84.1

separation of the first three grass samples (Fig. 6.21) and the first four bracken samples (August - November '76) (Fig. 6.22) from the remaining samples, which have higher values along axis 1. At both these sites, distinct grouping of samples according to a temporal pattern is not evident because of the small number of samples taken, but some consecutive samples, e.g. 2 and 3, appear closer together.

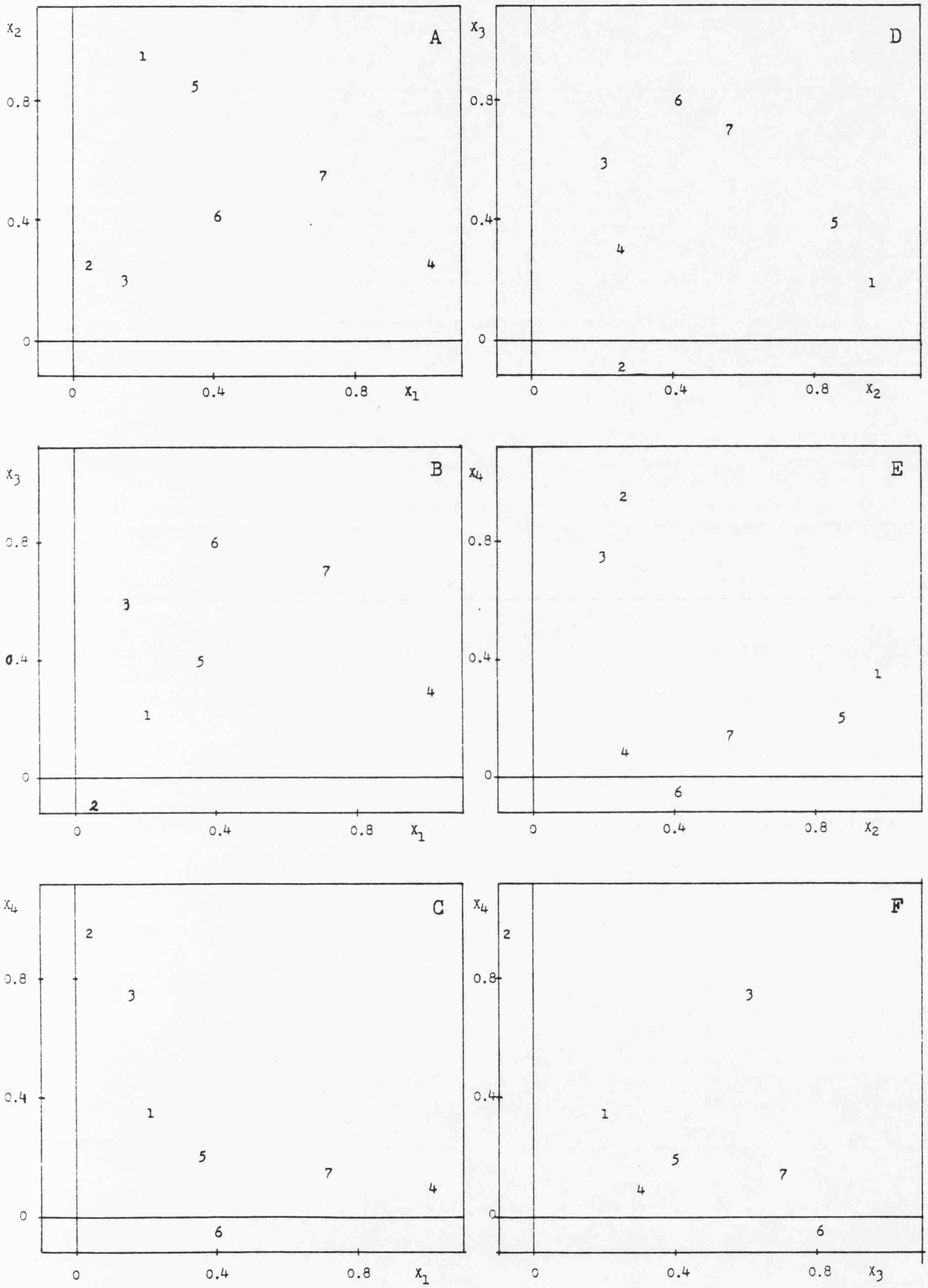


Fig. 6.21 Plots of the first four axes of the principal component analysis of 7 monthly samples from the grass site, Martinshaw Wood.

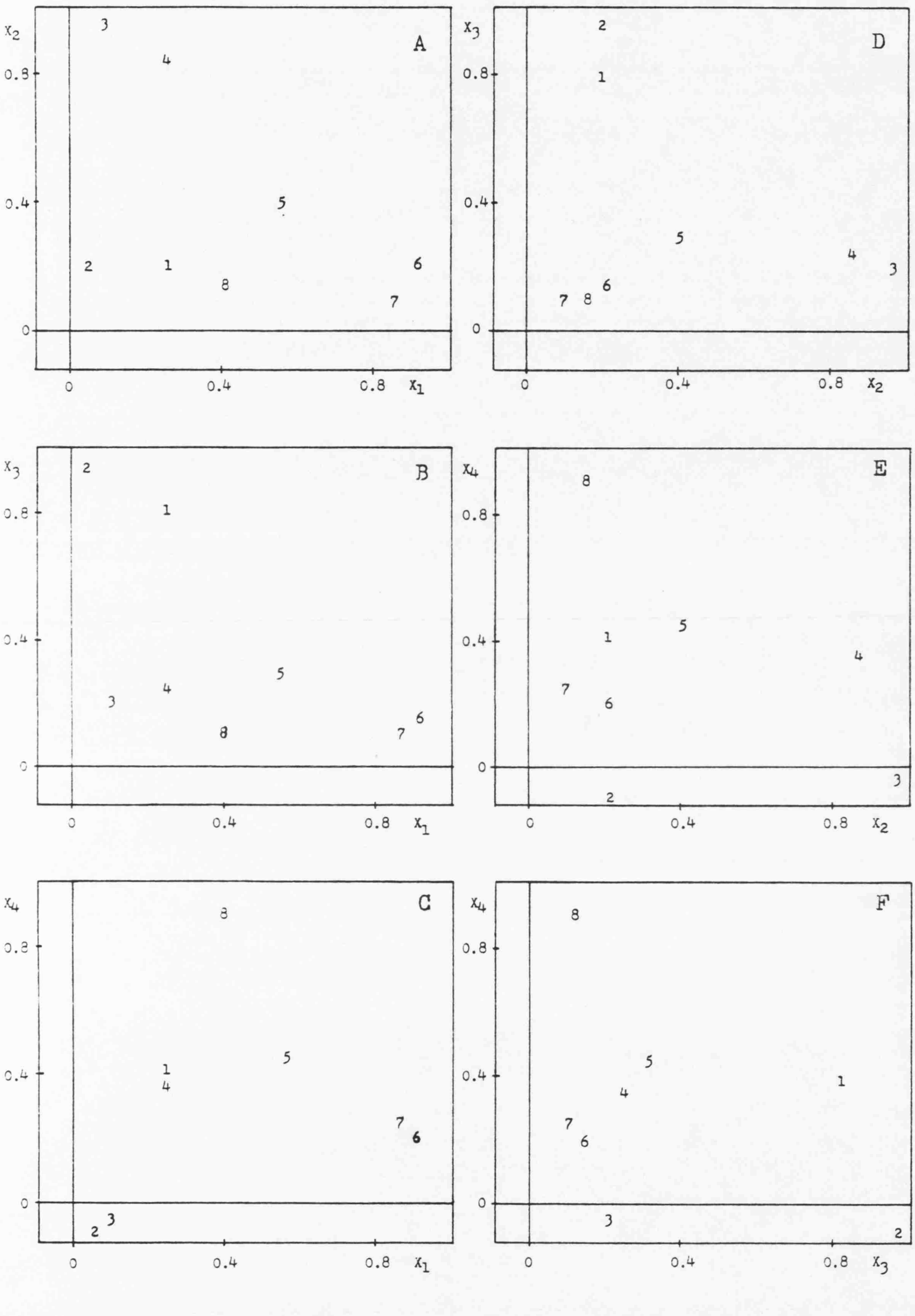


Fig. 6.22 Plots of the first four axes of the principal component analysis of 8 monthly samples from the bracken site, Martinshaw Wood.

Examination of the species abundance matrix reveals that the first three samples from the grass site are distinguished by the presence of Tachyporus chrysomelinus and Drusilla canaliculata, while in the bracken site, the first four samples are distinguished from samples 5 - 8 by the absence of both Tachyporus nitidulus and T. hypnorum.

At the oak site, mean index sorting results in a general grouping of samples according to a temporal pattern (Fig. 6.23), with three groups formed at the 34% level of similarity. The major group consists of October to April samples, and an August '76 sample (1, 5 - 9 and 16). Two smaller groups, one of June - September samples (2, 11 - 13) and another of September to November samples (3, 4, 14, 15) are also formed.

The first four eigenvalues extract 68% of the variation in these samples (Table 6.12). Axis 1 generally separates the September to

Table 6.12 First four eigenvalues from principal component analysis of r matrix of 16 monthly samples from Martinshaw oak site, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	6.42194	40.1	40.1
2	1.97855	12.4	52.5
3	1.37064	8.6	61.1
4	1.08095	6.8	67.8

November samples (3, 4, 14 and 15), in which both Quedius nigriceps and Autalia impressa are present, from the remaining samples (Fig. 6.24). Axis 4 separates the June and July (11 and 12) samples which are distinguished by the presence of Sepedophilus marshami and by the absence of A. impressa, from the rest.

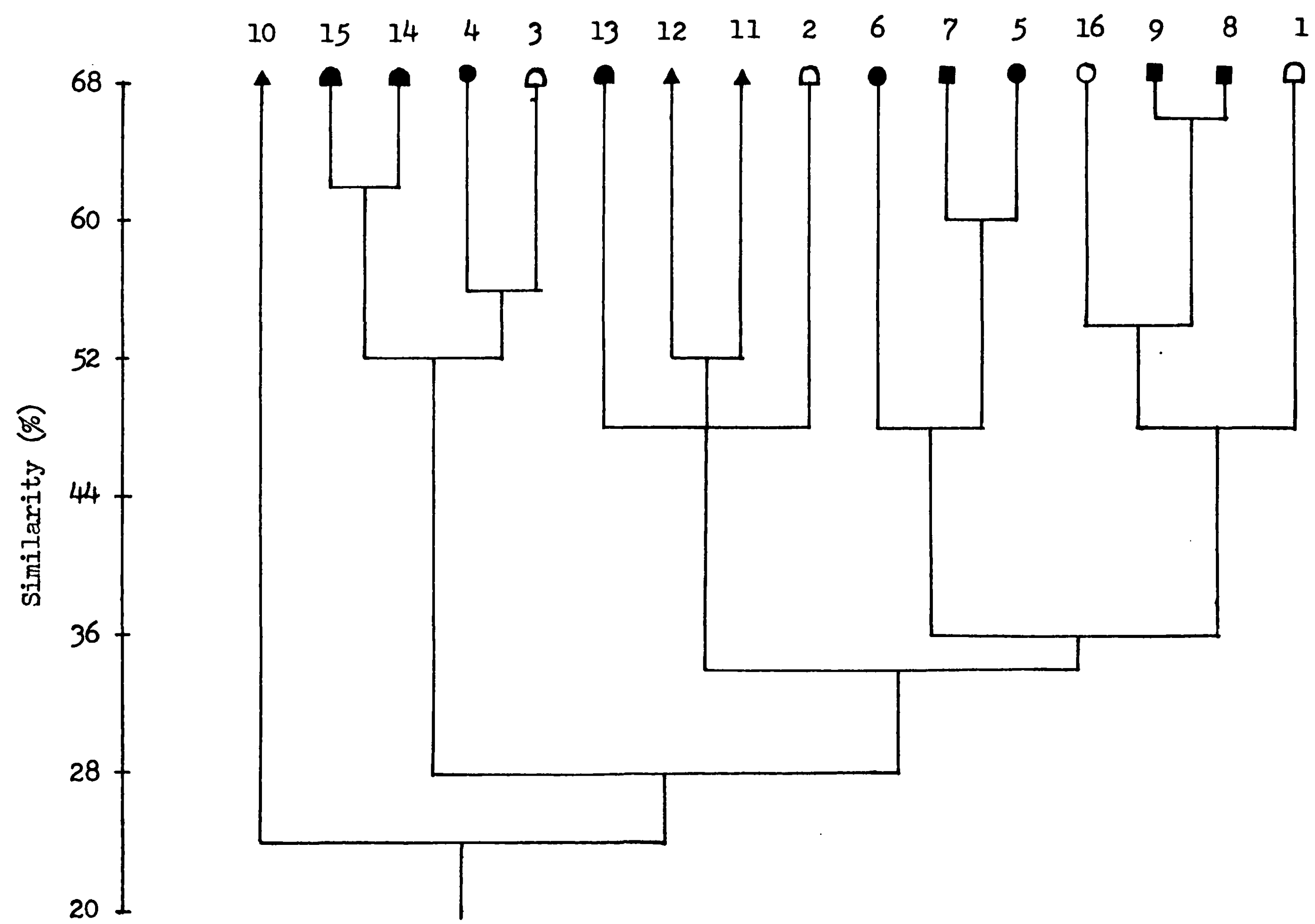
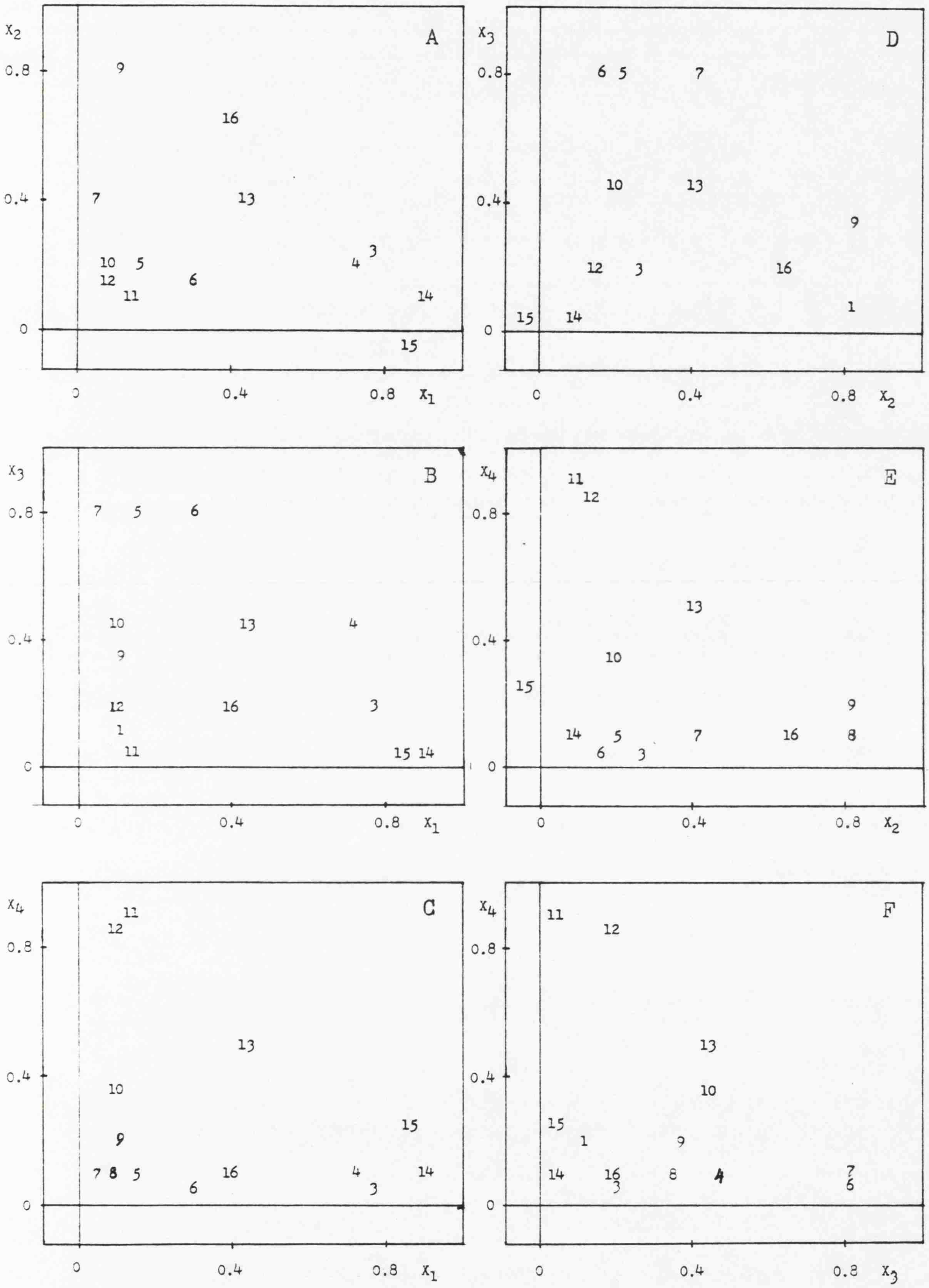


Fig. 6.23 Dendrogram resulting from mean index sorting of 16 monthly samples from the oak site, Martinshaw Wood.

Fig. 6.24 Plots of the first four axes of the principal component analysis of 16 monthly samples from the oak site, Martinshaw Wood.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A	1	9
	2	13
	8	9
B	2	13
	8	9
C	1	9
	2	13
D	2	13
	4	10
	8	9
	11	14
E	1	9
	2	13
	4	5
F	2	13
	5	7


A
x_2
0.8
0.4
0
0
0.4
0.8
x_1
9
16
7
13
10
5
12
11
6
4
3
14
15
D
x_3
0.8
0.4
0
0
0.4
0.8
x_2
6 5
7
10
13
9
12
3
16
1
15
14
B
x_3
0.8
0.4
0
0
0.4
0.8
x_1
7
5
6
10
13
4
9
12
16
3
1
11
15 14
E
x_4
0.8
0.4
0
0
0.4
0.8
x_2
11
12
13
10
15
9
14
5
7
16
8
6
3
C
x_4
0.8
0.4
0
0
0.4
0.8
x_1
11
12
13
10
15
9
7 8
5
16
4
14
6
3
F
x_4
0.8
0.4
0
0
0.4
0.8
x_3
11
12
13
10
15
1
9
14
16
3
8
4
7
6

At the pine site, both mean index sorting and principal component analysis do not result in the distinct grouping of samples according to a temporal pattern (Figs. 6.25 and 6.26; Table 6.13).

Table 6.13 First four eigenvalues from principal component analysis of τ matrix of 16 monthly samples from Martinshaw pine site, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	6.76252	42.3	42.3
2	1.71658	10.7	53.0
3	1.32558	8.3	61.3
4	1.26494	7.9	69.2

However, some consecutive samples, e.g. the March - May '77 samples (8 - 10), are grouped together, largely because of the presence of both *Proteinus brachypterus* and *Tachyporus hypnorum*.

Both mean index sorting and principal component analysis of the 12 quarterly and six half-yearly samples from the four Martinshaw Wood sites result in the general grouping of samples according to a temporal pattern rather than by site (Figs. 6.27 - 6.30; Tables 6.14 and 6.15)

Table 6.14 First four eigenvalues from principal component analysis of τ matrix of 12 quarterly samples from Martinshaw Wood, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	6.06262	50.5	50.5
2	1.15023	9.6	60.1
3	0.94733	7.9	68.0
4	0.86003	7.2	75.2

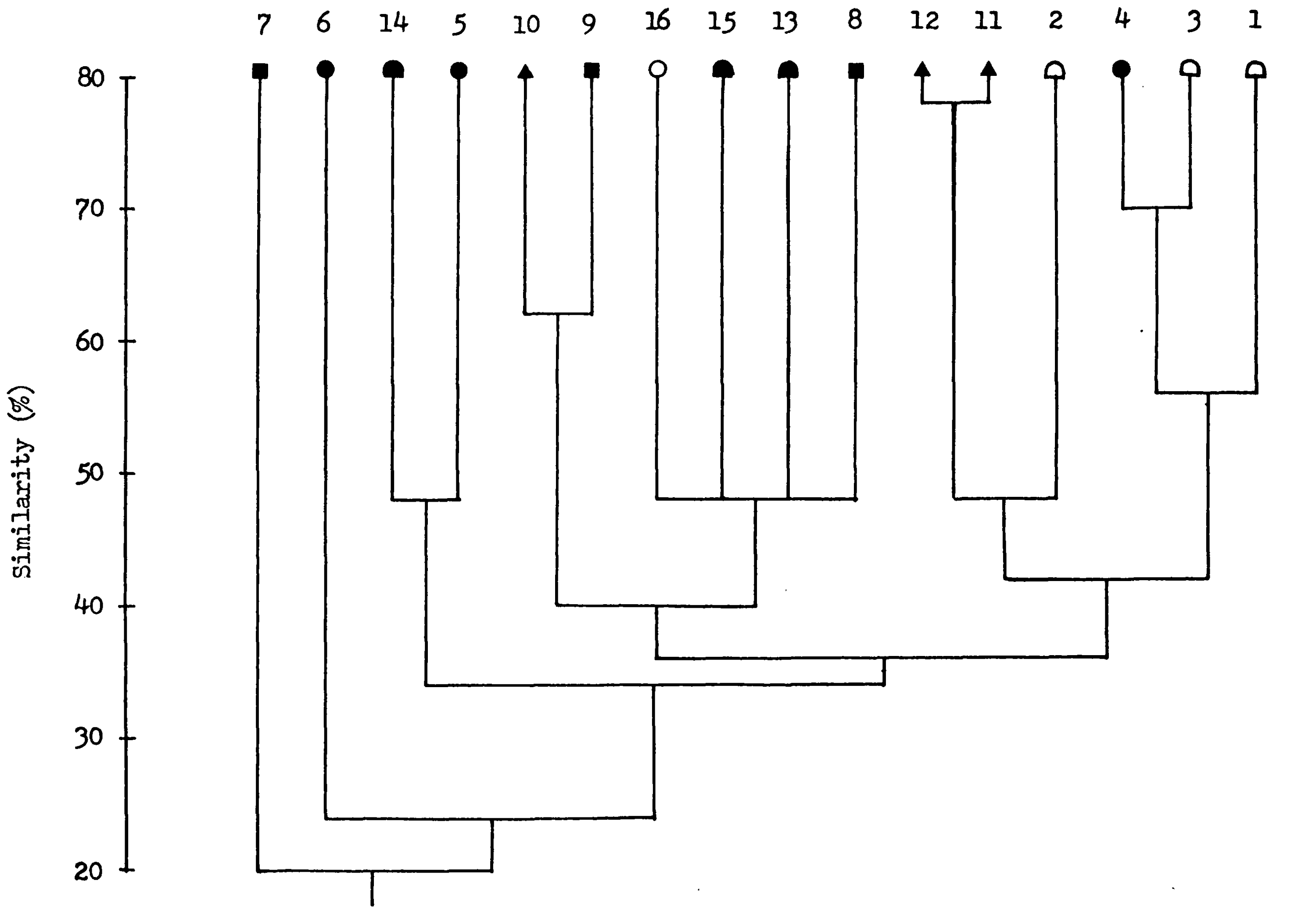
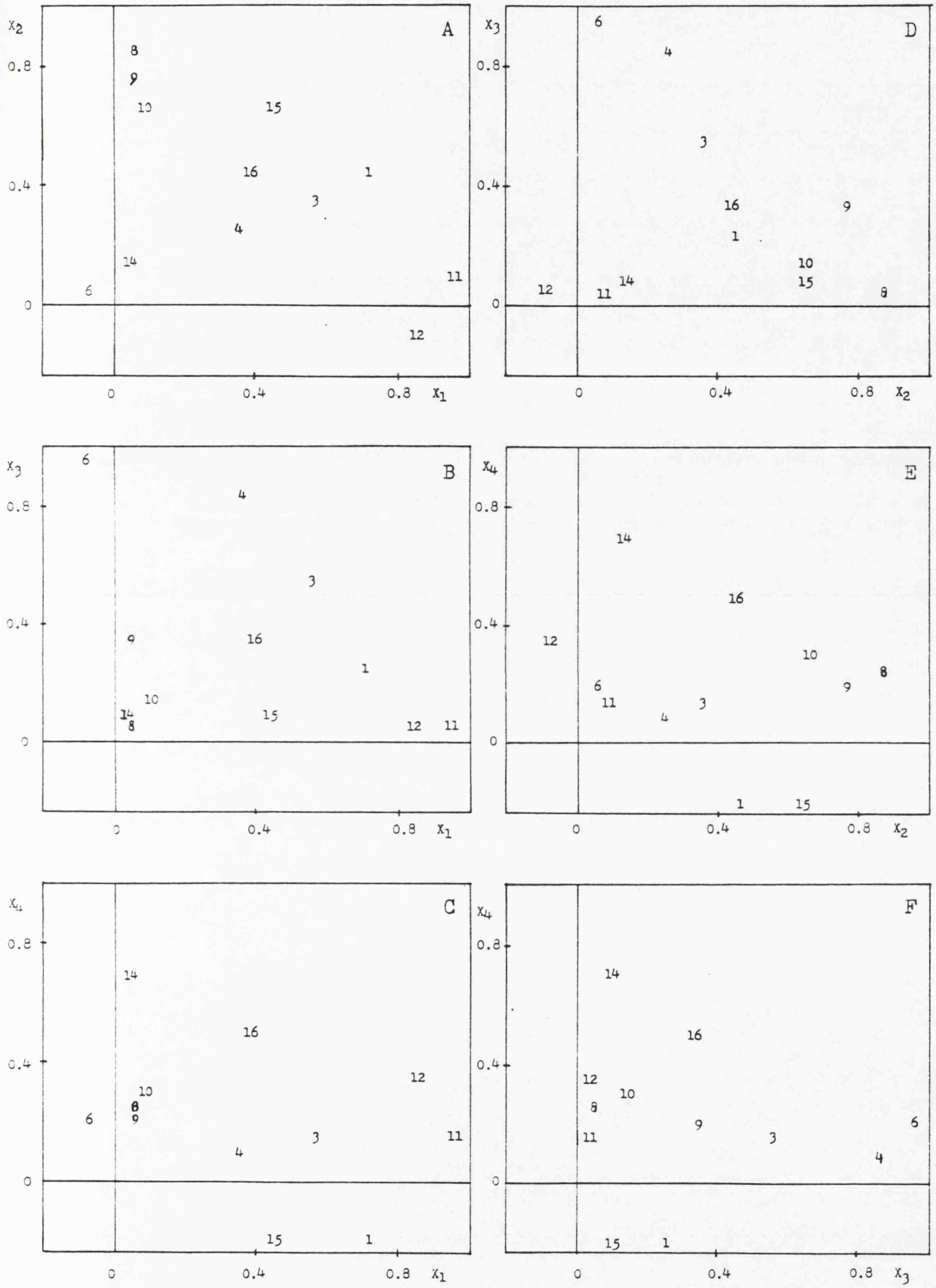


Fig. 6.25 Dendrogram resulting from mean index sorting of 16 monthly samples from the pine site, Martinshaw Wood.

Fig. 6.26 Plots of the first four axes of the principal component analysis of 16 monthly samples from the pine site, Martinshaw Wood.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples
A,B,C,D,E,F	2,5,13	16
	7	14



A
B
C
D
E
F
x1
x2
x3
x4
0
0.4
0.8

In Figs. 6.27 and 6.29, the numbers correspond to quarterly samples as follows:-

	Numbers				Quarter
Sites	MG	MB	MQ	MP	
	1	3	5	9	autumn (Aug '76 - Oct '76)
	2	4	6	10	winter (Nov '76 - Jan '77)
			7	11	spring (Feb '77 - Apr '77)
			8	12	summer (May '77 - Jul '77)

MG - Martinshaw grass site

MB - Martinshaw bracken site

MQ - Martinshaw oak site

MP - Martinshaw pine site

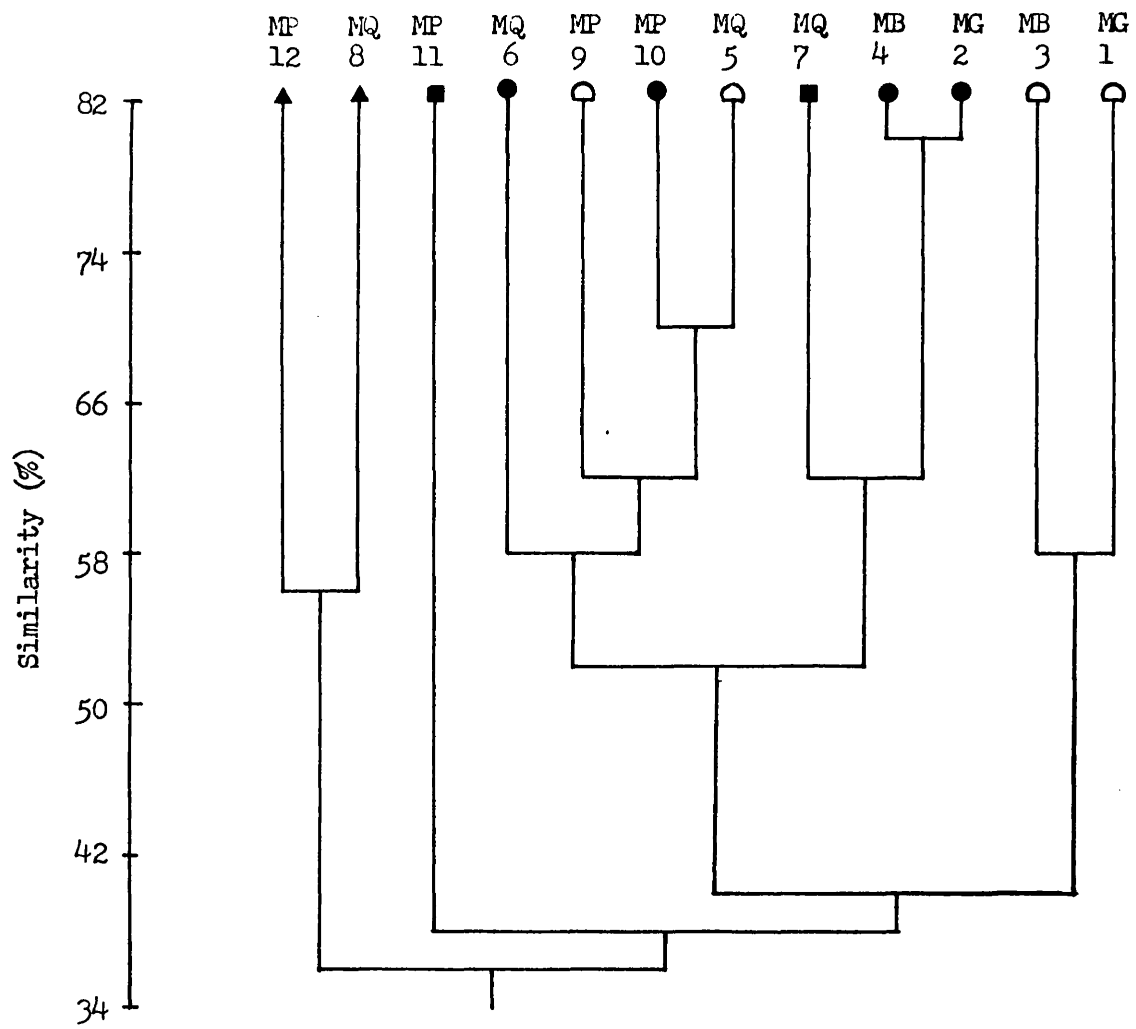


Fig. 6.27 Dendrogram resulting from mean index sorting of 12 quarterly samples from Martinshaw Wood sites.

In Figs. 6.28 and 6.30, the numbers correspond to half-yearly samples as follows :-

	Numbers				Half-year
Sites	MG	MB	MQ	MP	
	1	2	3	5	autumn-winter (Aug '76 - Jan '77)
			4	6	spring-summer (Feb '77 - Jul '77)

MG - Martinshaw grass site

MB - Martinshaw bracken site

MQ - Martinshaw oak site

MP - Martinshaw pine site

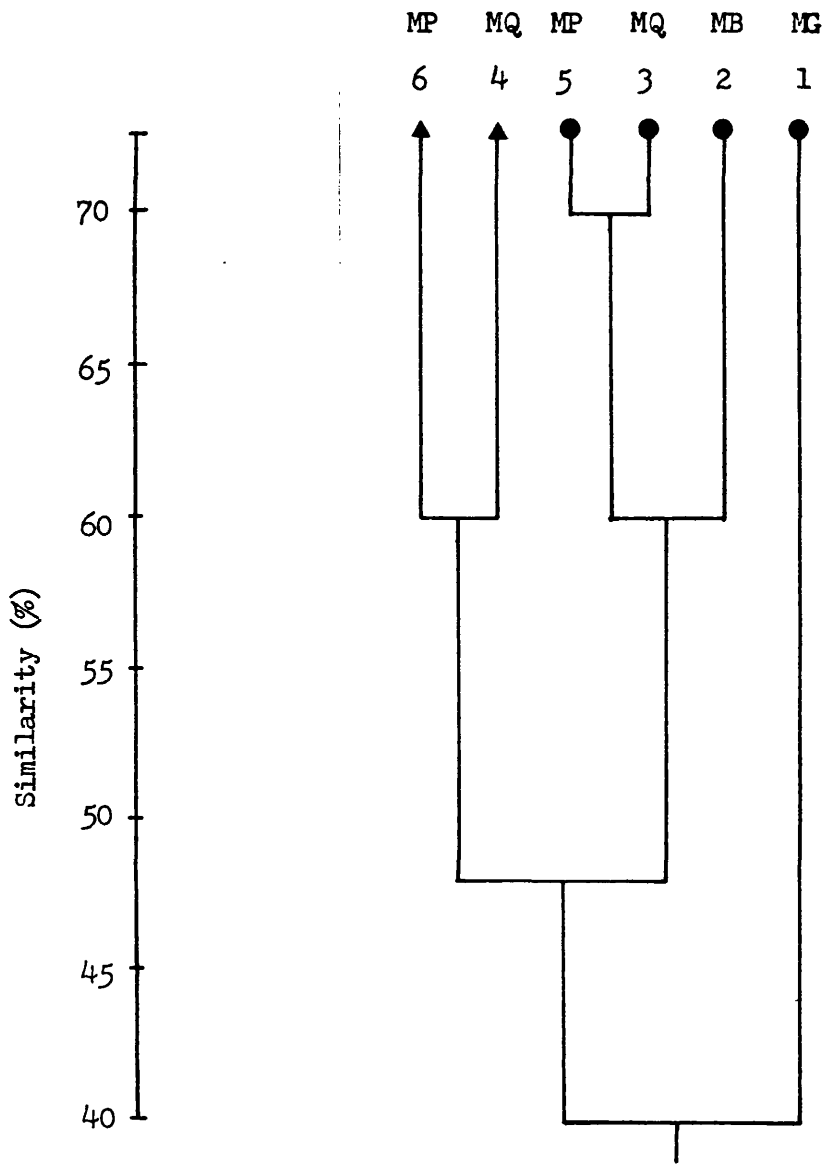


Fig. 6.28 Dendrogram resulting from mean index sorting of 6 half-yearly samples from Martinshaw Wood sites.

In the quarterly comparisons, the winter samples from the grass and bracken sites (samples 2 and 4) are more similar to one another because of the presence of Olophrum piceum, Othius punctulatus and Quedius nigriceps, than are the autumn and winter samples from each of these sites. Similarly, the autumn samples from these sites (1 and 3) form a distinct group because Autalia impressa, Drusilla canaliculata and Sepedophilus nigripennis are common to these samples and the summer samples from the oak and pine sites (8 and 12) are distinguished by the presence of Sepedophilus marshami. These patterns are reflected in the half-yearly comparisons. In mean index sorting, the autumn-winter samples from the two woodland sites (samples 3 and 5) are very similar and the spring-summer samples from these sites (4 and 6) form another distinct group.

In the half-yearly samples, the first four eigenvalues extract 90% of the variation. Plots of the first four axes result in the

Table 6.15 First four eigenvalues from principal component analysis of r matrix of 6 half-yearly samples from Martinshaw Wood, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	3.52932	58.8	58.8
2	0.77373	12.9	71.7
3	0.66616	11.1	82.8
4	0.41833	7.0	89.8

separation of the four autumn-winter samples from the two spring-summer samples. The plot of axes 1 and 2 groups the latter samples close to the origin. In the plots of axes 1 and 4 and 2 and 4, the autumn-winter samples take low values along axis 4 and are thus separated from the

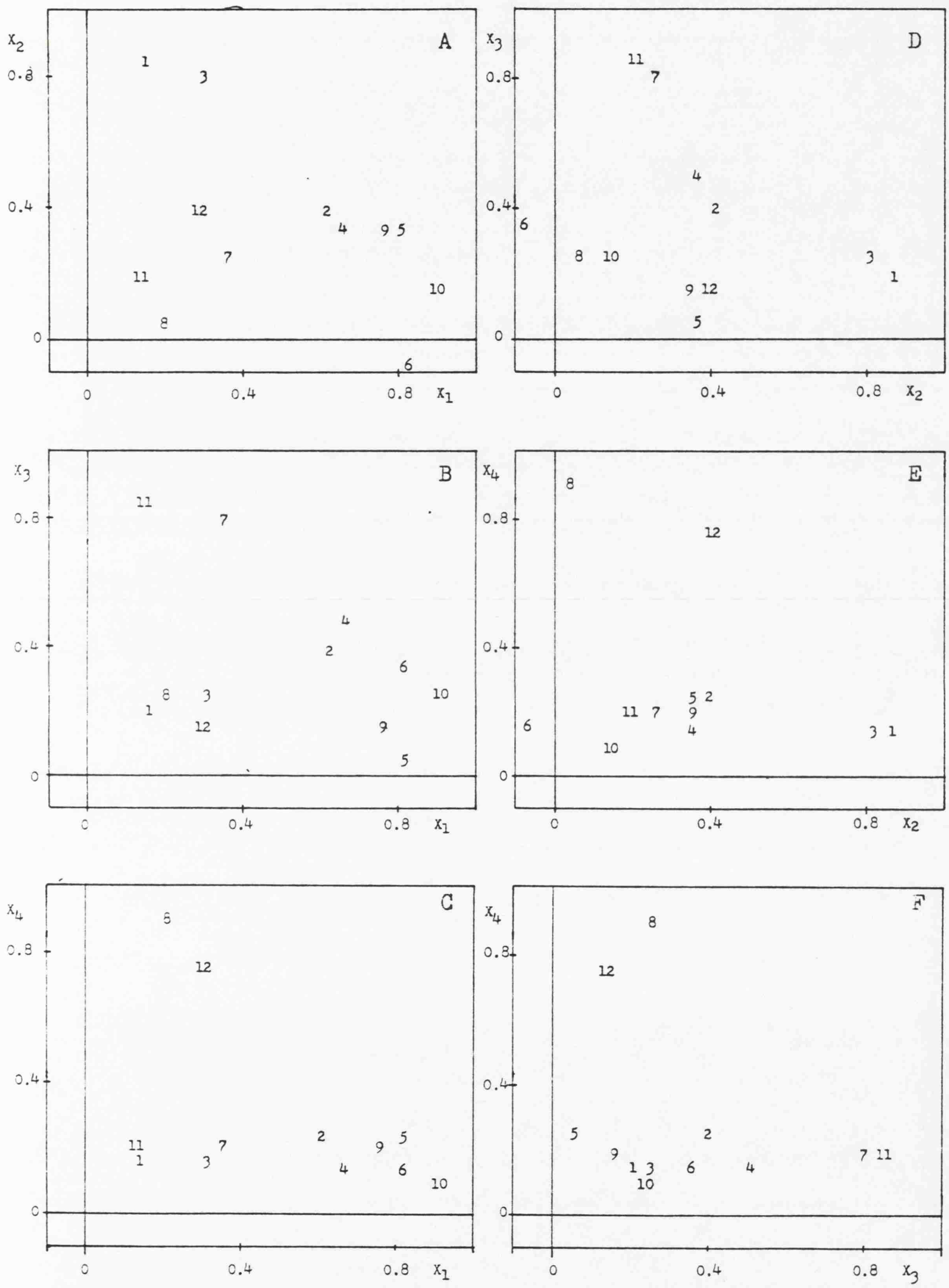


Fig. 6.29 Plots of the first four axes of the principal component analysis of 12 quarterly samples from the Martinshaw Wood sites.

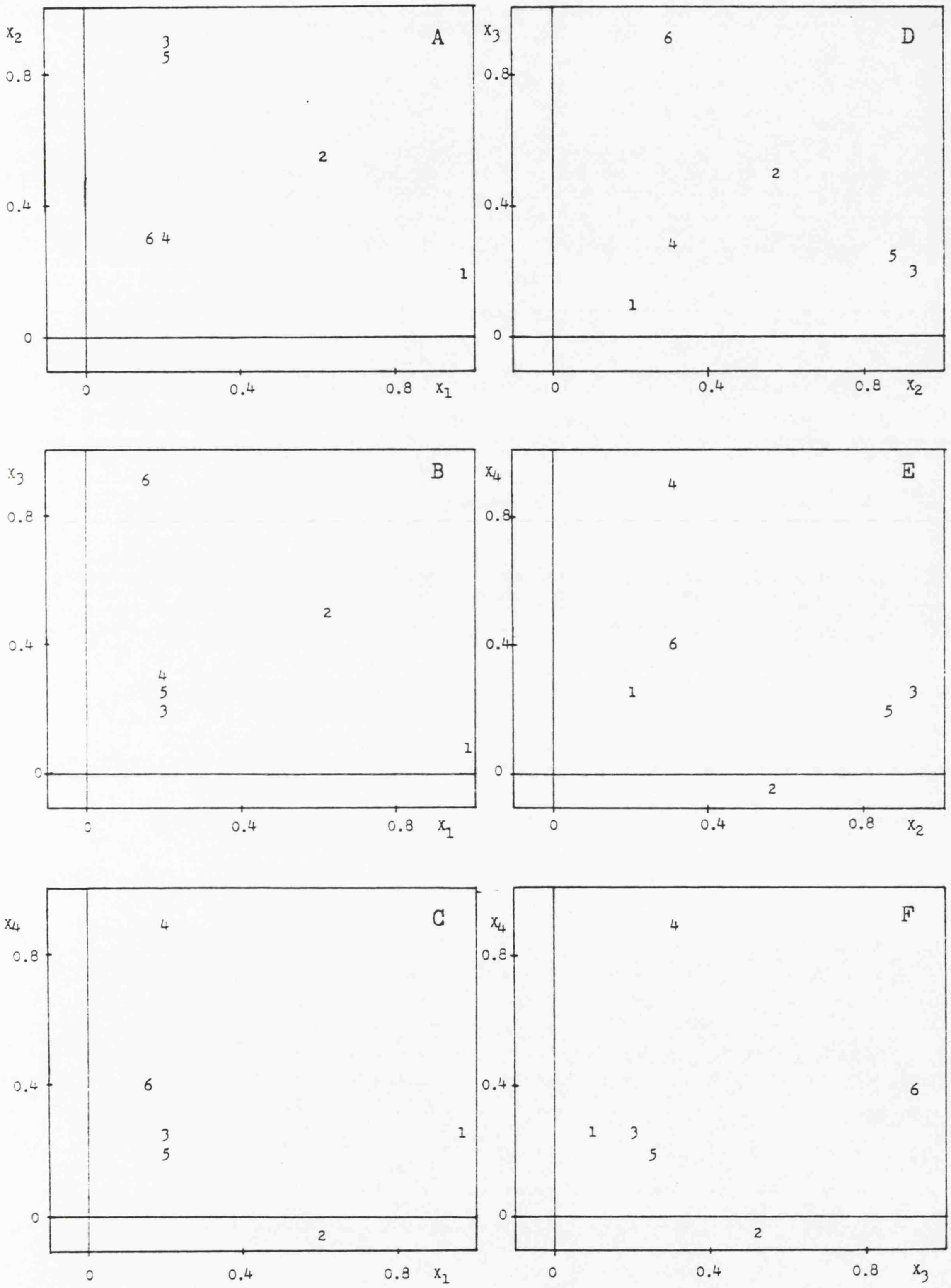


Fig. 6.30 Plots of the first four axes of the principal component analysis of the 6 half-yearly samples from the Martinshaw Wood sites.

spring-summer samples. The consistent close grouping of samples 3 and 5 (autumn-winter samples from the oak and pine wood sites) is also evident in these plots. This is because the autumn-winter samples are distinguished by the presence of Quedius nigriceps and Sepedophilus nigripennis, while the spring-summer samples are distinguished by the presence of S. marshami and Proteinus brachypterus.

6.4.4 Charnwood Lodge and Martinshaw Wood Quarterly Site Comparisons

When the indices for the 52 quarterly samples from both the study areas are compared in the one matrix, the relationships within the 40 Charnwood Lodge samples (numbered 1 - 40) and within the 12 Martinshaw Wood samples (numbered 41 - 52) remain much the same.

Mean index sorting results in the separation of woodland samples from open site samples (Fig. 6.31). Within the woodland grouping, a summer Martinshaw oak sample, and a spring Martinshaw pine sample are included with the Timberwood Plantation samples, leaving the relationships between the Collier's Wood samples unaltered. The remaining Martinshaw Wood samples are grouped with the Charnwood Lodge open site samples. A group which consists mainly of the autumn and winter samples from Martinshaw Wood is grouped with the open site samples from Charnwood Lodge, leaving the relationships between the latter samples generally unaltered, except that two autumn samples from Martinshaw Wood, one from the grass site and one from the bracken site, are grouped with the summer and autumn Flat Hill samples, and the summer and autumn stream samples are instead grouped with the Timberwood Hill samples.

56% of the variation in the combined Charnwood Lodge and Martinshaw Wood samples is accounted for by the first four eigenvalues (Table 6.16). Plots of the first four axes separate Martinshaw samples (41 - 52) from the Charnwood Lodge samples (1 - 40), especially along axis 4, where Martinshaw Wood samples assume greater positive values (Fig. 6.32).Plots

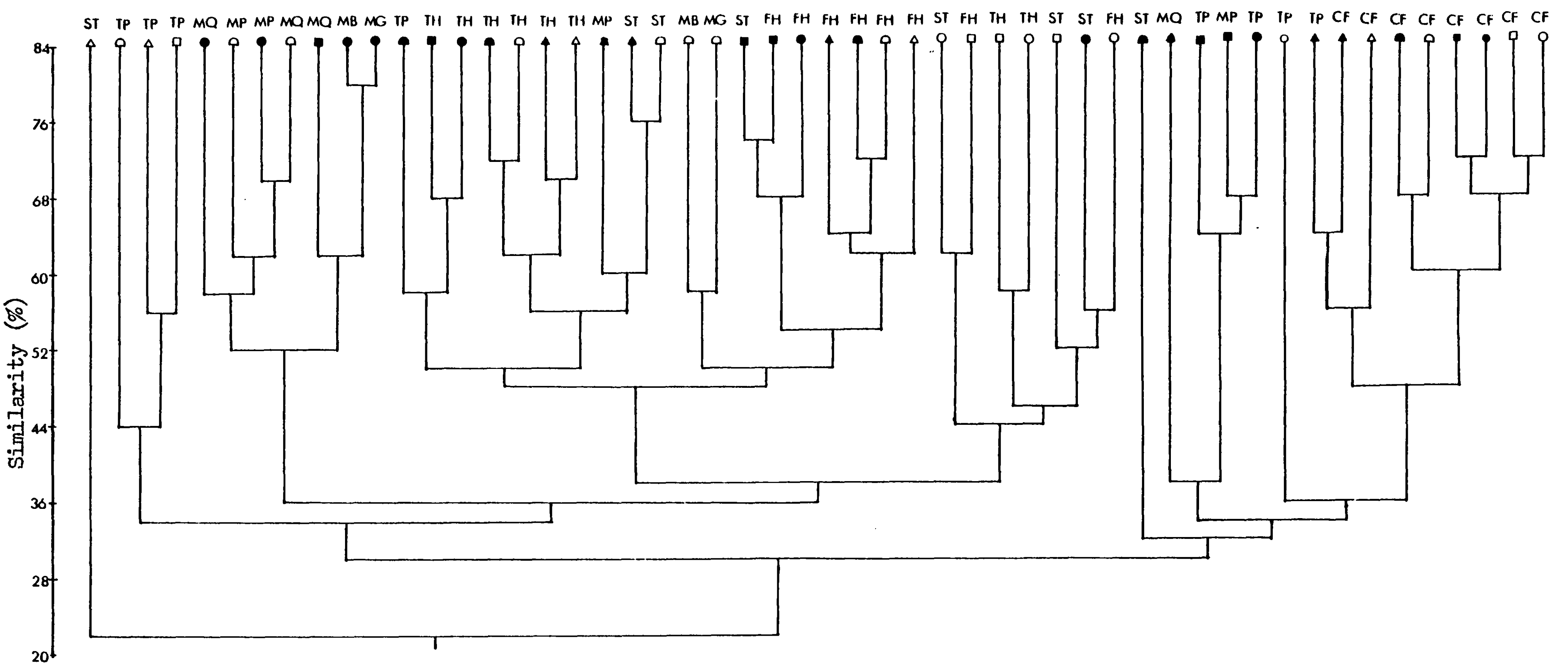


Fig. 6.31 Dendrogram resulting from mean index sorting of 52 quarterly samples from the Charnwood Lodge and Martinshaw Wood sites.

CF - Collier's Wood **FH - Flat Hill** **ST - stream** **TH - Timberwood Hill** **TP - Timberwood Plantation**
MG - Martinshaw Grass **MB - Martinshaw Bracken** **MQ - Martinshaw Oak** **MP - Martinshaw Pine**
○ **- winter sample** □ **- spring sample** △ **- summer sample** ⌓ **- autumn sample of first year**

Shaded symbols **represent second year samples**

Table 6.16 First four eigenvalues from principal component analysis of τ matrix of 52 combined quarterly samples from Charnwood Lodge and Martinshaw Wood, and percentage of variation extracted by each axis.

Axis	Eigenvalue	Percentage of Variation	Cumulative Percentage
1	20.50305	39.4	39.4
2	3.90921	7.5	46.9
3	2.56296	4.9	51.9
4	2.36284	4.5	56.4

of axes 1 and 3, 2 and 3 and 3 and 4 result in the separation of Charnwood Lodge woodland sites from the rest of the samples. There is also a general separation of winter and spring samples from summer and autumn samples along axis 2, the latter samples having higher positive values along this axis. Plots of axes 2 and 4 and 3 and 4 also result in a distinct group of autumn and winter samples (42, 44 - 47, 49, 50) from Martinshaw Wood. The similarities between the two autumn samples from the bracken and grass sites in Martinshaw Wood, and the stream samples from Charnwood Lodge Nature Reserve are also seen in the close grouping of samples 41 and 43 with 20, 22 and 23 in the plots of axes 2 and 4, and 3 and 4.

The generally unaltered relationships within the groupings of Collier's Wood, Flat Hill, Timberwood Hill and Martinshaw Wood samples emphasise the distinctiveness of the staphylinid faunas of Martinshaw Wood and the different study sites in Charnwood Lodge.

The general lack of similarity between the Charnwood woodland sites, especially Collier's Wood, and the Martinshaw woodland sites and the higher similarity between these latter samples and those from Timberwood Plantation, is largely due to the absence of large numbers of

Fig. 6.32 Plots of the first four axes of the principal component analysis of 52 quarterly samples from the Charnwood Lodge and Martinshaw Wood sites.

In the various plots, certain samples are not plotted as they coincide with plotted samples. These are listed below.

Plot	Coincident unplotted samples	Plotted samples	Plot	Coincident unplotted samples	Plotted samples
A	8	33	D	1	6
	9	21		3	4
	10	14		9	21
	11	20		10	45
	15	29		13	50
	35	52		16	20
	40	43		27	28
	44	47			
B	5	1	E	2	17
	9	21		4	48
	14	22		6	37
	28	27		8	33
	32	48		14	26
	47	51		15	29
				23	41
C	5,6,27	32	F	11	13
	8	7		12	28
	12	23		14,15	27
	15	30		17	25
	43	52		22	31
				29,30	32
				45	49

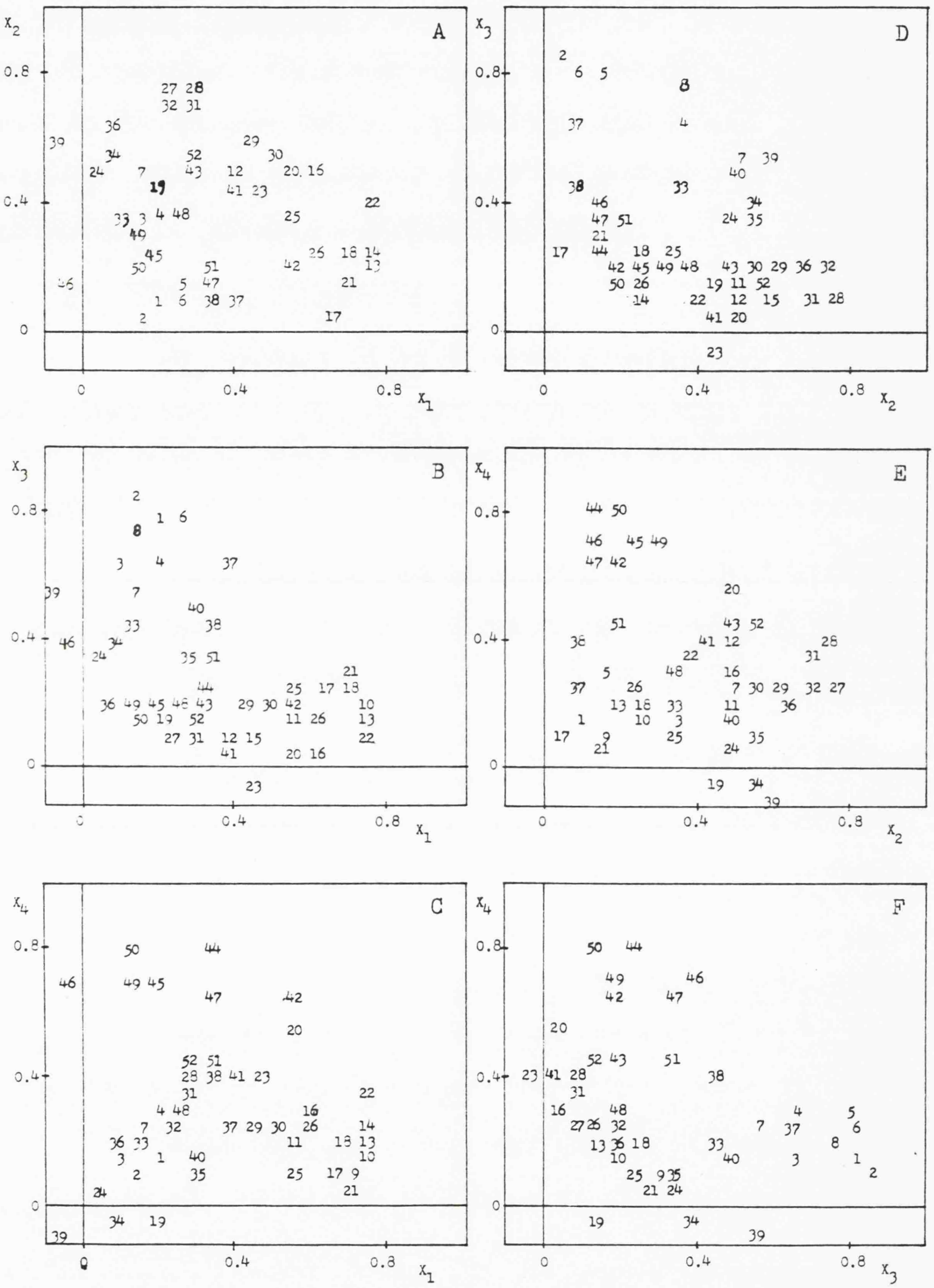
Samples 1 - 8 - Collier's Wood; 9 - 16 - Flat Hill

17 - 24 - Stream; 25 - 32 - Timberwood Hill

33 - 40 - Timberwood Plantation

41 - 42 - Martinshaw grass; 43 - 44 - Martinshaw bracken

45 - 48 - Martinshaw Oak; 49 - 52 - Martinshaw pine



A
B
C
D
E
F
x_1
x_2
x_3
x_4

Micropeplus staphylinoides, Anthobium atrocephalum, A. unicolor, Ocalea badia and Oxypoda lividipennis from the Martinshaw Wood sites and from Timberwood Plantation. The greater similarity between Martinshaw Wood samples and the open site samples from Charnwood Lodge is due to the presence in all these samples of open site and ubiquitous species, such as Tachyporus chrysomelinus, T. hypnorum and Drusilla canaliculata.

6.5 General Pattern of Similarities

The comparison of the 52 quarterly samples from Charnwood Lodge and Martinshaw Wood by mean index sorting and principal component analysis has shown the distinctiveness of the staphylinid faunas of the two areas.

In the Charnwood Lodge sites, the staphylinid faunas are generally distinguished on the basis of habitat preferences rather than temporal variations in abundance. The five study sites support very distinct 'woodland' and 'open site' type staphylinid faunas since both classificatory and ordinatory sorting techniques result in a grouping of woodland samples and another of open site samples. Within the woodland grouping, the staphylinid composition of the samples taken from Collier's Wood show a high degree of similarity. The first winter, and the first three quarterly samples of the second year from Timberwood Plantation, are included in the woodland group. The remaining Timberwood Plantation samples are more similar to the open site samples than to the woodland samples.

Within the group of open site samples, three distinct sub-groups are evident, one consisting of winter and spring samples from Flat Hill, the stream and Timberwood Hill, another consisting mainly of the summer and autumn Flat Hill samples, and a stream sample, and the third of summer and autumn Timberwood Hill and stream samples.

Within the distinct habitat groups, samples are generally grouped according to a temporal pattern, samples taken from the same season or from consecutive seasons showing the highest level of similarity.

In Martinshaw Wood, although groupings of woodland samples and open site samples are evident, samples are grouped more as a result of temporal factors than according to habitat type and the four study sites do not support distinctive staphylinid faunas. This is probably due to the close proximity of these study sites (see 4.2.1). The resultant edge effects probably account for the lack of distinctiveness in the staphylinid faunas of these sites.

Results generally agree well with what would be expected from visual examination of data on species composition and abundance in the various samples. Martinshaw Wood samples may generally be distinguished from Charnwood Lodge samples by the conspicuous absence of *Micropeplus staphylinoides*, *Anthobium atrocephalum*, *A. unicolor* and *Oxypoda lividipennis* in the former samples, and the presence in them of *Autalia impressa*. The grouping of Martinshaw Wood samples with the open site samples from Charnwood Lodge is probably due to the presence of species such as *Tachyporus chrysomelinus*, *T. hypnorum* and *Drusilla canaliculata* in all these samples.

Further, the grouping of Charnwood Lodge samples according to habitat type and as a result of temporal factors may be explained by the staphylinid species composition of the various habitats, and temporal variations in the abundance of these species in pitfall traps. Woodland species such as *M. staphylinoides*, *A. atrocephalum*, *A. unicolor*, *O. italicum*, *T. signatus*, *O. badia* and *O. lividipennis* distinguish Collier's Wood samples from the open site samples, which are distinguished by the presence in large numbers of open habitat species such as *T. chrysomelinus*, *T. hypnorum* and *D. canaliculata*. Open site samples are further distinguished by the presence in Flat Hill samples of *Xantholinus linearis*, *Staphylinus aeneo-*

cephalus and Sepedophilus nigripennis, and in Timberwood Hill samples of Dinaraea angustula and Mycetoporus rufescens.

Both the classificatory techniques used in the present study provide ecologically meaningful groupings of samples. However, mean index sorting was preferred since groupings of samples are better defined and widely separated, and separate groups of highly similar samples are successively fused to form larger groups whereas in nearest neighbour sorting, samples tend to be added 'on one by one.

Principal component analysis groups samples primarily according to site and secondarily according to temporal factors, especially at the Charnwood Lodge sites. The results of principal component analysis are in general agreement with those obtained by nearest neighbour and mean index sorting. However, principal component analysis provides more information on the relationships between samples than can be represented in the two-dimensional dendrograms resulting from the classificatory techniques used. The clustering together of open site winter and spring samples in Charnwood Lodge Nature Reserve, for example, is more evident in the plots of principal component analysis (Fig. 6.14), than in the corresponding dendrogram (Fig. 6.13). Similarly, the mid-summer samples from Collier's Wood are more effectively separated from the rest of the spring-summer samples by principal component analysis than by the classificatory techniques (Figs. 6.1 - 6.3). The consistent grouping of samples in the various plots of the principal component analysis serves to emphasise the similarities between these samples and point to the need to discover the basis of these similarities.

7. GENERAL DISCUSSION

The Staphylinidae exhibit a variety of habits and are found in a wide diversity of habitats, ranging from woodlands, to open habitats, to caves, mountains and littoral environments (cf. Ch. 1). Notwithstanding this diversity, the species which occur in different habitats have not been extensively compared in any one study, except by Nield (1974), who investigated the Staphylinidae and Carabidae of woodlands, fields and gardens in the greater Manchester area. The occurrence and abundance of the staphylinid and carabid species in a more limited variety of habitats have, however, been studied by several workers. Van der Drift (1959) studied two adjacent oakwoods and a Scots pine wood, Evans (1971) compared four different deciduous woodland sites, and Boyd (1960) compared grazed and ungrazed grassland. Of these studies, only Nield has attempted a quantitative comparison of the data, although Hanski and Koskela (1977), using the data of Renkonen (1944), have compared both qualitative and quantitative methods of ecological classification of samples of Staphylinidae and Carabidae collected on a lake shore in southern Finland.

In this study, the Staphylinidae were obtained by pitfall trapping on different sites, representing different habitat types in the Charnwood Forest Area. The diversities of the various samples were quantified, using Simpson's Index and the Shannon-Weiner Information Index, and the similarities between samples measured by an index of similarity, τ . The resulting matrices of indices were sorted using two classificatory techniques, nearest neighbour and mean index sorting, and one ordinatory method, principal component analysis. The resultant groupings were then examined to determine the factors which affect the formation of sample groups.

The quantitative comparison of the 52 quarterly samples from Charnwood Lodge and Martinshaw Wood resulted in the general separation of woodland samples from open site samples. Generally the Charnwood Lodge and Martinshaw Wood samples maintained their individual groupings although Martinshaw Wood sites mainly linked with the Charnwood Lodge open site samples. Within the woodland group, Collier's Wood samples appeared distinct from the woodland samples taken from Timberwood Plantation and Martinshaw Wood.

In this comparison of quarterly samples, only samples from the stream and Timberwood Plantation did not separate into clear site-groups. The winter and spring Timberwood Plantation samples grouped with the other woodland samples, while the summer and autumn samples showed greater similarities with the open site samples. Stream samples also showed a temporal variation with the summer and autumn samples being included with a group of mainly Timberwood Hill and Flat Hill summer and autumn samples, and the winter and spring samples with a smaller group of first year winter and spring samples from these two sites.

The distinction between the Staphylinidae of woodland and non-woodland sites was also evident in the sample comparisons by Nield (loc. cit.) who used presence-absence data to calculate various indices of similarity, and numerical data to calculate the correlation coefficient, r, between pairs of samples, and then used nearest neighbour sorting to group the various samples. In his studies, the high degree of similarity between the Staphylinidae of woodland samples, and the lesser similarity between fields, allotments and gardens was also evident, while the pattern of carabid distribution was the converse.

In this study, the distinctness of the staphylinid faunas of Collier's Wood, Flat Hill, Timberwood Hill and Martinshaw Wood was related to differences in the species occurring at the various sites. Collier's Wood was distinct from other woodland sites because of the presence of large numbers of Micropeplus staphylinoides, Omalium italicum, Ocalea badia, Anthobium atrocephalum, A. unicolor, Tachinus signatus and Oxypoda lividipennis. The first three species were exclusive to Collier's Wood, while sporadic occurrences of the remaining species have been recorded in Timberwood Plantation and the Martinshaw Wood sites. The preferences of both A. atrocephalum and A. unicolor for woodland habitats have also been recorded by Nield (1974), while Kasule (1968) and Evans (1969, 1971) have also recorded these species from woodland habitats. T. signatus has also been recorded from woodlands (Kasule, loc. cit.; Evans, 1969), although Evans (1971) considers that this species is probably characteristic of woodland edge habitats.

A number of the numerically less abundant species eg. Olophrum fuscum, Omalium excavatum, O. oxyacanthae, O. rugatum, Syntomium aeneum, Atrecus affinis, Quedius fumatus, Q. mesomelinus, Tachinus pallipes, Boreophilia islandica, Liogluta nitidula, Atheta fungicola, Dimetrota marcida and Tinotus morion occur as single individuals in Collier's Wood samples and may contribute to the separation of Collier's Wood from other sites. However, since the capture of single individuals of these species in Collier's Wood may be purely due to chance, their restriction to woodland habitats cannot be confirmed in the present study.

More open sites such as Timberwood Hill, Flat Hill and the Martinshaw Wood sites, were characterised by the absence of the woodland species and the presence in large numbers of Tachyporus chrysomelinus, T. hypnorum and Drusilla canaliculata; T. chrysomelinus and T. hypnorum have also been recorded in woodland sites, but in much smaller numbers. The ubiquitous distribution of T. chrysomelinus and T. hypnorum has been described by Horion (1967) and Nield (1974), while the preference of D. canaliculata for open habitats has been recorded by Horion (loc. cit.) and Obrtel (1968). Martinshaw Wood samples were further distinguished by the presence of Autalia impressa, Timberwood Hill samples by the presence of Mycetoporus rufescens and Dinaraea angustula, and Flat Hill by Othius angustus, Xantholinus linearis, Staphylinus aeneocephalus and Sepedophilus nigripennis. Rare occurrences which may be characteristic of open habitats include Micropeplus porcatus, Lesteva heeri and Lathrobium fulvipenne which were only ever recorded on the stream bank, Stenus clavicornis, Ochthephilum fracticorne, Gyrohypnus fracticornis, Xantholinus longiventris and Quedius nitipennis which were only recorded on Flat Hill, and Q. picipes which was only recorded on Timberwood Hill. As with the rare woodland species it was not possible to verify whether these species are restricted to open habitats because the isolated capture of such species may be purely due to chance. However, Steel (1952) has reported the restriction of Lesteva heeri to stream sites.

The differences between open and woodland habitats were also reflected in the results of fish baited pitfall traps, in which Tachinus humeralis and Philonthus spp., though present at both Collier's Wood and Flat Hill, were very much more abundant at the former site.

Comparisons of the various sites in terms of the number of species recorded in six pitfall traps per site from August 1976 to February 1977 showed Collier's Wood and the oak site in Martinshaw Wood to have the greatest number of species. In Charnwood Lodge, fewer species were recorded at Flat Hill, Timberwood Hill and Timberwood Plantation while the smallest number of species was found in the stream site. In Martinshaw Wood, differences in the number of species trapped at the various sites were less striking than in Charnwood Lodge.

Comparisons of the diversities of the August '76 - January '77 samples from Charnwood Lodge and Martinshaw Wood (Fig. 5.2 and 5.3) show that generally the Martinshaw Wood sites were more diverse than the Charnwood Lodge sites. However, during this half-year, the diversities of the Charnwood Lodge sites were generally lower than those of other half-yearly periods, largely because of the large numbers of _Tachyporus chrysomelinus_ and _T. hypnorum_ trapped during this period. Using H' as an index of diversity, Collier's Wood appeared the most diverse of the Charnwood Lodge sites, followed in order of decreasing diversity by Timberwood Plantation, Flat Hill, the stream and Timberwood Hill while in Martinshaw Wood, the oak site was most diverse, followed in order of decreasing diversity by the bracken, pine and grass sites so that in both these study areas, the oak woodland had the most diverse staphylinid fauna during this period. Further, differences in diversity values were not as marked in Martinshaw Wood sites as in Charnwood Lodge sites.

Within the Charnwood Lodge sites, comparisons of the diversities of half-yearly samples also showed Collier's Wood to be most diverse except in the first half-year, when the diversity of Collier's Wood samples was lower than that of all other sites, almost certainly because of the unevenness caused by the very large numbers of _Ocalea badia_ and _Oxypoda lividipennis_ in pitfalls.

All these differences in the number of species, species composition, and diversity serve to emphasise the distinctiveness of the fauna of Collier's Wood as compared to all other sites. Collier's Wood is the least disturbed of the study sites and the vegetation there, oak woodland, is apparently the natural climax vegetation of lowland

England. All other sites have a history of human interference, and habitat simplification. Flat Hill is used for rough grazing, as are the fields on both sides of the stream. Timberwood Hill has been drained, and the conifers in Timberwood Plantation are constantly being logged (Nature Conservancy Council, 1975). In Martinshaw Wood, major changes in forestry management practice have resulted in the native trees being replanted over the last 40 years with mixed conifers and deciduous species (Nature Conservancy Council, loc. cit.).

The effect on the staphylinid fauna of this disturbance to the habitat and the consequent habitat simplification is likely to be a reduction in the number of species and in the diversities of the disturbed sites. Similar effects on the composition of the insect fauna resulting from changes in land use are reviewed by Uvarov (1964).

Within Charnwood Lodge, samples were grouped primarily as a result of similarities in habitat preferences, so that distinct groups of Collier's Wood, Flat Hill and Timberwood Hill samples were formed. Within each of these sites, and at the stream and Timberwood Plantation sites, the tendency was for samples to form groups in response to temporal variations. Within the Martinshaw Wood sites, samples were grouped mainly in response to temporal variations, and the various sites did not have distinct staphylinid faunas. This was probably related to the proximity of all the study sites in Martinshaw Wood.

The staphylinid fauna of Collier's Wood showed a distinct seasonality in the occurrence and abundance of species. The most common species eg. Micropeplus staphylinoides, Anthobium atrocephalum, A. unicolor, Omalium italicum, Ocalea badia and Oxypoda lividipennis were most active during autumn and winter with peaks of activity and abundance from October to December. Other species, eg. Tachinus signatus, were most active and abundant around June - July, and were not taken in pitfall traps from December to March, In their studies, Evans (1969, 1971) and Kasule (1968) also recorded similar periods of activity for T. signatus and A. unicolor, which Kasule describes as an autumn and winter breeder. Othius punctulatus was mostly trapped from November to June, with a decrease during July to October, a pattern similar to that observed by Van der Drift (1959), Evans (1969) and Kasule (1970).

The common open site species were similarly active at different times during the year. Xantholinus linearis was most active from November to April, consistent with the findings of Van der Drift (1959) and Evans (1969). Philonthus cognatus was most active from April to June; this is contrary to the findings of Edwards, Butler and Lofty (1975) who recorded captures of this species throughout the year, and especially around May and August. Sepedophilus nigripennis was active from February to November, with a peak of activity in July, and Drusilla canaliculata from May to October, with a peak of activity in July. Obrtel (1968) obtained the latter species in pitfall traps from April to October, with maximum captures around May and August to September.

The common ubiquitous species such as Othius myrmecophilus, Tachyporus chrysomelinus, T. hypnorum and T. nitidulus were generally active throughout the year. Both Evans (1969) and Kasule (1970) similarly recorded year round activity in O. myrmecophilus while Horion (1967) found Tachyporus spp. throughout the year.

The occurrence of other species such as Olophrum piceum and Philonthus decorus appeared to be limited to certain months of the year. The former species, for example, was active from November to May, with greatest activity in November to December, a pattern similar to that reported by Kasule (1968) and Erichson (1968), although these authors report a further peak of activity around March, which is related to the emergence of the new generation. Philonthus decorus was captured from May to October, with peak captures occurring in May/June and September /October, consistent with the patterns of activity observed by Van der Drift (1959), Frank (1967), Kasule (1967), Evans (1969, 1971) and Kowalski (1976).

Species of a similar size show peaks of activity at different times of the year in both woodland and open sites. In Collier's Wood, among the species which are < 5 mm, there is a partial overlap in the peak abundances of Micropeplus staphylinoides, Anthobium atrocephalum, A. unicolor and Omalium italicum during October and November. Among the open site species, partial overlapping of peak abundances also occur but to a lesser extent - peak abundances of T. chrysomelinus and T. hypnorum, both < 5 mm long, overlap in April, while those of Othius myrmecophilus and Xantholinus linearis (5 - 10 mm) overlap in December and O. myrmecophilus and Philonthus cognatus overlap in May. Within the limited resources of a particular habitat, these partial overlaps are possibly because of the generalised feeding habits of the staphylinids.

Staphylinid captures suggest that the majority of species are aggregated. This, and the strong preference of certain species for certain sites suggest some specificity in other requirements of the habitat or microhabitat. It follows from this that sites which can support a greater number of species and a greater species diversity, should have a greater diversity of microhabitats.

In this study, the differences in the samples taken at the various sites at different times has prompted the quantitative comparison of samples. Using τ as an index of similarity, and classificatory techniques and principal component analysis, ecologically meaningful results were obtained.

The use of a rank correlation coefficient as an index of similarity between samples is considered especially useful in this study since the Staphylinidae are not normally distributed. Further, the use of ranked abundance values instead of absolute abundance values is preferred since the data obtained from different numbers of pitfall traps is being compared. Further, τ attaches equal importance to the more abundant as well as to the less abundant species. Nield (1974) mainly used indices based on presence-absence data for the comparison of pairs of samples of Coleoptera, both Carabidae and Staphylinidae, e.g. the Jaccard Index and the Disequilibrium Coefficient (Cole's Coefficient of Similarity (Cole, 1949)), both of which are mentioned in Greig-Smith (1964). Such indices are wasteful of information since they do not take into account the abundances of the various species. Nield (loc. cit.) therefore also used the correlation coefficient, r, for sample comparison. The use of r is, however, doubtfully valid because the normal distribution of these insects cannot be assumed and Nield (pers. comm.) regards the use of r as valid only when the abundances to be compared are large.

In this study, mean index sorting was preferred to nearest neighbour sorting, since groupings of samples were better defined and more widely separated while separate groups of highly similar samples were successively fused to form larger groups. In nearest neighbour sorting, samples were often added one by one, resulting in one large group. Nield (1974), who used nearest neighbour sorting for site and species analyses, also encountered this problem of large numbers of small clusters, but generally found this method adequate for his study. Hanski and Koskela (1977) in their analysis of 40 samples of carabid and staphylinid beetles collected by Renkonen (1944), considered that the minimum variance clustering method (Anderson, 1966; Pritchard and

Anderson, 1971) using log transformed data and half the squared Euclidean distance as a measure of similarity, provided results which corresponded best to that reached by 'ecological intuition' ie. the ' natural classification' produced by three people without the aid of numerical methods, while nearest neighbour sorting was unsatisfactory.

In the present study, the results of principal component analysis were generally in agreement with those obtained by mean index sorting, so that the major groups of samples obtained by these different methods were similar. Thus, both these techniques showed the general separation of woodland and non-woodland samples and the distinctness of the Collier's Wood samples. Generally, principal component analysis provided more information on the relationships between samples than can be represented by two-dimensional dendrograms. The mid-summer samples from Collier's Wood, for example, were more effectively separated from the rest of the spring-summer samples by principal component analysis than by the classificatory technique used. However, the increase in information obtained from the six plots of the first four axes of the principal component analysis is small compared to that obtained from a single dendrogram.

In the present study, it was considered unneccessary to analyse the physical, chemical and other environmental parameters of the various sites and to make site comparisons in terms of these parameters, although such comparisons would be essential in more detailed studies of selected species. Hanski and Koskela (1977), however, classified the quadrats they studied according to their physiognomic characteristics, and concluded that in microhabitats of a structurally extreme nature, such as those with dense vegetation, the distribution of beetle communities generally corresponded with those of the plant communities, whereas communities inhabiting less extreme microhabitats were probably controlled by different factors. Nield (1974) made detailed site analyses of 40 factors e.g. vegetation, litter, cover and soil, and compared these sites on the basis of these factors. The species and site dendrograms were then compared by observation. By this method, and especially by regression analysis of beetle numbers against various site characteristics, the site analyses were found to be generally similar to the animal analysis, with staphylinid distributions significantly associated with site type and history.

The results of sample comparisons have been complemented by the use of indices of diversity for sample description. The two indices used - the Shannon-Weiner Information Index, H', and the modified Simpson's Index, $\tilde{D}$ - could not be tested against any theoretical distribution and have not been used in the major ecological studies on the Staphylinidae, such as those of Van der Drift (1959) and Nield (1974), although indices such as α have been used by Jones (1976) to describe the carabid and staphylinid fauna of winter wheat and fallows while ε, the 'equitability' component of species diversity, has been applied to the Coleoptera from grass tussocks (Luff, 1966a). In spite of this, H' and $\tilde{D}$ have shown up the differences in the samples taken from the various sites at different times which has prompted the investigation into the reasons for these differences.

Having determined that broad differences do exist in the staphylinid fauna of woodland and non-woodland sites in the Charnwood Forest area at various times, more detailed autecological studies of selected species, especially those which were numerically more abundant in the present study, would be relevant for future work. For such studies, other sampling methods besides pitfall trapping and heat extraction should be investigated e.g. suction trapping for obtaining tussock or grassland inhabiting species (Johnson, Southwood and Entwistle, 1957), and mark-recapture methods for the larger staphylinids such as Staphylinus and Philonthus spp. The latter methods may be especially relevant for woodland species since the cover available in these sites may render marked beetles less conspicuous and therefore less susceptible to predation than in more open sites.

The autecological studies should include studies on diurnal activity patterns using for example, a mechanical time sorting pitfall trap (Williams, 1958) and other laboratory techniques, as well as field and laboratory experiments on feeding and breeding activity. Further studies on the sensitivity of these selected species to the environment, e.g. their cover, temperature and humidity preferences and related detailed site or microhabitat analyses would also be relevant.

Such detailed studies of selected species may further allow for the investigation of the species-abundance relationships within a limited group such as the Tachyporinae. Once these relationships are elucidated, it may be possible to apply diversity indices based on these relationships, for which tests of validity are available.

In general, therefore, these detailed autecological studies should aim to provide us with a greater understanding of the habits of the Staphylinidae, of their roles in the various ecosystems, and consequently, of the reasons for the differences in the staphylinid fauna of the various sites.

SUMMARY

1) The Staphylinidae of different sites representing different habitat types in the Charnwood Forest Area, were studied mainly by pitfall trapping at monthly intervals and by heat extraction of soil samples.

2) The results obtained from both these techniques were analysed, and temporal variations in the abundance of the numerically most abundant species were discussed.

3) The diversities of the various samples were quantified using the modified Simpson's index, $\check{D}$, and the Shannon-Weiner Information index, H'.

4) Samples were compared quantitatively using τ as an index of the similarity between samples, and the resulting matrices of indices of similarity were sorted using nearest neighbour and mean index sorting, and principal component analysis. The resultant groupings were then examined to determine the factors which affect the formation of sample groups.

5) The deciduous woodland sites in Martinshaw Wood were found to have the greatest number of species and the most diverse staphylinid fauna.

6) In the quantitative comparison of quarterly samples, woodland samples were generally separated from open site samples. Charnwood Lodge and Martinshaw Wood samples generally maintained their individual groupings, although the latter samples generally grouped with the Charnwood Lodge open site samples. Within the various habitat groupings, samples were generally grouped according to a temporal pattern.

7) These groupings were related to the species occurring at the various sites and temporal variations in their abundance.

8) Woodland species, species of open habitats and ubiquitous species could be distinguished.

9) The majority of woodland species were most active during autumn and winter, while open site species were active at different times during the year, and ubiquitous species were generally active throughout the year.

10) The results of the sample comparisons, the differences in the species occurring at the various sites, and their diversities, were related to site history.

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Plate 1 : Site 1 - Collier's Wood

Plate 2 : Site 2 - Flat Hill

Plate 3 : Site 3 - Stream site

Plate 4 : Site 4 - Timberwood Hill

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Plate 5 : Site 5 - Timberwood Plantation

Plate 6 : Site 1 - Martinshaw Grass site

Plate 7 : Site 2 - Martinshaw Bracken site

Plate 8 : Site 3 - Martinshaw Oak site


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Plate 9 : Site 4 - Martinshaw Pine site

Plate 10: Jar pitfall with rain shield in Collier's Wood

Plate 11: Square pitfall trap, SP1, in Collier's Wood

Plate 12: Square pitfall trap, SP2, in Collier's Wood

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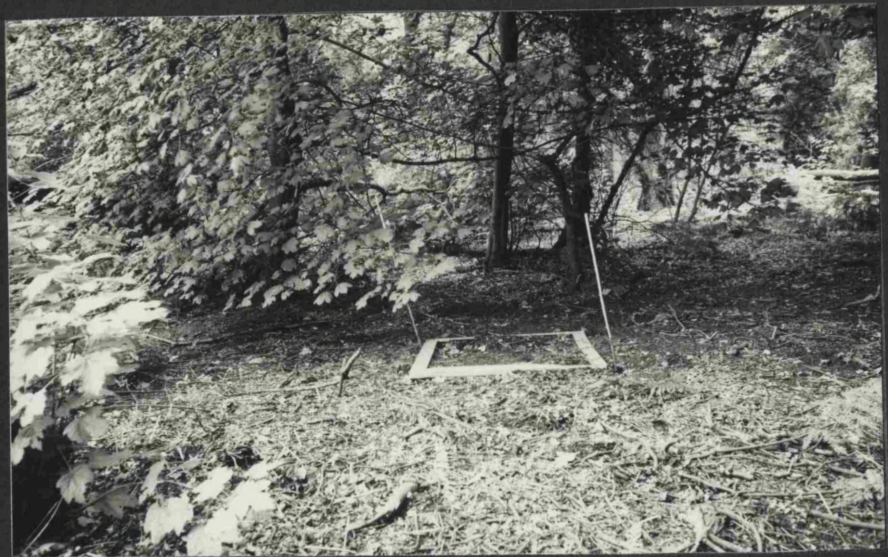


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Table (i). Staphylinid captures from four gutter pitfall traps at Collier's Wood, Charnwood.

Sampling Period / Species	21.5.76 - 25.5.76	25.5.76 - 1.6.76	1.6.76 - 9.6.76
1. _Anthobium atrocephalum_	3	1	-
2. _Anotylus rugosus_	2	-	-
3. _Lathrobium fulvipenne_	-	1	-
4. _Othius punctulatus_	-	1	-
5. _Philonthus decorus_	1	4	3
6. _Mycetoporus lepidus_	1	2	-
7. _Tachyporus chrysomelinus_	4	-	1
8. _Tachinus signatus_	-	1	-
9. _Oxypoda lividipennis_	17	11	-
10. Other Aleocharinae	6	2	3
Staphylinid totals	34	23	7

Table (ii) Staphylinid catches in square pitfall trap, SP 1, at Collier's Wood, Charnwood.

Species \ Sampling period beginning	11.5.77	15.6.77	25.7.77	25.8.77	22.9.77	26.10.77*	21.12.77	26.1.78	28.2.78	15.3.78	14.4.78	16.5.78	14.6.78	20.7.78 -16.8.78
1. _Micropeplus staphylinoides_	-	-	1	3	1	-	-	-	-	-	-	-	-	-
2. _Megarthrus sinuatocollis_	-	-	-	-	-	-	-	-	-	-	-	1	-	-
3. _Anthobium atrocephalum_	-	-	-	-	-	3	4	6	5	-	4	-	-	-
4. _Anthobium unicolor_	-	-	-	-	-	-	-	-	-	2	-	-	-	-
5. _Omalium caesum_	1	3	-	-	-	-	-	-	-	-	-	-	-	-
6. _Omalium italicum_	-	1	-	-	-	-	1	2	-	-	1	6	2	-
7. _Omalium rivulare_	-	2	-	-	-	-	-	-	-	-	-	-	-	-
8. _Omalium rugatum_	-	-	-	-	-	-	1	-	-	-	-	-	-	-
9. _Anotylus sculpturatus_	-	-	-	-	-	-	1	-	-	-	-	-	1	-
10. _Othius myrmecophilus_	-	-	-	-	1	-	-	1	-	1	1	-	-	-
11. _Othius punctulatus_	-	-	-	-	-	-	-	-	-	-	-	1	-	-
12. _Philonthus decorus_	13	3	-	1	-	-	-	-	-	-	1	3	-	-
13. _Quedius curtipennis_	2	-	-	-	-	-	-	-	-	-	-	-	-	-
14. _Quedius nigriceps_	1	-	-	-	1	-	-	-	-	-	-	-	-	-
15. _Mycetoporus lepidus_	-	-	-	-	-	-	-	-	-	-	3	1	-	1
16. _Mycetoporus rufescens_	1	1	-	-	-	-	-	-	-	-	-	-	-	-
17. _Bolitobius inclinans_	-	-	1	-	-	-	-	-	-	-	-	-	-	-
18. _Sepedophilus nigripennis_	-	-	-	-	-	-	-	-	-	-	-	1	-	-
19. _Tachyporus chrysomelinus_	1	-	-	-	-	-	-	-	-	-	-	-	-	-
20. _Tachyporus hypnorum_	-	-	-	1	1	-	-	-	-	-	-	-	-	-
21. _Tachinus signatus_	2	-	1	-	-	-	-	-	-	-	-	-	-	-
22. _Cypha longicornis_	-	1	-	-	-	-	-	-	-	-	-	-	-	-
23. _Aloconota gregaria_	-	1	-	-	-	-	-	-	-	-	-	-	-	-
24. _Ocalea badia_	-	-	-	-	-	1	-	-	-	-	-	-	-	-
25. _Astilbus canaliculatus_	1	-	-	-	-	-	-	-	-	-	-	-	-	-
26. _Oxypoda lividipennis_	8	1	-	-	-	2	7	1	-	-	-	10	1	-
27. _Oxypoda umbrata_	-	-	-	-	-	-	-	-	-	1	-	-	-	-
28. Other Aleocharinae	2	3	3	-	-	-	-	-	-	1	-	-	1	-
Total Staphylinidae	32	16	6	5	4	6	14	11	5	5	10	23	5	1

*This sampling period ended on 23.11.77 and the trap was reset on 21.12.77.

Table (iii) Staphylinid catches in square pitfall trap, SP 2, at Collier's Wood, Charnwood.

Species / Sampling period beginning	14.12.77	18.1.78	8.2.78	15.3.78	14.4.78	16.5.78	14.6.78	20.7.78 - 16.8.78
A. Outer gutter								
1. Micropeplus staphylinoides	2	-	-	-	-	-	-	-
2. Proteinus brachypterus	3	-	1	-	-	-	-	-
3. Anthobium atrocephalum	13	12	12	25	3	4	-	-
4. Anthobium unicolor	-	-	6	-	5	-	-	-
5. Olophrum piceum	1	-	-	-	-	-	-	-
6. Omalium caesum	3	1	-	1	-	-	-	-
7. Omalium italicum	42	21	9	1	-	4	2	-
8. Anotylus sculpturatus	-	-	-	-	2	1	-	-
9. Oxytelus fulvipes	-	1	-	-	-	-	-	-
10. Othius myrmecophilus	2	-	3	1	1	1	-	-
11. Othius punctulatus	-	-	-	1	3	-	-	-
12. Philonthus decorus	-	-	-	-	1	13	3	2
13. Staphylinus aeneocephalus	-	-	1	-	-	-	-	-
14. Quedius fumatus	-	-	-	-	-	1	-	-
15. Mycetoporus lepidus	-	-	-	-	14	34	-	13
16. Mycetoporus rufescens	-	-	-	-	1	-	-	-
17. Bolitobius inclinans	-	-	3	-	1	-	-	-
18. Sepedophilus nigripennis	-	-	-	-	1	-	-	-
19. Tachinus signatus	1	-	-	-	-	6	4	-
20. Tachinus subterraneus	-	1	-	-	-	-	-	-
21. Leptusa fumida	-	3	-	-	-	-	-	-
22. Autalia impressa	1	-	-	-	-	-	-	-
23. Geostiba circellaris	-	-	1	-	-	-	-	-
24. Ocalea badia	5	-	-	-	-	-	-	-
25. Oxypoda lividipennis	37	7	11	6	1	7	-	1
26. Other Aleocharinae	2	-	-	-	1	2	1	-
Total Staphylinidae	112	46	47	35	34	73	10	16
B. Inner gutter								
1. Proteinus brachypterus	-	1	1	-	-	-	-	-
2. Anthobium atrocephalum	1	-	7	2	1	-	-	-
3. Anthobium unicolor	-	-	1	-	1	-	-	-
4. Omalium caesum	-	5	-	-	-	-	-	-
5. Omalium italicum	3	9	4	-	2	3	-	-
6. Anotylus sculpturatus	-	-	1	-	-	-	-	-
7. Philonthus decorus	-	-	-	-	-	1	-	-
8. Philonthus varians	-	-	-	-	-	1	-	-
9. Mycetoporus lepidus	-	-	-	-	1	13	-	9
10. Tachyporus chrysomelinus	-	-	-	-	-	1	-	-
11. Tachyporus hypnorum	-	-	-	1	-	-	-	-
12. Tachyporus nitidulus	-	-	-	-	-	1	-	-
13. Tachinus signatus	-	1	-	-	-	1	-	-
14. Ocalea badia	6	1	1	-	-	-	-	-
15. Oxypoda lividipennis	2	2	2	-	-	11	-	-
16. Other Aleocharinae	1	-	1	-	-	-	-	-
Total Staphylinidae	13	19	18	3	5	32	0	9

Table iv . File NAMES.

Staphylinid captures in jar pitfalls at Charnwood Lodge from October 1975 to October 1977.

```
* MICROPEPLUS PORCATUS (PAYKULL,1789)
        $ST03        08      1
*                 STAPHYLINOIDES (MARSHAM,1802)
        $CF01        01      1       $CF02      01     1
       $CF02      02      1       $CF02      03     4      $CF03     03     1
       $CF01      04      2       $CF02      04     1      $CF03     04     4
       $CF02      05      1       $CF03      05     1      $CF03     06     1
       $CF01      07      1       $CF03      07     2      $CF04     07     1
       $CF01      11      4       $CF03      11     11
       $CF01      12      5       $CF02      12     2      $CF03     12     3
       $CF01      13      1       $CF02      13     1      $CF03     13     1
       $CF08      13      1       $CF09      13     1
       $CF01      14      4        $CF17      14     1
       $CF10      15      1       $CF16      15     1
       $CF05      16      1       $CF05      17     1
       $CF02      18      1       $CF03      18     1
       $CF03      22      2       $CF10      22     1      $CF14     22     2
       $CF15      22      1
       $CF04      23      1       $CF08      23     7      $CF15     23     1
       $CF11      23      1

       $CF01      24      3       $CF02      24     29     $CF03     24     24
       $CF09      24      1       $CF10      24     1      $CF11     24     1
       $CF13      24      1       $CF14      24     1      $CF15     24     4
       $CF18      24      2
* PROTEINUS BRACHYPTERUS (FABRICIUS,1792)
      $TP05       13     1      $TP05      15     1      $TP02    16     1
  $TP04      17      1     $TP05      17     1     $TP03     24     1
      $ST04      06      1      $ST02       23     1      $ST03     24     1
   $CF09     13      1      $CF11       13     2      $CF04     14     1
 $CF16     15      1      $CF04      16     2      $CF17      16     1
      $CF08      23      2
 $CF01    24      1
*                OVALIS STEPHENS,1834
        $TP03        07      1
* ANTHOBIUM ATROCEPHALUM (GYLLENHAL,1827)
         $TH10       24       1        $TP05      14      1      $FH05     02     1
         $CF01       01       4        $CF02      01      8      $CF03     01     9
         $CF04       01       6        $CF05      01      11     $CF05     01     3
       $CF01       02       1        $CF03      02      3      $CF04     02     4
         $CF05       02       1        $CF06      02      1
         $CF01       03       3        $CF02      03      10     $CF03     03     2
         $CF04      03        4        $CF06      03      1
         $CF01       04       4        $CF02      04      5      $CF03     04     3
         $CF05       04       1        $CF06      04      4
         $CF01       05       4        $CF02      05      3      $CF03     05     3
         $CF04       05       1        $CF06      05      1
         $CF01       06       5        $CF02      06      3      $CF03     06     2
         $CF04       06       2        $CF05      06      1
         $CF05       06       3
         $CF01       07       7        $CF02      07      3      $CF03     07     3
         $CF04       07       3        $CF05      07      3      $CF06     07     4
         $CF01       12       7        $CF08      12      1      $CF09     12     8
         $CF13       12       1        $CF14      12      1      $CF15     12     3
         $CF16       12       2
         $CF01       13       4        $CF02      13      2      $CF03     13     1
         $CF04       13       2        $CF05      13      2      $CF07     13     3
         $CF08       13       3        $CF10      13      1      $CF11     13     2
         $CF14       13       4        $CF15      13      6      $CF16     13     5
         $CF17       13       1        $CF18      13      7
         $CF01       14       2        $CF02      14      6      $CF03     14     2
      $CF04       14       3        $CF05      14      3      $CF08     14     3
         $CF09       14       2        $CF10      14      1      $CF12     14     2
         $CF13       14       2        $CF14      14      1      $CF15     14     6
         $CF16       14       3        $CF17      14      1      $CF18     14     6
         $CF02       15       4        $CF03      15      5      $CF07     15     1
         $CF08       15       2        $CF09      15      1      $CF11     15     4
         $CF13       15       5        $CF14      15      4      $CF15     15     2
         $CF15       15       6        $CF17      15      2      $CF18     15     1
         $CF01       16       1        $CF05      16      1      $CF10     16     1
         $CF14       16       1
         $CF03       17       1        $CF05      17      3      $CF07     17     2
         $CF08       17       9        $CF11      17      4      $CF12     17     1
         $CF13       17       5        $CF16      17      3      $CF18     17     4
         $CF01       18       1        $CF02      18      2      $CF03     18     2
         $CF04       18       1        $CF05      18      1      $CF06     18     5
         $CF07       18       5        $CF08      18      3      $CF10     18     7
         $CF11       18       8        $CF12      18      1      $CF13     18     5
         $CF14       18       7        $CF15      18      2      $CF17     18     2
         $CF18       18       1
         $CF09       19       2        $CF13      19      1      $CF16     19     1
         $CF01       24       2        $CF02      24      4      $CF03     24     7
         $CF04       24       4        $CF10      24      5      $CF11     24     1
         $CF12       24       3        $CF13      24      1      $CF14     24     2
         $CF15       24       3        $CF16      24      4      $CF18     24     5
```

Table iv cont'd

* UNICOLOR (MARSHAM,1802)								
$CF01	01	2	$CF02	01	2	$CF05	01	1
$CF06	01	1						
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$CF13	12	1	$CF14	12	3	$CF15	12	3
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$CF18	13	2						
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$CF09	14	1	$CF11	14	3	$CF13	14	2
$CF14	14	1	$CF15	14	5	$CF16	14	1
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$CF14	24	4	$CF15	24	1	$CF18	24	4
* OLOPHRUM FUSCUM (GRAVENHORST,1806)								
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$TH06	01	1						
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$FH02	02	1	$FH05	02	1			
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$CF04	01	1	$CF02	02	4	$CF05	02	1
$CF06	03	1	$CF06	05	1	$CF15	13	1
$CF07	14	1						
* ACIDOTA CRUENTATA MANNERHEIM,1830								
$TH04	02	1	$TP02	01	1	$TP03	01	1
$TP05	01	1	$FH06	13	1	$FH15	13	1
* LESTEVA HEERI FAUVEL,1872								
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* OMALIUM CAESUM GRAVENHORST,1806								
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$CF16	13	1	$CF13	17	1			
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$CF03	22	1	$CF18	22	1	$CF02	24	1
$CF03	24	1	$CF04	24	1	$CF09	24	1
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* EXCAVATUM STEPHENS,1834								
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* ITALICUM BERNHAUER,1902								
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$CF16	12	1	$CF01	13	2	$CF02	13	3
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$CF07	14	1	$CF10	14	1	$CF11	14	1
$CF13	14	1	$CF14	14	1			
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$CF06	16	3	$CF08	17	1	$CF15	17	1
$CF16	17	1	$CF18	17	1			
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Table iv cont'd

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* RIVULARE (PAYKULL,1789)									
	$TP05	08	1	$FH01	02	1			
* RUGATUM MULSANT & REY,1880									
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* SYNTOMIUM AENEUM (MULLER,P.W.J.,1821)									
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* ANOTYLUS RUGOSUS (FABRICIUS,1775)									
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	$CF02	07	1	$CF02	10	1	$CF03	10	1
	$CF16	10	1	$CF13	13	1			
* SCULPTURATUS(GRAVENHORST,1806)									
	$FH09	21	1	$CF02	07	1	$CF04	19	1
* TETRACARINATUS (BLOCK,1799)									
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	$TP01	20	1	$ST05	09	1			
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	$CF05	06	1	$CF01	07	1	$CF02	07	2
	$CF06	14	1	$CF09	19	1	$CF16	19	1
	$CF17	19	1						
* STENUS CLAVICORNIS (SCOPOLI,1763)									
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* IMPRESSUS GERMAR,1824									
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	$TH01	16	1	$TH02	16	1	$TH04	16	1
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	$TH09	20	1	$TH09	22	1	$TH13	22	1
	$TH03	23	1	$TH06	23	1	$TH03	24	1
	$TH09	24	1						
	$FH05	03	1	$FH06	07	1	$FH05	09	1
	$FH05	12	1	$FH02	17	1	$FH07	19	1
	$FH16	23	2	$FH04	24	1	$FH16	24	4
* LATHROBIUM FULVIPENNE (GRAVENHORST,1806)									
	$ST01	09	1						
* OCHTHEPHILUM FRACTICORNE (PAYKULL,1800)									
	$FH02	09	1						
* OTHIUS ANGUSTUS STEPHENS,1833									
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	$FH03	05	1	$FH01	06	1	$FH03	06	1
	$FH04	09	1	$FH03	14	1			
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	$CF04	07	1	$CF03	10	1			
* MYRMECOPHILUS KIESENWETTER,1843									
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	$TH05	13	1	$TP03	04	1	$TP03	07	2
	$TP03	08	1	$TP05	11	1			
	$ST06	04	1	$ST03	06	2	$ST01	08	1
	$ST04	14	1						
	$FH04	01	1	$FH03	02	1	$FH06	02	1
	$FH03	03	2	$FH01	06	1	$FH06	07	2
	$FH05	18	1						
	$CF02	01	1	$CF03	02	1	$CF05	02	4
	$CF06	02	1						
	$CF02	03	2	$CF05	03	1	$CF04	04	1
	$CF03	05	1	$CF05	05	1	$CF06	05	1
	$CF03	07	1	$CF06	11	1	$CF06	14	1
	$CF04	16	2	$CF05	17	1	$CF10	17	1
	$CF02	18	1	$CF03	23	1	$CF06	23	1
	$CF02	24	1	$CF03	24	2	$CF06	24	1
	$CF12	24	1						
* PUNCTULATUS (GOEZE,1777)									
	$TH07	16	1						
	$TP05	03	2	$TP05	18	1	$FH04	03	1
	$CF01	01	1	$CF01	02	1	$CF02	02	1
	$CF01	03	2	$CF02	03	1	$CF04	03	1
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	$CF01	08	1	$CF03	14	1	$CF06	14	1
	$CF10	14	1	$CF02	15	1	$CF03	15	1
	$CF07	15	1	$CF01	16	1	$CF04	16	1
	$CF03	18	1						
* ATRECUS AFFINIS (PAYKULL,1789)									
	$CF05	09	1						
* GYROHYPNUS FRACTICORNIS (MULLER,O.F.,1776)									
	$FH04	05	1						
* XANTHOLINUS GALLICUS COIFFAIT,1956									
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	$FH03	02	2	$FH05	14	1			
* LINEARIS (OLIVIER,1795)									
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	$TH05	18	1	$TH03	20	1			
	$TP03	03	1	$ST04	02	1	$ST03	06	1
	$ST05	13	1	$ST01	14	1	$ST04	15	2
	$ST02	17	1	$ST03	17	1	$ST06	18	1

Table iv cont'd

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$FH06	13	1						
$FH03	14	4	$FH04	14	2	$FH05	14	2
$FH08	14	1	$FH18	14	1	$FH15	15	2
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$FH10	17	1	$FH14	17	1			
$FH01	18	1	$FH03	18	1	$FH09	18	1
$FH14	18	1	$FH05	19	1	$FH03	20	1
$FH09	22	1	$FH14	24	1			
$CF15	14	1	$CF03	15	1	$CF14	22	1
* LONGIVENTRIS HEER,1839								
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* PHILONTHUS COGNATUS STEPHENS,1832								
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$TH13	19	2						
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$FH16	19	10	$FH17	19	1			
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$FH11	20	2	$FH07	23	1			
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* DECORUS (GRAVENHORST,1802)								
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$FH09	12	1	$FH03	19	1	$FH05	21	1
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$CF04	07	1	$CF06	07	4			
$CF01	08	1	$CF02	08	2	$CF03	08	2
$CF04	08	1	$CF06	08	1			
$CF01	09	1	$CF02	09	1	$CF15	09	1
$CF14	10	1	$CF18	10	1			
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$CF04	11	1	$CF11	11	1	$CF12	11	1
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$CF06	20	3	$CF13	20	1	$CF16	20	1
$CF14	21	1	$CF15	21	1	$CF18	21	3
$CF08	22	1	$CF18	22	1			
$CF03	23	1	$CF04	23	1	$CF12	23	1
$CF17	23	1						
$CF01	24	1	$CF03	24	1	$CF11	24	1
$CF13	24	1	$CF15	24	1			
* LAMINATUS (CREUTZER,1799)								
$TH02	06	1	$FH04	18	2	$CF04	19	1
* VARIUS (GYLLENHAL,1810)								
$TH03	07	1	$ST02	08	1			
$FH09	11	1	$FH01	23	1			
* VARIANS (PAYKULL,1789)								
$TH12	18	1	$FH03	02	1	$FH15	13	1
* STAPHYLINUS AENEOCEPHALUS DEGEER,1774B								
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$FH03	05	1	$FH02	12	1	$FH15	12	1
$FH03	14	1	$FH04	14	1	$FH09	14	1
$FH03	16	1	$FH05	16	2	$FH09	17	1
$FH12	17	1	$FH04	18	1	$FH10	18	1
$FH01	24	1	$FH02	24	1	$FH04	24	1
$FH15	24	1						
* OLENS MULLER,O.F.,1764								
$FH05	01	1	$CF12	12	3	$CF04	19	1
$CF02	23	1	$CF14	23	1	$CF15	23	1
$CF01	24	1	$CF04	24	1	$CF12	24	1
* QUEDIUS CURTIPENNIS BERNHAUER,1908								
$TH03	02	1	$TH02	05	1	$TH02	06	1
$ST01	07	1	$ST01	08	1	$ST01	09	1
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$FH04	06	1						
$FH05	05	1	$FH03	13	1	$FH05	13	1
$FH09	24	1	$FH15	24	1	$CF09	19	1
* FUMATUS (STEPHENS,1833)								
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* MESOMELINUS (MARSHAM,1802)								
$CF09	13	1						

Table iv cont'd

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	$TH05	24	1	$ST05	11	1	$ST01	20	1
	$ST01	22	1	$ST04	23	1			
	$FH01	01	1	$FH02	01	1	$FH04	02	1
	$FH06	23	1						
*	NEMORALIS BAUDI,1848								
	$CF04	02	1	$CF11	21	1			
*	NIGRICEPS KRAATZ,1857								
	$TH01	11	1	$TH11	12	1	$TH13	12	1
	$TH14	12	1	$TH04	24	1	$FH03	24	1
	$CF06	01	1	$CF14	14	1	$CF16	14	1
	$CF10	24	1	$CF18	24	1			
*	NITIPENNIS (STEPHENS,1833)								
	$FH03	02	1						
*	PICIPES (MANNERHEIM,1830)								
	$TH02	03	1						
*	TRISTIS (GRAVENHORST,1802)								
	$TH03	15	1	$TH01	19	1	$ST03	07	1
*	MYCETOPORUS CLAVICORNIS (STEPHENS,1832)								
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*	LEPIDUS (GRAVENHORST,1802)								
	$TP04	07	1	$FH04	06	1	$FH05	08	1
	$CF06	01	2	$CF04	02	1	$CF05	02	1
	$CF04	07	3	$CF05	07	2	$CF04	08	1
	$CF07	18	1	$CF08	18	1	$CF13	19	1
	$CF18	22	1						
*	RUFESCENS (STEPHENS,1832)								
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	$TH02	04	1	$TH03	04	1	$TH04	04	1
	$TH03	05	1	$TH03	06	1	$TH05	07	1
	$TH03	12	1	$TH14	12	1	$TH16	12	1
	$TH11	15	1	$TH14	15	2	$TH05	16	2
	$TH09	16	1	$TH11	16	1	$TH11	17	1
	$TP05	02	1	$TP02	05	1	$TP02	12	1
	$TP05	12	1	$ST03	05	1	$FH05	03	1
	$FH05	14	1	$FH18	16	1	$FH01	20	1
*	BOLITOBIUS ANALIS (FABRICIUS,1787)								
	$TH05	06	1	$TH01	07	1	$TH02	08	1
	$TH02	20	1	$TP04	10	1			
*	CINGULATUS (MANNERHEIM,1830)								
	$TH02	08	1	$TH06	09	1	$TH06	19	1
	$TH03	20	1	$ST01	08	1	$ST01	09	1
	$ST02	21	1						
*	INCLINANS (GRAVENHORST,1806)								
	$CF01	05	1	$CF02	05	2	$CF14	15	2
	$CF06	21	1	$CF17	22	1			
*	SEPEDOPHILUS MARSHAMI (STEPHENS,1832)								
	$TH03	01	1	$TH10	10	1	$TH07	11	1
	$TH08	11	3	$TH06	12	2	$TH08	12	3
	$TH11	12	1	$TH01	19	1	$TH09	20	1
	$TH05	22	1	$TH18	23	1	$TH04	24	2
	$TH05	24	2	$TH17	24	1			
	$ST01	08	6	$ST06	08	1	$ST01	09	1
	$ST05	09	1	$ST01	18	1	$ST06	19	1
	$ST04	20	1	$ST04	21	1	$ST06	21	3
	$FH05	03	1	$FH09	21	1			
*	NIGRIPENNIS (STEPHENS,1832)								
	$ST02	20	1						
	$FH03	01	1	$FH05	05	1	$FH06	05	1
	$FH01	06	1	$FH02	06	2	$FH03	06	1
	$FH06	06	1	$FH02	07	1	$FH03	08	4
	$FH02	09	2	$FH03	09	2	$FH06	09	1
	$FH03	11	1	$FH04	11	1	$FH15	11	1
	$FH02	13	1	$FH03	13	1	$FH05	18	3
	$FH01	20	1	$FH05	20	3	$FH09	21	1
	$FH11	21	1	$FH12	21	2	$FH17	21	2
	$FH14	22	1	$FH15	22	1	$FH10	23	1
	$FH03	24	1	$FH11	24	1	$FH14	24	1
*	TACHYPORUS CHRYSOMELINUS (LINNAEUS,1758)								
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	$TH02	06	3	$TH05	06	4	$TH06	06	1
	$TH01	07	2	$TH02	07	1	$TH03	07	8
	$TH04	07	2	$TH05	07	4	$TH06	07	1
	$TH04	08	1	$TH03	09	1	$TH14	09	1
	$TH01	10	1	$TH02	10	2	$TH03	10	9
	$TH08	10	1	$TH09	10	3	$TH11	10	1
	$TH12	10	2	$TH17	10	1	$TH18	10	1
	$TH08	11	1	$TH01	12	2	$TH03	12	1
	$TH08	12	1	$TH10	12	6	$TH11	12	3
	$TH18	12	1						
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	$TH05	13	1	$TH06	13	4	$TH07	13	3
	$TH09	13	3	$TH11	13	5	$TH16	13	3

Table iv cont'd

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$TH04	18	4	$TH05	18	6	$TH06	18	11
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$TH14	18	2	$TH15	18	3	$TH17	18	4
$TH18	18	5						
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$TH08	19	7	$TH10	19	2	$TH12	19	11
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$TH01	20	2	$TH02	20	1	$TH12	20	1
$TH11	21	1	$TH02	24	1	$TH09	24	1
$TH14	24	1						
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$TP04	08	3						
$TP02	09	2	$TP05	09	1			
$TP04	10	1	$TP05	10	4	$TP05	11	1
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$ST01	10	1	$ST03	10	1	$ST02	11	2
$ST01	18	1	$ST02	18	1	$ST03	18	1
$ST04	18	4						
$ST01	19	2	$ST02	19	4	$ST03	19	2
$ST05	19	1	$ST04	20	1	$ST01	21	1
$ST03	21	1	$ST04	21	1			
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$FH04	07	1	$FH05	07	2	$FH06	07	1
$FH03	08	5	$FH05	08	1			
$FH03	09	1	$FH06	09	1			
$FH05	10	1	$FH10	10	1	$FH14	10	1
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$FH03	11	1	$FH04	11	3	$FH09	11	5
$FH12	11	1	$FH15	11	2			
$FH04	12	1	$FH08	12	1	$FH11	12	3
$FH15	12	1						
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$FH11	13	1	$FH14	13	1	$FH15	13	2
$FH08	14	1	$FH14	14	1	$FH15	14	1
$FH03	17	1	$FH05	17	1	$FH16	17	1
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$FH10	18	2	$FH11	18	2	$FH12	18	2
$FH14	18	1	$FH18	18	2			
$FH03	19	2	$FH04	19	3	$FH05	19	2
$FH09	19	1	$FH11	19	3	$FH13	19	1
$FH14	19	1	$FH15	19	1	$FH18	19	1
$FH09	21	2	$FH03	22	1	$FH12	22	4
$FH15	22	1	$FH01	23	1	$FH05	23	2
$FH07	23	1	$FH10	23	1	$FH13	23	2
$FH16	23	1	$FH17	23	1	$FH18	23	1
$FH09	24	1	$FH10	24	2			
$CF15	09	1	$CF01	10	3	$CF03	10	1
$CF06	10	1	$CF09	10	2	$CF14	10	1
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$CF08	13	1						
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$CF09	19	2	$CF13	19	1	$CF17	19	1
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$CF10	23	1	$CF11	23	1	$CF14	23	1

HYPNORUM (FABRICIUS,1781)

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$TH01	06	1	$TH03	06	2	$TH05	06	1
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$TH01	10	2	$TH02	10	2	$TH03	10	10
$TH08	10	3	$TH09	10	1	$TH10	10	1
$TH11	10	2	$TH17	10	2			
$TH06	11	1	$TH18	11	1			
$TH10	12	2	$TH11	12	2	$TH13	12	1
$TH16	12	1	$TH18	12	1			
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Table iv cont'd

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$TH11	14	2
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$TH01	15	4
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$TH14	15	4
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$TH18	16	1
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$TH10	17	2
$TH17	17	2
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$TH18	18	13
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$TH08	19	12
$TH12	19	2
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$FH03	18	1
$FH06	18	2

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$TH13	19	3
$TH16	19	8
$TH14	20	1
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$FH17	15	1
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$FH09	16	1
$FH12	16	1
$FH16	16	1
$FH03	17	4
$FH05	17	8
$FH11	17	4
$FH15	17	3
$FH04	18	2
$FH03	18	1

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$TH06	16	2
$TH09	16	6
$TH12	16	1
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$ST03	19	1
$FH06	04	1
$FH03	06	1
$FH04	09	1
$FH10	10	7
$FH10	12	2
$FH05	13	1
$FH09	13	9
$FH14	13	1
$FH05	14	10
$FH11	14	10
$FH15	14	4
$FH18	14	1
$FH05	15	7
$FH15	15	1
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$FH13	16	1
$FH17	16	1
$FH04	17	3
$FH09	17	3
$FH13	17	1
$FH16	17	15
$FH05	18	14
$FH10	18	2

Table iv cont'd

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$FH03	19	3	$FH04	19	2	$FH05	19	5
$FH09	19	1	$FH11	19	3	$FH13	19	1
$FH15	19	2	$FH16	19	2	$FH18	19	5
$FH01	20	2	$FH06	20	1	$FH09	20	1
$FH16	20	1						
$FH14	21	1						
$FH01	22	1	$FH12	22	1	$FH15	22	3
$FH18	22	1						
$FH02	23	1	$FH03	23	3	$FH06	23	2
$FH07	23	4	$FH09	23	1	$FH10	23	7
$FH11	23	2	$FH13	23	1	$FH14	23	2
$FH15	23	3	$FH18	23	1			
$FH01	24	4	$FH02	24	2	$FH03	24	2
$FH04	24	1	$FH07	24	3	$FH08	24	3
$FH11	24	2	$FH12	24	1	$FH13	24	2
$FH15	24	1	$FH16	24	4	$FH18	24	1
$CF03	03	1	$CF02	07	1	$CF01	10	2
$CF02	10	2	$CF07	10	1	$CF11	10	1
$CF12	10	2	$CF14	10	2			
$CF07	13	1	$CF08	13	1			
$CF08	17	3	$CF16	17	1			
$CF01	18	1	$CF11	18	1	$CF18	18	1
$CF07	19	1	$CF09	19	2	$CF16	19	1
$CF01	23	2	$CF05	23	1			
$CF12	24	1						
* NITIDULUS (FABRICIUS,1781)								
$TH16	12	1	$TH05	20	1	$TH06	20	2
$TH07	20	1	$TH08	21	1			
$TP04	01	1	$TP05	01	1			
$TP05	11	2	$TP03	12	2			
$FH04	10	3	$FH10	10	4	$FH15	10	1
$FH05	19	1						
$CF11	10	1	$CF01	11	1	$CF17	18	1
$CF12	20	1						
* OBTUSUS (LINNAEUS,1767)								
$FH04	11	1						
$CF01	08	1	$CF02	11	1	$CF08	23	1
* SOLUTUS ERICHSON,1839								
$TH06	03	1	$TH01	06	1			
$ST01	20	1	$FH02	01	1			
$CF02	10	1	$CF12	10	1			
* TACHINUS HUMERALIS GRAVENHORST,1802								
$CF03	10	1	$CF06	10	1	$CF10	10	1
$CF15	10	1	$CF05	12	1	$CF10	24	1
* MARGINELLUS (FABRICIUS,1781)								
$TH05	04	1	$TP04	01	1	$ST01	05	1
$FH05	01	1	$CF04	01	1	$CF01	02	1
$CF02	02	1						
* PALLIPES (GRAVENHORST,1806)								
$CF11	13	2						
* SIGNATUS GRAVENHORST,1802								
$CF05	01	2	$CF02	06	1	$CF01	07	2
$CF02	07	3	$CF03	07	1	$CF04	07	4
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$CF05	08	1	$CF06	08	5	$CF11	08	2
$CF01	09	1	$CF02	09	3	$CF03	09	1
$CF06	09	11	$CF07	09	1	$CF10	09	2
$CF12	09	1	$CF18	09	2			
$CF02	10	1	$CF03	10	5	$CF04	10	4
$CF14	10	1	$CF15	10	3	$CF17	10	1
$CF01	11	1	$CF02	11	1	$CF03	11	1
$CF06	11	3	$CF11	11	1	$CF06	12	1
$CF03	19	1	$CF04	19	2			
$CF02	20	2	$CF03	20	3			
$CF15	21	1	$CF18	21	2			
$CF15	22	2						
$CF04	23	1	$CF05	23	1	$CF09	23	1
$CF11	24	1						
* SUBTERRANEUS (LINNAEUS,1758)								
$TP03	06	1	$FH03	04	1			
* CYPHA LONGICORNIS (PAYKULL,1800)								
$TH01	20	1	$FH04	07	1	$CF07	13	1
* BOREOPHILIA ISLANDICA (KRAATZ,1857)								
$CF02	08	1						
* ALOCONOTA GREGARIA (ERICHSON ,1839)								
$TP03	05	1	$TP01	06	1	$TP04	07	2
$TP05	09	1	$ST05	09	1			
* GEOSTIBA CIRCELLARIS (GRAVENHORST,1806)								
$TH10	22	1	$TH13	22	3	$TP04	01	1
$TP05	01	1	$TP05	07	1	$TP05	08	1
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Table iv cont'd

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$CF03	12	1	$CF18	21	1	$CF18	23	1
* DINARAEA ANGUSTULA (GYLLENHAL,1810)								
$TH02	07	4	$TH01	10	3	$TH07	13	1
$TH03	19	3	$TH11	19	1			
$TH01	20	1	$TH05	20	1	$TH11	20	1
$TH15	20	2	$TH14	23	2			
* LIOGLUTA NITIDULA (KRAATZ,1856)								
$CF18	10	1						
* ATHETA GAGATINA (BAUDI,1848)								
$TH05	23	1	$TP05	11	1			
* MOCYTA AMPLICOLLIS (MULSANT & REY, 1873)								
$TH05	06	1	$CF06	10	1			
* ATHETA CRASSICORNIS (FABRICIUS,1792)								
$TP05	12	1	$CF13	10	2	$CF14	10	2
* FUNGICOLA (THOMSON,C.G.,1852)								
$CF02	09	1						
* DIMETROTA ATRAMENTARIA (GYLLENHAL,1810)								
$TH06	18	1						
$FH01	01	1						
* MARCIDA (ERICHSON,1837)								
$CF17	15	1						
* OCALEA BADIA ERICHSON,1837								
$TP03	07	1	$FH05	05	1			
$CF01	01	16	$CF02	01	9	$CF03	01	7
$CF04	01	5	$CF05	01	3			
$CF01	02	20	$CF02	02	26	$CF03	02	12
$CF04	02	23	$CF05	02	4	$CF06	02	5
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$CF04	04	10	$CF05	04	2	$CF06	04	4
$CF01	05	1	$CF02	05	3	$CF03	05	1
$CF05	05	1	$CF05	05	9			
$CF03	06	2	$CF04	06	1			
$CF01	07	1	$CF05	07	1			
$CF01	10	3	$CF14	10	1			
$CF03	11	1	$CF14	11	1			
$CF01	12	1	$CF02	12	1	$CF05	12	2
$CF06	12	1	$CF08	12	2	$CF14	12	1
$CF15	12	1						
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$CF08	13	3	$CF13	13	1	$CF15	13	2
$CF01	14	13	$CF02	14	5	$CF07	14	2
$CF08	14	4	$CF10	14	2	$CF13	14	7
$CF14	14	1	$CF15	14	7	$CF16	14	2
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$CF01	15	3	$CF02	15	1			
$CF03	15	6	$CF05	15	1	$CF11	15	1
$CF14	15	1	$CF18	15	2			
$CF01	16	1	$CF04	16	1	$CF05	16	5
$CF05	16	3	$CF09	16	1	$CF10	16	1
$CF01	17	2	$CF05	17	1	$CF07	17	1
$CF08	17	3	$CF13	17	1			
$CF18	18	1						
$CF09	23	2	$CF02	24	1	$CF03	24	5
$CF04	24	1	$CF06	24	1	$CF08	24	2
$CF15	24	1						
* DRUSILLA CANALICULATA (FABRICIUS,1797)								
$TH01	01	1	$TH02	08	1	$TH01	09	1
$TH03	09	1	$TH13	09	5	$TH16	09	4
$TH13	10	3	$TH15	10	4	$TH16	10	1
$TH04	11	1						
$TH05	19	1	$TH08	19	1			
$TH05	20	1						
$TH01	21	12	$TH02	21	3	$TH04	21	1
$TH08	21	13	$TH11	21	2	$TH16	21	1
$TH01	22	2	$TH07	22	3			
$TH01	23	1	$TH09	23	2	$TH12	23	2
$TH14	23	1						
$TH01	24	1	$TH13	24	1			
$TP05	12	1	$ST04	23	1			
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$FH05	09	2	$FH09	09	2	$FH10	09	2
$FH17	09	1						
$FH13	10	2	$FH04	10	5	$FH09	10	1
$FH10	10	1						
$FH03	11	1	$FH04	11	3			
$FH04	19	1	$FH05	19	1			
$FH15	20	3						
$FH11	21	1	$FH13	21	2	$FH14	21	3
$FH15	21	5						

Table iv cont'd

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$CF08	15	1	$CF03	23	1	$CF03	24	1
* OXYPODA ANNULARIS MANNERHEIM,1830								
$TP01	01	1						
* ISLANDICA KRAATZ,1857								
$TH09	20	1	$ST03	08	1			
* LIVIDIPENNIS MANNERHEIM,1830								
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$TP03	01	1	$TP03	02	1	$TP05	02	1
$TP02	04	1	$TP03	06	1	$TP02	14	1
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$CF01	01	6	$CF02	01	22	$CF03	01	13
$CF04	01	15	$CF05	01	5	$CF06	01	7
$CF01	02	1	$CF02	02	15	$CF03	02	3
$CF04	02	8	$CF05	02	3	$CF06	02	2
$CF01	03	5	$CF02	03	19	$CF04	03	2
$CF05	03	3	$CF06	03	6			
$CF02	04	3	$CF06	04	1			
$CF02	05	1	$CF04	05	1	$CF05	05	1
$CF06	05	1						
$CF01	06	1	$CF02	08	1			
$CF02	12	1	$CF03	12	1	$CF06	12	1
$CF08	12	1	$CF09	12	1			
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$CF06	13	1	$CF09	13	1	$CF11	13	1
$CF12	13	2	$CF14	13	2	$CF16	13	1
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$CF08	14	1	$CF09	14	4	$CF10	14	2
$CF11	14	5	$CF07	14	6	$CF13	14	1
$CF14	14	1	$CF15	14	5	$CF16	14	2
$CF17	14	1	$CF18	14	8			
$CF01	15	1	$CF09	15	1	$CF15	15	2
$CF01	16	2	$CF05	16	1	$CF06	16	1
$CF16	16	1						
$CF05	17	1	$CF10	17	1	$CF11	17	1
$CF12	17	1						
$CF01	19	1	$CF04	19	2			
$CF02	20	1	$CF03	20	7	$CF06	20	1
$CF11	20	1	$CF15	20	1			
$CF15	21	1						
$CF02	24	3	$CF03	24	11	$CF04	24	1
$CF08	24	9	$CF10	24	4	$CF11	24	3
$CF13	24	2	$CF15	24	1	$CF16	24	1
* OPACA (GRAVENHORST,1802)								
$TH05	04	1	$CF14	13	1			
* UMBRATA (GYLLENHAL,1810)								
$TP05	09	2	$TP05	10	1			
$CF03	07	1	$CF01	08	1	$CF15	10	1
* TINOTUS MORION (GRAVENHORST,1802)								
$CF03	20	1						
* OTHER ALEOCHARINAE								
$TH02	02	1	$TH05	08	2	$TH01	09	1
$TH02	09	1	$TH07	09	1	$TH09	09	1
$TH01	10	2	$TH03	10	1	$TH04	10	1
$TH09	10	1	$TH17	10	5			
$TH03	11	1	$TH12	11	1	$TH18	11	1
$TH04	12	1	$TH08	12	1	$TH13	12	1
$TH06	13	1	$TH03	13	1	$TH14	13	1
$TH10	14	1						
$TH04	16	1	$TH05	16	1	$TH07	16	1
$TH11	17	1						
$TH01	18	3	$TH03	18	1	$TH05	18	3
$TH07	18	1	$TH08	18	3	$TH10	18	1
$TH01	19	1	$TH02	19	2	$TH03	19	6
$TH06	19	3	$TH11	19	1	$TH12	19	1
$TH14	19	1						
$TH06	20	2	$TH11	20	5			
$TH14	20	2	$TH15	20	2			
$TH03	21	1	$TH05	21	1	$TH10	21	2
$TH11	21	1	$TH13	21	1	$TH16	21	1
$TH02	22	1	$TH04	22	1	$TH05	22	5
$TH09	22	1	$TH13	22	3			
$TH01	23	2	$TH02	23	1	$TH03	23	1
$TH04	23	1	$TH05	23	3	$TH06	23	2
$TH08	23	1	$TH09	23	4	$TH10	23	2
$TH11	23	3	$TH12	23	4	$TH13	23	2
$TH14	23	3	$TH15	23	1	$TH18	23	1
$TH03	24	2	$TH04	24	1	$TH06	24	1
$TH07	24	1	$TH08	24	1	$TH09	24	2
$TH13	24	4	$TH14	24	2	$TH17	24	1
$TH18	24	2						
$TP01	01	1	$TP02	01	1	$TP05	02	1

Table iv cont'd

$TP04	04	1						
$TP03	05	1	$TP04	05	1	$TP05	05	1
$TP01	06	1	$TP03	06	1	$TP04	06	1
$TP02	08	1	$TP04	08	1	$TP05	08	2
$TP01	10	1	$TP04	10	1	$TP05	10	3
$TP05	11	1						
$TP01	20	2	$TP05	21	1	$TP03	23	1
$ST05	09	1	$ST03	22	1			
$FH04	06	1	$FH03	07	1	$FH06	08	1
$FH17	09	1	$FH04	11	1			
$FH01	19	1	$FH06	20	1	$FH06	21	1
$FH09	22	1						
$CF05	01	2	$CF06	05	1			
$CF03	07	1	$CF04	07	1	$CF06	07	2
$CF02	09	2	$CF03	09	1	$CF05	09	1
$CF06	09	5	$CF11	09	1	$CF12	09	1
$CF17	09	2	$CF18	09	2			
$CF01	10	1	$CF02	10	2	$CF03	10	2
$CF06	10	1	$CF11	10	1	$CF13	10	7
$CF14	10	2	$CF15	10	1	$CF17	10	2
$CF02	11	2	$CF12	11	2			
$CF09	12	1						
$CF02	13	1	$CF06	13	1	$CF11	13	3
$CF14	13	2	$CF15	13	1			
$CF08	15	1	$CF05	16	1			
$CF04	18	1						
$CF03	19	1	$CF04	19	3	$CF17	19	1
$CF03	20	2	$CF06	20	2			
$CF03	21	1	$CF04	21	2	$CF06	21	2
$CF13	21	1	$CF14	21	1	$CF15	21	1
$CF18	21	1						
$CF04	22	1	$CF05	22	1	$CF06	22	1
$CF08	22	2	$CF14	22	1	$CF16	22	2
$CF01	23	3	$CF08	23	1			
$CF04	24	1	$CF07	24	1	$CF10	24	1
$CF15	24	1	$CF18	24	2			

*

17.13.55.UCLP, 22, 0.924KLNS.

Table v . File DATAMS.

Staphylinid captures in jar pitfall traps in Martinshaw Wood from August 1976 to October 1977.

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* PROTEINUS BRACHYPTERUS (FABRICIUS,1792)
      $MQ03     06     1     $MQ01     07     1     $MQ03     10     1
      $MQ01     12     1     $MQ02     16     1     $MQ05     16     1
      $MP04     08     1     $MP05     08     2     $MP03     09     1
      $MP06     10     1     $MP04     15     1
* ANTHOBIUM ATROCEPHALUM (GYLLENHAL,1827)
      $MB02     03     3     $MB01     04     1     $MB02     04     1
      $MQ01     04     1     $MQ03     09     2     $MQ02     16     1
      $MQ04     16     2     $MQ06     16     1
      $MP06     03     2     $MP03     08     2
*               UNICOLOR(MARSHAM,1802)
      $MB02     04     1
      $MQ03     06     1     $MQ01     07     1     $MQ04     08     1
* OLOPHRUM PICEUM (GYLLENHAL,1810)
      $MG06     04     1     $MB01     04     1     $MB02     04     1
      $MB02     05     2     $MB03     05     1
* ACIDOTA CRUENTATA MANNERHEIM,1830
    $MB01     05     1
* ANOTYLUS TETRACARINATUS (BLOCK,1799)
    $MP03     09     1
* STENUS IMPRESSUS GERMAR,1824
    $MG01     02     1
* LATHROBIUM BRUNNIPES (FABRICIUS,1792)
    $MB01     01     1     $MQ03     01     1
* OTHIUS MYRMECOPHILUS KIESENWETTER,1843
    $MQ01     04     1     $MQ03     14     1     $MP01     14     2
*            PUNCTULATUS (GOEZE,1777)
    $MG05     06     1     $MB02     06     2     $MB02     07     1
    $MQ03     01     1     $MQ05     03     1     $MQ05     04     3
    $MQ05     05     3     $MQ06     05     2     $MQ03     06     1
    $MQ05     06     2     $MQ05     07     2     $MQ06     07     1
    $MQ05     08     1     $MQ01     09     2     $MQ06     09     2
    $MQ04     10     1     $MQ03     12     1     $MQ04     16     2
    $MQ05     16     1
    $MP01     06     1
* XANTHOLINUS LONGIVENTRIS HEER,1839
    $MP03     04     1
* PHILONTHUS COGNATUS STEPHENS,1832
    $MG01     01     2     $MG03     01     1
    $MQ05     09      1    $MQ05     10     1
*              DECORUS (GRAVENHORST,1802)
    $MQ01     12     1
*              INTERMEDIUS (BOISDUVAL & LACORDAIRE,1835)
    $MG04     03     1
* STAPHYLINUS OLENS MULLER,O.F.,1764
    $MG02     02     2     $MG06     02     1
    $MG04     03     1     $MG06     03     1
* QUEDIUS CURTIPENNIS BERNHAUER,1908
    $MB02     07     1
    $MQ03     10     1     $MQ06     12     2
*         FUMATUS (STEPHENS,1833)
    $MG04     03     1
*         MOLOCHINUS (GRAVENHORST,1806)
    $MQ03     01     1
*         NEMORALIS BAUDI,1848
    $MQ03     03     1
*         NIGRICEPS
    $MG02     04     1
    $MB02     04     2
    $MQ01     03     6     $MQ02     03     1     $MQ03     03   5
    $MQ04     03     2     $MQ05     03     4
    $MQ01     04     1     $MQ04     04     1     $MQ05     04     1
    $MQ06     04     2     $MQ04     14     1     $MQ04     15     2
    $MP01     03     3     $MP02     03     2     $MP03     03     5
    $MP05     03     1     $MP05     03     5
    $MP01     04     4     $MP03     04     3     $MP01     06      1
* MYCETOPORUS RUFESCENS (STEPHENS,1832)
    $MB05     07     1     $MP04     07     1
* BOLITOBIUS ANALIS (FABRICIUS,1787)
    $MQ02     01     1
*              INCLINANS (GRAVENHORST,1806)
    $MQ01     10     1     $MP06     09     1
* SEPEDOPHILUS MARSHAMI (STEPHENS,1832)
    $MQ04     11     1     $MQ05     11     1     $MQ01     12     1
    $MQ02     12     3     $MQ06     12     1     $MQ04     15     1
    $MQ02     16     2
    $MP02     03     1     $MP01     11     1     $MP01     12     1
    $MP03     12     2
*                NIGRIPENNIS (STEPHENS,1832)
    $MG01     01     1     $MB02     01     1     $MB03     05     1
    $MQ05     03     1     $MQ01     12     1
    $MP01     09     1
* TACHYPORUS CHRYSOMELINUS (LINNAEUS,1758)
    $MG01     01     4     $MG02     01     6     $MG03     01     5
    $MG04     01     1     $MG06     01     1
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Table v cont'd

$MG02	02	1	$MG03	02	3	$MG06	02	2
$MG04	03	1	$MG05	05	2			
$MB02	01	1	$MB03	01	1	$MB05	01	2
$MB05	01	1	$MB05	02	1	$MB01	03	1
$MB02	03	2	$MB03	03	2			
$MB01	04	1	$MB02	04	2	$MB03	04	2
$MB04	04	3	$MB05	04	2			
$MB02	05	4	$MB04	05	2			
$MB02	06	1						
$MQ03	01	2	$MQ02	03	1	$MQ01	04	2
$MQ01	09	1	$MQ03	09	2	$MQ01	10	2
$MP03	01	1	$MP01	03	1	$MP02	03	1
$MP03	03	2	$MP06	03	4			
$MP01	04	1	$MP02	04	2			
$MP05	09	1	$MP05	10	1	$MP01	11	1
$MP02	12	1	$MP04	15	1			
* HYPNORUM (FABRICIUS,1781)								
$MG01	01	5	$MG02	01	3	$MG03	01	6
$MG04	01	1	$MG05	01	5	$MG06	01	6
$MG01	03	1	$MG04	03	1			
$MG02	04	3	$MG03	04	1	$MG04	04	2
$MG05	04	1	$MG05	04	1			
$MG01	05	1	$MG02	05	4	$MG04	05	1
$MG05	05	1	$MG06	05	4			
$MG01	06	1	$MG04	06	2			
$MG01	07	1	$MG03	07	1	$MG04	07	2
$MG05	07	1	$MG05	07	1			
$MB01	01	2	$MB02	01	2	$MB03	01	1
$MB05	01	5	$MB01	04	1	$MB02	04	1
$MB03	04	3	$MB04	04	1	$MB05	04	2
$MB01	05	3	$MB02	05	8	$MB04	05	5
$MB05	05	6	$MB06	05	1			
$MB05	06	2	$MB02	07	5			
$MB01	08	2	$MB02	08	1	$MB03	08	1
$MB05	08	3						
$MQ03	01	1	$MQ04	01	1			
$MQ05	03	1	$MQ05	07	1	$MQ01	08	1
$MQ02	08	1	$MQ01	09	3	$MQ02	09	3
$MQ03	09	2	$MQ05	09	1	$MQ01	12	1
$MQ01	16	1	$MQ04	16	4	$MQ05	16	1
$MP02	03	1	$MP03	03	1	$MP06	03	2
$MP02	04	1	$MP06	04	1	$MP02	08	1
$MP01	09	1	$MP05	09	2	$MP01	10	1
$MP03	10	1						
* NITIDULUS (FABRICIUS,1781)								
$MB03	05	2	$MB05	05	1	$MB05	06	1
$MB05	07	2	$MQ03	04	1	$MQ06	04	1
$MQ02	05	1	$MQ06	07	1	$MQ01	09	2
$MQ04	11	1	$MP01	03	1	$MP04	04	1
$MP05	04	1	$MP06	04	2	$MP02	06	1
$MP03	08	1	$MP03	09	1	$MP05	09	2
* TACHINUS SIGNATUS GRAVENHORST,1802								
$MB02	04	1	$MQ05	03	1			
* SUBTERRANEUS (LINNAEUS,1758)								
$MB06	06	1						
* AUTALIA IMPRESSA (OLIVIER,1795)								
$MG04	03	1						
$MB01	03	1	$MB02	03	1	$MB01	04	1
$MB02	04	1	$MB05	04	3	$MB06	04	1
$MB05	07	1						
$MQ01	03	4	$MQ02	03	1	$MQ03	03	1
$MQ04	03	1	$MQ05	03	5	$MQ06	03	1
$MQ01	04	1	$MQ03	04	1	$MQ04	04	1
$MQ03	06	1	$MQ01	14	1	$MQ02	14	1
$MQ03	15	1	$MQ04	15	5	$MQ02	16	1
$MQ03	16	1	$MQ04	16	1	$MQ06	16	1
$MP01	03	10	$MP02	03	8	$MP03	03	12
$MP04	03	1	$MP05	03	2	$MP06	03	9
$MP01	04	1	$MP03	04	1	$MP05	04	1
$MP03	12	1						
* ATHETA GAGATINA (BAUDI,1848)								
$MQ01	12	1	$MQ03	12	2			
* OCALEA BADIA (ERICHSON,1837)								
$MQ03	03	2						
* DRUSILLA CANALICULATA (FABRICIUS,1787)								
$MG01	01	6	$MG03	01	1	$MG04	01	2
$MG05	01	4	$MG01	02	5	$MG02	02	3
$MG03	02	5	$MG06	02	2			
$MG01	03	1	$MG02	03	1			
$MB01	01	6	$MB02	01	6	$MB05	01	3
$MB06	01	1						
$MB01	02	2	$MB02	02	4	$MB04	02	1
* OXYPODA ALTERNANS (GRAVENHORST,1802)								
$MQ04	15	1						
$MP01	03	1	$MP04	03	1	$MP05	03	1

Table v cont'd

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*       ISLANDICA KRAATZ,1857
    $MG01     01     1
*       LIVIDIPENNIS MANNERHEIM,1830
    $MQ03     06     1
* OTHER ALEDCHARINAE
    $MB01     02     1     $MB05     08     1
    $MQ05     01     1     $MQ04     05     1     $MQ04     12     1
    $MQ01     14     1     $MQ02     16     2     $MQ04     16     1
    $MP01     03     1     $MP04     12     1

17.10.18.JCLP, 22,      0.336KLNS.
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Table vi. Dates corresponding to sampling periods (Jar pitfall traps) and sampling occasions (heat extractions) at Charnwood Lodge Nature Reserve.

Jar Pitfall Traps		Heat Extractions		Month
Sampling Period	Dates	Sampling Occasion	Dates	
1	23.10.75 - 20.11.75	1	20.11.75	November
2	20.11.75 - 18.12.75	2	18.12.75	December
3	18.12.75 - 15.1.76	3	15.1.76	January
4	15.1.76 - 12.2.76	4	12.2.76	February
5	12.2.76 - 18.3.76	5	18.3.76	March
6	18.3.76 - 12.4.76	6	12.4.76	April
7	12.4.76 - 14.5.76	7	14.5.76	May
8	14.5.76 - 15.6.76	8	15.6.76	June
9	15.6.76 - 8.7.76	9	8.7.76	July
10	8.7.76 - 13.8.76	10	13.8.76	August
11	13.8.76 - 24.9.76	11	24.9.76	September
12	24.9.76 - 21.10.76	12	21.10.76	October
13	21.10.76 - 18.11.76	13	18.11.76	November
14	18.11.76 - 16.12.76	14	16.12.76	December
15	16.12.76 - 13.1.77	15	13.1.77	January
16	13.1.76 - 14.2.77	16	14.2.77	February
17	14.2.77 - 16.3.77	17	16.3.77	March
18	16.3.77 - 27.4.77	18	27.4.77	April
19	27.4.77 - 25.5.77	19	25.5.77	May
20	25.5.77 - 23.6.77	20	23.6.77	June
21	23.6.77 - 25.7.77	21	25.7.77	July
22	25.7.77 - 25.8.77	22	25.8.77	August
23	25.8.77 - 22.9.77	23	22.9.77	September
24	22.9.77 - 26.10.77	24	26.10.77	October

Table vii. Dates corresponding to sampling periods (Jar pitfall traps) and sampling occasions (heat extractions) at Martinshaw Wood.

Jar Pitfall Traps		Heat Extractions		Month
Sampling Period	Dates	Sampling Occasion	Dates	
1	27.7.76 - 20.8.76	1	20.8.76	August
2	20.8.76 - 29.9.76	2	29.9.76	September
3	29.9.76 - 28.10.76	3	28.10.76	October
4	28.10.76 - 24.11.76	4	24.11.76	November
5	24.11.76 - 17.12.76	5	17.12.76	December
6	17.12.76 - 20.1.77	6	20.1.77	January
7	20.1.77 - 22.2.77	7	22.2.77	February
8	22.2.77 - 23.3.77	8	23.3.77	March
9	23.3.77 - 22.4.77	9	22.4.77	April
10	22.4.77 - 18.5.77	10	18.5.77	May
11	18.5.77 - 15.6.77	11	15.6.77	June
12	15.6.77 - 19.7.77	12	19.7.77	July
13	19.7.77 - 16.8.77	13	16.8.77	August
14	16.8.77 - 16.9.77	14	16.9.77	September
15	16.9.77 - 12.10.77	15	12.10.77	October
16	12.10.77 - 2.11.77			

Table viii. Staphylinid catches in fish baited pitfall traps in Collier's Wood, Charnwood Lodge Nature Reserve.

Figures are totals over the sampling period 6.5.76 - 21.5.76

Species	Number of individuals
Omalium caesum Gravenhorst	10
Philonthus decorus (Gravenhorst)	1
Cypha longicornis (Paykull)	1
Aleochara curtula (Goeze)	1

Table ix. Staphylinid catches in rat-baited pitfall traps in Martinshaw Wood.

Figures are totals of 4 pitfall traps, initially set on 3.8.76

Species / Time from Setting	Day 2	Day 5	Day 6	Day 8
Omalium caesum Gravenhorst				2
Philonthus succicola Thomson, C.G.			6	10
Philonthus varius (Gyllenhal)			1	
Tachyporus chrysomelinus (Linnaeus)	1			
Aleochara curtula (Goeze)		1	2	
Other Aleocharinae	3			

Table x. Staphylinid catches in fish-baited pitfall traps set on Flat Hill and in Collier's Wood, Charnwood.

Figures are totals of six pitfall traps per site, initially set on 14.6.78

Species	Site:	Flat Hill		Collier's Wood	
	Time from Setting: (days)	7	14	7	14
Philonthus sp.		5	-	> 40	20
Tachinus humeralis Gravenhorst				>200	50
Aleochara curtula (Goeze)				2	

Table xi. The abundance of the Staphylinidae (as determined by heat extraction) at Collier's Wood, Charnwood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasions and numbers of individuals (in brackets)
Olophrum piceum	9(1)
Anotylus tetracarinatus	15(1)
Oxytelus fulvipes	24(2)
Othius myrmecophilus	11(1)
Tachyporus chrysomelinus	16(1)
T. hypnorum	18(1)
T. nitidulus	19(1)
T. obtusus	18(1)
Geostiba circellaris	5(2), 6(1), 7(1), 12(1)
Ocalea badia	12(2)
Oxypoda lividipennis	13(1)
Tinotus morion	15(1)
Other Aleocharinae	4(1), 5(1), 16(2), 19(3)
Total Staphylinidae	4(1), 5(3), 6(1), 7(1), 9(1), 11(1), 12(3), 13(1), 15(2), 16(3), 18(2), 19(4), 24(2)
Moisture content of samples (% dry weight)	5(117.7), 6(255.2), 7(52.7), 8(39.5), 9(24.8), 10(159.4), 11(95.6), 12(71.7), 13(233.2), 14(178.2), 15(163.5), 16(154.8), 17(224.5), 18(182.1), 19(153.9), 20(177.5), 23(88.4)
Samples containing 0 individuals	1, 2, 3, 8, 10, 14, 17, 20, 21, 22, 23

Table xii. The abundance of Staphylinidae (as determined by heat extraction) at Flat Hill, Charnwood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasions and numbers of individuals (in brackets)
Othius angustus	3(1), 24(1)
O. myrmecophilus	1(2), 12(1)
Xantholinus linearis	17(1), 22(2)
Sepedophilus nigripennis	1(1)
Tachyporus chrysomelinus	2(3), (2), 19(3)
T. hypnorum	2(2), 6(1), 17(1)
Ocalea badia	1(1)
Other Aleocharinae	1(5), 3(2), 6(2), 19(3), 24(1)
Total Staphylinidae	1(9), 2(5), 3(3), 6(3), 9(2), 12(1), 17(2), 19(6), 22(1), 24(2)
Moisture content of samples (% dry weight)	5(115.3), 6(98.8), 7(80.6), 8(34.4), 9(32.5), 10(26.2), 11(254.8), 12(111.8), 13(143.1), 14(253.4), 15(146.4), 16(211.3), 17(360.4), 18(78.4), 19(38.7), 20(138.0), 23(85.71)
Samples containing 0 individuals	4, 5, 7, 8, 10, 11, 13, 14, 15, 16, 18, 20, 21, 23

Table xiii. The abundance of Staphylinidae (as determined by heat extraction) at the Stream Bank, Charnwood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasions and numbers of individuals (in brackets)
Omalium caesum	2(1)
Anotylus tetracarinatus	6(1)
Oxytelus fulvipes	22(1)
Othius myrmecophilus	6(1)
Xantholinus linearis	7(1)
Tachyporus chrysomelinus	2(1), 3(1), 6(1), 10(1), 11(1), 17(1)
T. hypnorum	11(1), 15(4), 17(1)
T. solutus	4(1)
Tachinus signatus	4(1)
Geostiba circellaris	2(2), 4(1), 5(1), 6(1)
Other Aleocharinae	2(1), 3(1), 5(3), 6(3), 9(4), 10(5), 11(1), 23(5), 24(1)
Total Staphylinidae	2(5), 3(2), 4(3), 5(4), 6(7), 7(1), 9(4), 10(6), 11(3), 15(4), 17(2), 22(1), 23(5), 24(1)
Moisture content of samples (% dry weight)	5(132.1), 6(106.1), 7(131.7), 8(54.9), 9(72.3), 10(215.7), 11 (65.8), 12(170.1), 13(83.3), 14(171.4), 15(118.0), 16 (106.4), 17(161.5), 18(77.9), 19(109.2), 20(185.6), 23(174.4)
Samples with 0 individuals	1, 8, 12, 13, 14, 16, 18, 19, 20, 21

Table xiv. The abundance of Staphylinidae (as determined by heat extraction) at Timberwood Hill, Charnwood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasions and numbers of individuals (in brackets)
Othius myrmecophilus	6(1), 24(2)
Philonthus varians	24(1)
Tachyporus chrysomelinus	1(1), 15(1)
T. hypnorum	2(1), 3(1), 5(1), 13(1), 16(1), 17(1)
Geostiba circellaris	9(2)
Mocyta orbata	2(1), 6(1)
Acrotona muscorum	3(1)
Other Aleocharinae	2(1), 3(2), 7(2), 11(1), 15(2), 17(1)
Total Staphylinidae	1(1), 2(3), 3(4), 5(1), 6(2), 7(2), 9(2), 11(1), 13(1), 15(3), 16(1), 17(2), 24(3)
Moisture content of samples (% dry weight)	5(130.3), 6(168.4), 7(141.0), 8(88.6), 9(42.0), 10(87.0), 11(186.5), 12(243.5), 13(298.9), 14(135.2), 15(223.5), 16(306.2), 17(260.8), 18(218.9), 19(155.6), 20(132.9), 23(105.9)
Sample with 0 individuals	4, 8, 10, 12, 14, 18, 19, 20, 21, 22, 23

Table xv. The abundance of Staphylinidae (as determined by heat extraction) at Timberwood Plantation, Charnwood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasions and numbers of individuals (in brackets)
Anotylus tetracarinatus	2(1), 6(1)
Stenus impressus	14(1)
Othius myrmecophilus	6(1)
Xantholinus linearis	12(1), 23(1)
Tachyporus hypnorum	5(1)
Geostiba circellaris	6(2)
Dimetrota atramentaria	4(2)
Other Aleocharinae	1(1), 2(2), 6(3), 12(1), 17(1), 19(1), 23(1)
Total Staphylinidae	1(1), 2(3), 4(2), 5(1), 6(7), 12(2), 14(1), 17(1), 19(1), 23(2)
Moisture content of samples (% dry weight)	5(96.5), 6(88.8), 7(65.5), 8(65.4), 9(41.3), 10(77.5), 11(130.4), 12(131.5), 13(146.1), 14(90.0), 15(138.9), 16(145.0), 17(177.6), 18(132.0), 19(109.4), 20(84.2), 23(99.2)
Samples with 0 individuals	3, 7, 8, 9, 10, 11, 13, 15, 16, 18, 20, 21, 22, 24

Table xvi. The abundance of Staphylinidae (as determined by heat extraction) at the grass site, Martinshaw Wood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasions and numbers of individuals (in brackets)
Othius myrmecophilus	1(1)
Philonthus cognatus	1(1), 4(1)
Tachyporus chrysomelinus	4(1)
T. hypnorum	4(1), 7(1)
Geostiba circellaris	3(1)
Other Aleocharinae	3(1), 4(1), 7(1)
Total Staphylinidae	1(2), 3(2), 4(4), 7(2)
Moisture content of samples (% dry weight)	3(76.2), 4(157.1), 7(57.5)
Samples with 0 individuals	2, 5, 6

Table xvii. The abundance of Staphylinidae (as determined by heat extraction) at the bracken site, Martinshaw Wood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasion and numbers of individuals (in brackets)
Anthobium atrocephalum	4(1)
Quedius curtipennis	7(1)
Tachyporus chrysomelinus	4(1)
T. hypnorum	1(1), 4(1), 7(1)
Geostiba circellaris	1(1)
Total Staphylinidae	1(2), 4(3), 7(2)
Moisture content of samples (% dry weight)	3(231.3), 4(109.2), 6(322.4), 7(189.3)
Samples with 0 individuals	2, 3, 5, 6

Table xviii. The abundance of Staphylinidae (as determined by heat extraction) at the oak site, Martinshaw Wood. Figures are totals from 2 soil samples.

Species/Items	Sampling occasion and numbers of individuals (in brackets)
Othius myrmecophilus	7(1)
Xantholinus linearis	7(1)
Tachyporus nitidulus	11(1)
Total Staphylinidae	7(2), 11(1)
Moisture content of samples (% dry weight)	3(102.6), 4(99.7), 7(160.0), 8(162.7), 9(93.9), 10(97.3), 11(107.0), 14(57.2), 15(96.2)
Samples with 0 individuals	1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, 14, 15, 16

Table xix. The abundance of the Staphylinidae (as determined by heat extraction) at the pine site, Martinshaw Wood. Figures are totals from 2 soil samples.

Species	Sampling occasion and number (in brackets)
Othius myrmecophilus	11(1), 15(1)
Tachyporus nitidulus	7(2)
Other Aleocharine	11(1)
Total Staphylinidae	7(2), 11(2), 15(1)
Mean moisture content of samples (% dry weight)	3(108.4), 4(139.4), 7(216.8) 8(136.0), 9(73.1), 10(136.3), 11(166.9), 14(72.3), 15(116.2)
Sampling occasions with 0 individuals	1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13

Table (xx) Climatic data obtained from Meteorological Station, Newton Linford.

Month	Temperatures (°C) Max.	Min.	Mean	Rainfall (mm)	Sunshine (hrs)	Wind Speed (knots)
Nov 75	8.8	2.1	5.5	1.4	2.4	5.0
Dec	7.4	1.8	4.6	1.2	1.4	5.6
Jan 76	7.7	2.3	5.0	1.2	1.7	8.2
Feb	6.6	1.0	3.8	0.7	1.7	5.2
Mar	8.2	0.6	4.4	0.7	3.2	5.8
Apr	12.1	3.5	7.8	0.5	4.1	5.4
May	16.3	6.7	11.5	1.4	4.2	5.7
Jun	22.8	10.2	16.5	0.5	8.1	3.7
Jul	24.8	11.5	18.2	0.8	7.9	4.0
Aug	23.4	10.7	17.1	0.9	7.2	3.6
Sep	17.1	8.4	12.8	2.9	3.3	3.6
Oct	13.1	6.3	9.7	3.1	1.8	4.5
Nov	8.4	1.8	5.1	1.3	2.3	4.3
Dec	3.8	-1.2	1.3	2.6	1.9	4.2
Jan 77	4.4	-0.7	3.7	2.7	1.5	4.9
Feb	6.8	1.0	3.9	6.0	1.4	5.3
Mar	9.6	2.9	6.3	1.6	2.4	7.0
Apr	10.8	2.5	6.7	1.1	4.9	7.0
May	14.9	5.0	10.0	1.5	6.8	5.3
Jun	16.4	7.2	11.8	3.0	5.1	4.6
Jul	20.1	10.5	15.3	0.5	6.2	4.5
Aug	19.0	10.7	14.9	2.7	4.7	3.7
Sep	16.7	8.9	12.8	0.6	3.5	5.8
Oct	14.5	7.1	10.8	0.9	3.1	5.4
Nov	8.8	2.7	5.8	2.8	3.2	8.2

APPENDIX II

Program 1. STAPHS

```
      PROGRAM STAPHS (INPUT,OUTPUT, TAPE7, TAPE10, TAPE5= INPUT,
     + TAPE6 = OUTPUT,TAPE11)
C
C*****************************************************************
C
C            ANALYSIS OF THE DATA FROM A PROJECT ON THE STUDY
C            OF STAPHYLININIDAE.
C
C                 AUTHORS          : DEREK PEACOCK AND IRENE LEOW
C                 DEPT             : ZOOLOGY
C                 UNIVERSITY       : LEICESTER
C                 DATE             : 6TH JULY 1978
C
C*****************************************************************
C
C        DATA
C        ----
C
C               1. * SPECIES NAME               COL 1 -80
C               2. $SITE/PITFALL E.G. $CF01     ANYWHERE
C               3. SAMPLING OCCASION            ANYWHERE
C               4. NUMBER OF INDIVIDUALS        ANYWHERE
C               5. REPEAT FROM 2. OR 1.
C
C        VARIABLES
C        ---------
C
C               INDIV     = NUMBER OF INDIVIDUALS
C               STPRES    = INDICATES THE PRESENCE OF SPECIES IN A
C                           SITE
C               STCODE    = SITE CODE
C               STNAME    = FULL SITE NAME
C               SPNAME    = SPECIES NAME
C             TOTSTA      = TOTAL NUMBER OF STAPHYLINIDS FOR EACH SITE
C             IREAD     =   NUMBER OF RUNS THROUGH PROGRAM
C              IREAD.EQ.1 CALLS HISTOG,MEANVAR,TOTAL
C                           AND EACH SAMPLING OCCASION
C
      IMPLICIT INTEGER ( A-Z )
      COMMON LINE
      COMMON /A1/ NINDIV, STPRES, STNAME,  SPNAME, TOTSTA,PERCNT,
     +  MATI
      DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     +  STPRES(5),TOTSTA(5,24),PERCNT (5,24),
     +  MATI(87,5,24)

      DATA  STNAME/"CF","FH","ST","TH","TP"/
       DATA TOTSTA/120*0/
       DATA KOUNT/0/
      REWIND 7
      REWIND 10
      IREAD = 1
      IF (IREAD.NE.1)GOTO 501
       DO 500 ST = 1,5
       DO 500 SO = 1,24
       TOTSTA(ST,SO) = 0
  500  CONTINUE
  100 READ (7,1000) LINE
     IF (LINE(1).EQ."*") GOTO 103
     WRITE(6,1030)LINE
     STOP
  103 DO 102 I=1,5

      STPRES(I) = 0
      DO 102 J = 1,24
      DO 102 K = 1,18
  102 NINDIV (I,J,K) = 0
      DO 104 I = 1,80
 104   SPNAME(I) = LINE(I)
       KOUNT = KOUNT + 1

  105 READ (7,1000)LINE
      IF (EOF(7))260,106
  106 IF(LINE(1).EQ."*")GOTO 250
  110 FIRSTI = 1
  120 SN1 = " "
      DO 140 I = FIRSTI, 80
         IF (LINE(I).NE."$") GOTO 140
         SN1 = LINE (I+1)
         SN2 = LINE(I+2)
         ENCODE (2,1010,SITE) SN1,SN2
         P1 = I+3
         CALL TRANSFR (P1,PITFALL)
         FIRST = I+5
         DO 130 J = FIRST, 80
```

Program 1 cont'd

```
            IF (LINE (J).EQ." ") GOTO 130
            CALL TRANSFR (J,DATE)
            FIRSTK = J+2
            DO 125 K = FIRSTK, 80
               IF (LINE(K).EQ." ") GOTO 125
                  CALL TRANSFR (K,INDIV)
                  GOTO 160
125         CONTINUE
130         CONTINUE
140         CONTINUE
         IF (SN1.EQ." ") GOTO 105
160      FIRSTI = K
         DO 200 ST = 1,5
            IF (STNAME(ST).NE.SITE) GOTO 200
            GOTO 210
200      CONTINUE
          PRINT (6,*)SITE
          WRITE (6,1000)LINE
         PRINT (6,*) "ERROR SITE ",SITE,"  NOT FOUND"
         WRITE(6,1000)LINE
210      IF(NINDIV(ST,DATE,PITFALL).EQ.0)GOTO 220
         PRINT(6,*)" DATA ITEM REPEATED "
         WRITE(6,1000)SPNAME
         WRITE(6,1000)LINE
220      NINDIV(ST,DATE,PITFALL) = INDIV
         STPRES (ST) = STPRES(ST) + 1
         IF (K.GT.76) GOTO 105
         GOTO 120
250   IF (IREAD.EQ.1) GOTO 260
      CALL PERCEN
      GOTO 270
260       CALL QTOT(KOUNT,LASTI)
270       IF (KOUNT.EQ.87.OR.KOUNT.EQ.174)300,103
501   CONTINUE
300     WRITE (10,1060)
          DO 410 ST=1,5
        DO 400 SP=1,10
        WRITE (10,1070)STNAME(ST),(MATI(SP,ST,I),I=1,LASTI)
400     CONTINUE
410     CONTINUE
        REWIND 10
1000  FORMAT (80A1)
1010  FORMAT (A1,A1)
1020  FORMAT (I2)
1030  FORMAT(//"  ERROR IN TITLE - FIRST CHARACTER SHOULD BE AN *",
     +         /"  TITLE READ IN -"/" ",80A1)
1050  FORMAT(/" ",80A1/)
1060  FORMAT(//3X,"SITE",3X,"  SPECIES MATRIX"//)
1070  FORMAT(" ",4X,A2,4X,24I5)
1090  FORMAT(//"QTOT COMPLETED")
        STOP
        END
         SUBROUTINE TRANSFR (I1,NUMBER)
         IMPLICIT INTEGER (A-Z)
         COMMON LINE
         DIMENSION LINE (80),CH(4)
         DIGIT = 0
         I3 = I1 +3
         DO 121 I = I1,80
            IF (LINE (I).EQ." ") GOTO 122
            DIGIT = DIGIT + 1
            CH(DIGIT) = LINE (I)
121      CONTINUE
122      D10 = DIGIT * 10
         ENCODE(D10,1000,CHAR)(CH(I),I=1,DIGIT)
         ENCODE(4,1040,FORM1)DIGIT
         DECODE(DIGIT,FORM1,CHAR)NUMBER
         RETURN
1000  FORMAT (4A1)
1040  FORMAT("(I",I1,")")
1020  FORMAT(10A1)
1030  FORMAT(R2)
     END
      SUBROUTINE HISTOG
C
C*******************************************************************
C
C     PRINT A HISTOGRAM TO SHOW THE TOTAL NUMBER OF INDIVIDUALS
C     ON ONE SITE TOTALED FOR ALL PITFALLS OVER 24 SAMPLING
C     OCCASIONS
C
C*******************************************************************
C
      IMPLICIT INTEGER (A-Z)
      COMMON /A1/ NINDIV, STPRES, STNAME,  SPNAME,
```

Program 1 cont'd

```
     +  TOTSTA,PERCNT,MATI
        DIMENSION  NINDIV(5,24,18), STPRES(5), STNAME(5), STARS(80),
     +   SPNAME(80),TOTAL(24)
        DATA STARS /80*"*"/
        NUMHIS = 0
        DO 200  ST=1,5
        IF  (STPRES(ST).LT.6) GOTO 200
        NUMHIS = NUMHIS +1
        IF(NUMHIS.EQ.1)WRITE(10,1000)SPNAME
        WRITE (10,1010) STNAME(ST)
        MAXI = 0
        DO 140 SO = 1,24
           TOTAL(SO) = 0
           DO 130 PT = 1,18
              TOTAL(SO) = TOTAL(SO) + NINDIV(ST,SO,PT)
  130      CONTINUE
           IF(TOTAL(SO).GT.MAXI)MAXI = TOTAL(SO)
  140   CONTINUE
        DO 180 SO=1,24
           T40 = TOTAL(SO)*40/MAXI
           WRITE(10,1020)(SO,TOTAL(SO),(STARS(I),I=1,T40))
180     CONTINUE
200     CONTINUE
        RETURN
1000    FORMAT ("1",/////,20X,80A1,/////)
1010    FORMAT (" ",10X,"HISTOGRAM FOR SITE",A10,/11X,
     +          "------------------",/////)
1020    FORMAT(" ", 4X,I2,2X,I3,4X,80A1)
1030    FORMAT (" ")
        END
      SUBROUTINE MEANVAR
C
C******************************************************************
C
C       THIS PROGRAM CALCULATES THE MEAN NUMBER OF INDIVIDUALS
C       OF ONE SPECIES, ON ONE SAMPLING OCCASION,OVER 6 OR 18
C       PITFALLS,THE VARIANCE OF THE SERIES AND THE RATIO OF
C       MEAN TO VARIANCE
C
C*********************************************************************   C
        IMPLICIT INTEGER(A-Z)
        REAL MEAN,VAR,X,SUM,SUMSQ
        COMMON /A1/ NINDIV,STPRES,STNAME,SPNAME,TOTSTA,PERCNT,
     +   MATI
        DIMENSION NINDIV(5,24,18),SPNAME(80),STNAME(5),STPRES(5)
        WRITE (10,1000)SPNAME
        DO 200 ST =1,5
        DO 190 SO = 1,24
           SUMSQ = 0.0
           NPT = 6
           SUM = 0.0
           DO 180 PT = 1,18
              IF ((NINDIV(ST,SO,PT).NE.0).AND.(PT.GT.6))NPT = 18
              SUM = SUM + NINDIV(ST,SO,PT)
              SUMSQ = SUMSQ + NINDIV(ST,SO,PT)**2
  180     CONTINUE
          IF (SUM.LT.10) GOTO 190
          MEAN = SUM/NPT
          VAR = (SUMSQ - NPT*(MEAN**2))/NPT
          X = MEAN/VAR
          WRITE (10,1010)STNAME(ST),SO,MEAN,VAR,X
  190     CONTINUE
  200     CONTINUE
          RETURN
 1000     FORMAT (/////20X,80A1,////,5X,"SITE",5X,"SAMPLING OCCASION",
     +    5X,"MEAN",5X,"VARIANCE",5X,"X" //)
 1010     FORMAT (" ",5X,A2,14X,I2,14X,F8.3,5X,F8.3,5X,F8.3/)
          END
        SUBROUTINE TOTAL
C
C*********************************************************************
C
C    ADD UP THE NUMBER OF INDIVIDUALS OF ALL SPECIES FOR EACH SITE
C    ON ANY ONE SAMPLING OCCASION
C
C*********************************************************************
        IMPLICIT INTEGER (A-Z)
        COMMON /A1/ NINDIV,STPRES,STNAME,SPNAME,TOTSTA,
     +     PERCNT,MATI

        DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     +  STPRES(5),TOTSTA(5,24)
         DATA KOUNT/0/

        DO 101 ST =1,5
```

Program 1 cont'd

```
      DO 101 SO =1,24
      DO 101 PT =1,18
101      TOTSTA(ST,SO) = TOTSTA(ST,SO)+ NINDIV(ST,SO,PT)
         KOUNT = KOUNT + 1
         IF (KOUNT.EQ.10.OR.KOUNT.EQ.174)506,505
506       WRITE (10,1000)
1000      FORMAT (/////10X,"SITE",10X,"SAMPLING OCCASION",10X,
     +    "TOTAL STAPHYLINIDAE"//)
          DO 507 ST = 1,5
          DO 507 SO = 1,24
          IF (TOTSTA(ST,SO).EQ.0)GOTO 507

      WRITE (10,1010)STNAME(ST),SO,TOTSTA(ST,SO)
507   CONTINUE
1010   FORMAT(" ",11X,A2,18X,I2,25X,I5/)
505     RETURN
       END
      SUBROUTINE PERCEN
C
C*******************************************************************
C     THIS SUBROUTINE DETERMINES WHAT PERCENTAGE EACH SPECIES
C      CONSTITUTES OF THE TOTAL STAPHYLINIDAE PRESENT AT ANY
C      SITE,ON ANY PARTICULAR SAMPLING OCCASION
C
C**********************************************************************
       IMPLICIT INTEGER (A-Z)
       REAL SUM,     PERCNT
       COMMON /A1/ NINDIV,STPRES, STNAME, SPNAME, TOTSTA,PERCNT,
     +  MATI
       DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     + STPRES(5),TOTSTA(5,24),PERCNT(5,24)
       WRITE (10,1000) SPNAME
       DO 200 ST = 1,5
       DO 190 SO = 1,24
       SUM = 0.0
       DO 150 PT = 1,18
       SUM = SUM + NINDIV(ST,SO,PT)
150    CONTINUE
           IF (SUM.EQ.0.0) GOTO 190
           PERCNT(ST,SO) = 100*SUM/TOTSTA(ST,SO)
           WRITE (10,1010) STNAME(ST),SO,SUM,PERCNT(ST,SO)
190    CONTINUE
200    CONTINUE
1000   FORMAT (/////20X,80A1,/////,5X,"SITE",5X,"SAMPLING OCCASION",
     + 5X, "SPECIES TOTAL",5X,"PERCENTAGE OF TOTAL"//)
1010    FORMAT(" ",5X,A2,14X,I2,15X,F8.3,11X,F8.3/)
       RETURN
       END
```

Program 2. MATRIX

```
      PROGRAM MATRIX (INPUT,OUTPUT, TAPE7, TAPE10, TAPE5= INPUT,
     + TAPE6 = OUTPUT,TAPE11)
C
C*************************************************************
C
C             ANALYSIS OF THE DATA FROM A PROJECT ON THE STUDY
C             OF STAPHYLINIDAE.
C
C                AUTHORS          : DEREK PEACOCK AND IRENE LEOW
C                DEPT             : ZOOLOGY
C                UNIVERSITY       : LEICESTER
C                DATE             : 6TH JULY 1978
C
C*************************************************************
C
C       DATA
C       ----
C
C              1. * SPECIES NAME               COL 1 -80
C              2. $SITE/PITFALL E.G. $CF01     ANYWHERE
C              3. SAMPLING OCCASION            ANYWHERE
C              4. NUMBER OF INDIVIDUALS        ANYWHERE
C              5. REPEAT FROM 2. OR 1.
C
C       VARIABLES
C       ---------
C
C              INDIV     = NUMBER OF INDIVIDUALS
C              STPRES    = INDICATES THE PRESENCE OF SPECIES IN A
C                          SITE
C              STCODE    = SITE CODE
C              STNAME    = FULL SITE NAME
C              SPNAME    = SPECIES NAME
C           TOTSTA    = TOTAL NUMBER OF STAPHYLINIDS FOR EACH SITE
C           IREAD     =  NUMBER OF RUNS THROUGH PROGRAM
C            IREAD.EQ.1 CALLS HISTOG,MEANVAR,TOTAL
C                         AND EACH SAMPLING OCCASION
C
      IMPLICIT INTEGER ( A-Z )
      COMMON LINE
      COMMON /A1/ NINDIV, STPRES, STNAME,  SPNAME,
     +  MATI
      DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     +   STPRES(5),
     +    MATI(87,5,24)

      DATA  STNAME/"CF","FH","ST","TH","TP"/
       DATA KOUNT/0/
      REWIND 7
      REWIND 10
      IREAD = 1
      IF  (IREAD.NE.1)GOTO 501
       DO 500 ST = 1,5
       DO 500 SO = 1,24
  500  CONTINUE
  100 READ (7,1000) LINE
     IF (LINE(1).EQ."*") GOTO 103
     WRITE(6,1030)LINE
     STOP
 103 DO 102 I=1,5

      STPRES(I) = 0
      DO 102 J = 1,24
      DO 102 K = 1,13
  102 NINDIV (I,J,K) = 0
      DO 104 I = 1,80
104    SPNAME(I) = LINE(I)
       KOUNT = KOUNT + 1

  105 READ (7,1000)LINE
      IF  (EOF(7))260,106
  106 IF(LINE(1).EQ."*")GOTO 250
  110 FIRSTI = 1
  120 SN1 = " "
      DO 140 I = FIRSTI, 80
         IF  (LINE(I).NE."$") GOTO 140
         SN1 = LINE (I+1)
         SN2 = LINE(I+2)
         ENCODE (2,1010,SITE) SN1,SN2
         P1 = I+3
         CALL TRANSFR (P1,PITFALL)
         FIRST = I+5
         DO 130 J = FIRST, 80
            IF (LINE (J).EQ." ") GOTO 130
            CALL TRANSFR (J,DATE)
```

Program 2 cont'd

```
              FIRSTK = J+2
              DO 125 K = FIRSTK, 80
                 IF (LINE(K).EQ." ") GOTO 125
                    CALL TRANSFR (K,INDIV)
                    GOTO 160
 125          CONTINUE
 130          CONTINUE
 140          CONTINUE
          IF (SN1.EQ." ") GOTO 105
 160      FIRSTI = K
          DO 200 ST = 1,5
              IF (STNAME(ST).NE.SITE) GOTO 200
              GOTO 210
 200      CONTINUE
           PRINT (5,*)SITE
            WRITE (6,1000)LINE
          PRINT (5,*) "ERROR SITE ",SITE,"  NOT FOUND"
          WRITE(6,1000)LINE
 210      IF(NINDIV(ST,DATE,PITFALL).EQ.0)GOTO 220
          PRINT(6,*)" DATA ITEM REPEATED "
          WRITE(6,1000)SPNAME
          WRITE(6,1000)LINE
 220      NINDIV(ST,DATE,PITFALL) = INDIV
          STPRES (ST) = STPRES(ST) + 1
          IF (K.GT.75) GOTO 105
          GOTO 120
 250    IF (IREAD.EQ.1) GOTO 260
        GOTO 270
 260         CALL YTOT(KOUNT,LASTI)
 270         IF (KOUNT.EQ.87.OR.KOUNT.EQ.174)300,103
 501  CONTINUE
 300     WRITE (10,1060)
         DO 400 SP=1,37
         WRITE (10,1070) ((MATI(SP,ST,I),I=1,LASTI),ST=1,5)
400      CONTINUE
         DO 420 SP=1,37
         WRITE (11,1080)((MATI(SP,ST,I),I=1,LASTI),ST=1,5)
420      CONTINUE
         REWIND 10
1000    FORMAT (80A1)
1010    FORMAT (A1,A1)
1020    FORMAT (I2)
1030    FORMAT(//"  ERROR IN TITLE - FIRST CHARACTER SHOULD BE AN *",
      +          /"  TITLE READ IN -"/" ",80A1)
1050    FORMAT(/" ",80A1/)
1060    FORMAT(//3X,"SITE",3X,"  SPECIES MATRIX"//)
1070    FORMAT(" ", 4X,20I5/20I5)
1080     FORMAT (" ",20I5/20I5)
         STOP
         END
           SUBROUTINE TRANSFR (I1,NUMBER)
           IMPLICIT INTEGER (A-Z)
           COMMON LINE
           DIMENSION LINE (80),CH(4)
           DIGIT = 0
           I3 = I1 +3
           DO 121 I = I1,80
               IF (LINE (I).EQ." ") GOTO 122
               DIGIT = DIGIT + 1
               CH(DIGIT) = LINE (I)
 121       CONTINUE
 122       D10 = DIGIT * 10
           ENCODE(D10,1000,CHAR)(CH(I),I=1,DIGIT)
           ENCODE(4,1040,FORM1)DIGIT
           DECODE(DIGIT,FORM1,CHAR)NUMBER
           RETURN
1000    FORMAT (4A1)
1040    FORMAT("(I",I1,")")
1020    FORMAT(10A1)
1030     FOPMAT (R2)
           END
```

Program 2 cont'd

```
      SUBROUTINE MTTOT(SP,LASTSO)
C*****************************************************************
C
C
C       THIS SUBROUTINE CALCULATES THE TOTAL NUMBER OF INDIVIDUALS
C       OF EACH SPECIES, AT EACH SITE, ON EACH SAMPLING OCCASION,OVER 6
C       OR 18 PITFALLS.
C
C*******************************************************************
C
        IMPLICIT INTEGER (A-Z)
        COMMON /A1/ NINDIV,STPRES,STNAME,SPNAME,
     +   MATI
        DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     +  STPRES(5),MATI(87,5,24)
        DATA KOUNT /0/
        KOUNT=SP
         LASTSO=24
        DO 200 ST=1,5
        DO 180 SO=1,LASTSO
        MATI(SP,ST,SO)=0
        DO 170 PT=1,18
           MATI(SP,ST,SO) = MATI(SP,ST,SO) + NINDIV(ST,SO,PT)
  170   CONTINUE
  180   CONTINUE
  200   CONTINUE
        RETURN
        END
        SUBROUTINE QTOT(SP,LASTI)
C
C*********************************************************************
C                                L
C       THIS SUBROUTINE CALCUATES THE TOTAL NUMBER OF INDIVIDUALS
C       OF EACH SPECIES OVER EACH 3 MONTH PERIOD, OVER 6 OR 18
C       PITFALLS, AT EACH SITE.
C
C**********************************************************************
C
        IMPLICIT INTEGER (A-Z)
        COMMON /A1/ NINDIV, STPRES,STNAME, SPNAME,
     +   MATI
        DIMENSION NINDIV(5,24,18),LINE(80), SPNAME(80),STNAME(5),
     +   STPRES(5),
     +   MATI(87,5,24)
        DATA KOUNT /0/
        KOUNT=SP
        LASTI=8
        DO 190 ST=1,5
           DO 180 I=1,LASTI
           MATI(SP,ST,I)=0
           FIRST = (I-1)*3+1
           LAST = FIRST+2
           DO 170 SO = FIRST,LAST
             DO 160 PT=1,18
               MATI(SP,ST,I) = MATI(SP,ST,I) + NINDIV(ST,SO,PT)
  160        CONTINUE
  170      CONTINUE
  180     CONTINUE
  190  CONTINUE
  300     RETURN
 1000     FORMAT(//10X,"SITE",5X,"QUARTERLY SPECIES MATRIX"//)
 1010     FORMAT (" ",11X,A2,6X,8I7)
       END
       SUBROUTINE HYTOT(SP,LASTI)
C
C*********************************************************************
```

Program 2 cont'd

```
C                          L
C      THIS SUBROUTINE CALCUATES THE TOTAL NUMBER OF
C      INDIVIDUALS OF EACH SPECIES OVER 6 OR 18 PITFALLS, OVER
C      EACH 6 MONTH PERIOD, AT EACH SITE.
C
CC*********************************************************************
C
       IMPLICIT INTEGER(A-Z)
       COMMON /A1/ NINDIV,STPRES, STNAME,SPNAME,
     +    MATI
       DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     + STPRES(5),MATI(87,5,24)
       DATA KOUNT /0/
       KOUNT=SP

       LASTI=4
       DO 200 ST=1,5
       DO 180 I=1,LASTI
          MATI(SP,ST,I)=0
          FIRST=(I-1)*6+1
          LAST=FIRST+5
          DO 170 J=FIRST,LAST
             SO=J
             DO 160 PT=1,18
                MATI(SP,ST,I)=MATI(SP,ST,I)+ NINDIV(ST,SO,PT)
 160    CONTINUE
 170    CONTINUE
 180    CONTINUE
 200    CONTINUE
        RETURN
        END
        SUBROUTINE YTOT(SP,LASTI)
C
C*********************************************************************
C
C
C       THIS SUBROUTINE CALCULATES THE TOTAL NUMBER OF INDIVIDUALS
C       OF EACH SPECIES OVER 6 OR 18 PITFALLS, OVER EACH 12 MONTH
C       PERIOD ,AT EACH SITE.
C
C*********************************************************************
C
        IMPLICIT INTEGER (A-Z)
        COMMON /A1/ NINDIV, STPRES,STNAME,SPNAME,
     +     MATI
        DIMENSION NINDIV(5,24,18),LINE(80),SPNAME(80),STNAME(5),
     +  STPRES(5),MATI(87,5,24)
        LASTI=2

        DO 200 ST=1,5
        DO 180 I=1,LASTI
           MATI(SP,ST,I)=0
           SUM=0
           FIRST=(I-1)*12+1
           LAST= FIRST + 11
           DO 170 J=FIRST,LAST
              SO=J
              DO 160 PT=1,18
                 SUM = SUM + NINDIV(ST,SO,PT)
 160    CONTINUE
 170    CONTINUE
           MATI(SP,ST,I)=MATI(SP,ST,I)+SUM
 180    CONTINUE
 190    CONTINUE
 200    CONTINUE
        RETURN
        END


14.43.58.JCLP, 22,        0.420KLNS.
```

Program 3. DIVSTY

```
      PROGRAM DIVSTY (INPUT,OUTPUT,TAPE7,TAPE10,TAPE5=INPUT,
     + TAPE6=OUTPUT)
C
C**********************************************************************
C
C     THIS PROGRAM CALCULATES THE SHANNON WEINER INDEX OF
C     DIVERSITY, AND SIMPSON'S INDEX OF DIVERSITY, GIVEN A MATRIX OF
C     ABUNDANCES OF VARIOUS SPECIES
C
C     C = NUMBER OF COLUMNS
C     R = NUMBER OF ROWS
C     NC= MAXIMUM NUMBER OF COLUMNS
C     N = NUMBER OF INDIVIDUALS
C     HIND = SHANNON-WEINER INDEX OF DIVERSITY PER INDIVIDUAL
C    HSAM = SHANNON-WEINER INDEX OF DIVERSITY PER SAMPLE
C     D = MODIFIED SIMPSON'S INDEX
C
C*************************************************************************
C
      IMPLICIT INTEGER (A-Z)
      REAL SUMNI,HIND, HSAM,X,N,SUMXI,D
      DIMENSION Y(87,24)
      REWIND 7
      REWIND 10
      NC = 24
      SP = 87
      WRITE (10,1020)
      DO 100 I=1,5
      DO 105 R=1,SP
      READ (7,1000)  (Y(R,C),C=1,NC)
       IF(EOF(7)) 102,105
105   CONTINUE
102   DO 110 C=1,NC
      HIND = 0.0
      HSAM = 0.0
      SUMNI=0.0
      SUMXI=0.0
      N=0.0
      DO 120 R=1,SP
      IF (Y(R,C).EQ.0) GOTO 120
      X=0.0
      X=X+Y(R,C)
      N=N+Y(R,C)
      IF (X.EQ.1.0)GOTO 120
      XI  = X*(X-1)
      SUMNI=SUMNI + Y(R,C)*ALOG10(X)
      SUMXI=SUMXI + XI
120   CONTINUE
      IF ((N.EQ.0.0).OR.(N.EQ.1.0))GOTO 110
      HIND = ((N*ALOG10(N))-SUMNI)/N
      HSAM = (N*ALOG10(N))-SUMNI
      D = 1-(SUMXI/(N*(N-1)))
      WRITE (10,1010) C,N,SUMNI,HIND,HSAM,SUMXI,D
110   CONTINUE
100   CONTINUE
1020  FORMAT (//4X,"COLUMN",5X,"N",9X,"SUMNI",8X,"HIND",8X,"HSAM",
     + 7X,"SUMXI",8X,"D"//)
1000  FORMAT (1X,24I5 )
1010  FORMAT (" ",2X,I5,2X,F10.4,2X,F10.4,2X,F10.4,2X,F10.4,2X,F10.2,
     + 2X,F7.4)
      STOP
      END
```

16.37.22.UC_P, 22,   0.084KLNS.

Program 4. CHTAUM.

```
PROGRAM CHTAUM      73/72    OPT=1 ROUND=+-*/ MANTRAP          FTN 4.6+452

               PROGRAM CHTAUM (INPUT,OUTPUT,TAPE7,TAPE10,TAPE5=INPUT,
     +          TAPE6=OUTPUT ,TAPE11)
      C
      C*****************************************************************C
      C
      C         CALCULATES THE TAU CORRELATION COEFFICIENT FOR PAIRS OF
      C         SAMPLES
      C
      C******************************************************************
      C
                IMPLICIT INTEGER (A-Z)
                REAL TAO, A, B, M,MOT
                DIMENSION X(91),Y(91,52),TAO(52,52),MOT(52,52)
                REWIND 7
                REWIND 10
                SP=91

                DO 170 Q=1,SP
                N=52
                R = Q
                READ (7,*) (Y(R,C),C=1,N)
                WRITE (10,1000) (Y(R,C),C=1,N)
                IF (EOF(7))180,170
       170      CONTINUE
       180      LASTC=N-1
                DO 200 C1 = 1,LASTC
                  C1PL1 = C1 + 1
                  DO 190 C2 = C1PL1,N
                    DO 210 R = 1,SP
                    IF (Y(R,C1).EQ.0.AND.Y(R,C2).EQ.0) GOTO 100
                    X(R) = 1
                    GOTO 210
       100          X(R) = 0
       210      CONTINUE
                M = 0.0
                LASTR = SP-1
                SUM = 0
                T = 0
                U = 0
                DO 510 R1 = 1,LASTR
                IF (X(R1).EQ.0) GOTO 510
                R1PL1 = R1 + 1
                  DO 560 R2 = R1PL1,SP
                  IF (X(R2).EQ.0) GOTO 560
                  M = M+1
                IF (Y(R1,C1).GT.Y(R2,C1).AND.Y(R1,C2).GT.Y(R2,C2)) GOTO 520
                IF (Y(R1,C1).GT.Y(R2,C1).AND.Y(R1,C2).LT.Y(R2,C2))GOTO 530
                IF (Y(R1,C1).LT.Y(R2,C1).AND.Y(R1,C2).LT.Y(R2,C2))GOTO 520
                IF (Y(R1,C1).LT.Y(R2,C1).AND.Y(R1,C2).GT.Y(R2,C2))GOTO 530
                IF (Y(R1,C1).EQ.Y(R2,C1))540,550
       520      SUM = SUM + 1
                GOTO 560
       530      SUM = SUM - 1
                GOTO 560
       540      T = T+1
       550     IF (Y(R1,C2).NE.Y(R2,C2)) GOTO 560
                U = U+1
       560      CONTINUE
       510      CONTINUE
                IF (SUM.EQ.0) GOTO 570
                A = M-T
                B = M-U
                TAO(C1,C2) = SUM /(A*B)**0.5
                MOT(C1,C2) = (TAO(C1,C2) + 1)/2
                GOTO 580
       570      TAO(C1,C2) =0.0
                MOT(C1,C2) = 0.5
        580     WRITE (10,1010) SUM,M,T,U,A,B
                WRITE (10,1020) C1,C2,TAO(C1,C2)
                WRITE (10,1030) C1,C2,MOT(C1,C2)
       190      CONTINUE
       200      CONTINUE
                DO 600 C2 = 2,N
                C2L1 = C2 -1
                    WRITE (11,1040)(MOT(C1,C2),C1=1,C2L1)
       600      CONTINUE
                DO 620 C1=1,N
                C2=C1
                MOT(C1,C2)=1.0
       620      CONTINUE
                DO 630 C2=1,N
```

Program 4 cont'd

```
PROGRAM CHTAUM      73/72    OPT=1 ROUND=+-*/ MANTRAP          FTN 4.6+452

                WRITE (11,1040)(MOT(C1,C2),C1=1,C2)
        530     CONTINUE

        1000    FORMAT (1X,20I5/20I5/20I5)
        1010    FORMAT (" ",10X,I5,5X,F7.2,5X,I5,5X,I5,5X,F7.2,5X,F7.2)
        1020    FORMAT (" ",1X,I2,1X,I2,2X,F8.3)
        1030   FORMAT (" ",1X,I2,1X,I2,2X,F8.3)
        1040    FORMAT (1X,12F7.3 /1X,12F7.3/1X,12F7.3/1X,12F7.3/1X,6F7.3)
                STOP
                END
```

Program 5

```
'REFE' HIER
'UNIT' $40
'INTEGER' CLORDER $40
'SYMM' SIMS $40
'READ' SIMS
'MATR' PSCORES $40,4
'DIAGMAT' SSQ $4
'SCALAR' TRCE
'PCO/PRIN=LTSQ,NLR=4' ASSOCIATIONS=SIMS;RESULTS=PSCORES,SSQ,TRCE
'FACT' LABEL $40=1...40
'EQUA' Y,X=PSCORES $(1,3X)40,1X
'GRAPH/EQXY=Y,NRF=58' X;Y $ ;LABEL
'SMPRINT/PR=1' SIMS
'HIER/CM=1,CT=2' SIMS ;CLORDER
'HIER/CM=3,CT=2' SIMS ;CLORDER
'RUN'
```

Program 6

```
SEE THE 2ND EDITION OF 'SPSS - VERSION 6 AT UMRCC' FOR DETAILS OF VERSION 6.5


RUN NAME          PRINCIPAL COMPONENT ANALYSIS OF TAU MATRIX
FILE NAME         MATRIX
VARIABLE LIST     V1 TO V24
INPUT MEDIUM      CARD
N OF CASES        40
FACTOR            VARIABLES=V1 TO V24/
                  TYPE=PA1/
                  NFACTORS=4/
OPTIONS           1,3
STATISTICS        4,5,6,7,8
READ MATRIX

046400 SCM, 004000 LCM NEEDED FOR FACTOR
```

Program 7

```
PROGRAM TAU         73/72   OPT=1 ROUND=+-*/ MANTRAP        FTN 4.6+452

          PROGRAM TAU(INPUT,OUTPUT,TAPE4=INPUT,TAPE5=OUTPUT,TAPE9)
          DIMENSION A(16,16)
          DO 10 I=2,16
          K=I-1
          READ(4,*) (A(I,J),J=1,K)
     10   CONTINUE
          DO 11 I=1,16
          DO 11 J=1,16
          IF(I-J)13,12,11
     12   A(I,J)=1.
          GOTO 11
     13   A(I,J)=A(J,I)
     11   CONTINUE
          DO 14 I=1,16
          WRITE(5,1001) (A(I,J),J=1,16)
   1001   FORMAT (20F6.3/20F6.3)
          WRITE(9,1000) (A(I,J),J=1,16)
   1000   FORMAT(3(8F10.7/))
     14   CONTINUE
          STOP
          END
```

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Ecological Studies on the Staphylinidae (Coleoptera)

of the Charnwood Forest Area, Leicestershire

by Irene Leow Kim Choo

Abstract

The Staphylinidae of various woodland and non-woodland sites in Charnwood Lodge Nature Reserve and Martinshaw Wood were studied, mainly by pitfall trapping at monthly intervals and by heat extraction of soil samples. The species occurring at the various sites and their temporal variations in abundance were examined. The diversities of the various samples were quantified using the modified Simpson's Index, $\breve{D}$, and the Shannon-Weiner Information Index, H'. Samples were also compared quantitatively using γ as an index of similarity between samples. The resulting matrices of indices of similarity were sorted by the nearest neighbour and mean index sorting techniques and principal component analysis.

In the quantitative comparison of samples, woodland samples were generally separated from open site samples. Charnwood Lodge and Martinshaw Wood samples generally maintained their individual groupings although the latter samples generally grouped with the Charnwood Lodge open site samples. Within the various habitat groupings, samples were generally grouped according to a temporal pattern. Different characteristic species were found in different habitats. *Anthobium atrocephalum*, *A. unicolor*, *Omalium italicum*, *Tachinus signatus*, *Ocalea badia* and *Oxypoda lividipennis* were found in woodland habitats while *Tachyporus chrysomelinus*, *T. hypnorum* and *Drusilla canaliculata* were present in large numbers in open habitats. Many woodland species were most active during autumn and winter, while open habitat species were active at different times during the year and ubiquitous species, such as *T. chrysomelinus*, *T. hypnorum* and *Othius myrmecophilus*, were generally active throughout the year.

The deciduous woodland sites had the greatest number of species and the most diverse staphylinid fauna. The differences in the staphylinid fauna at the various sites, and their diversities, were related to site history.