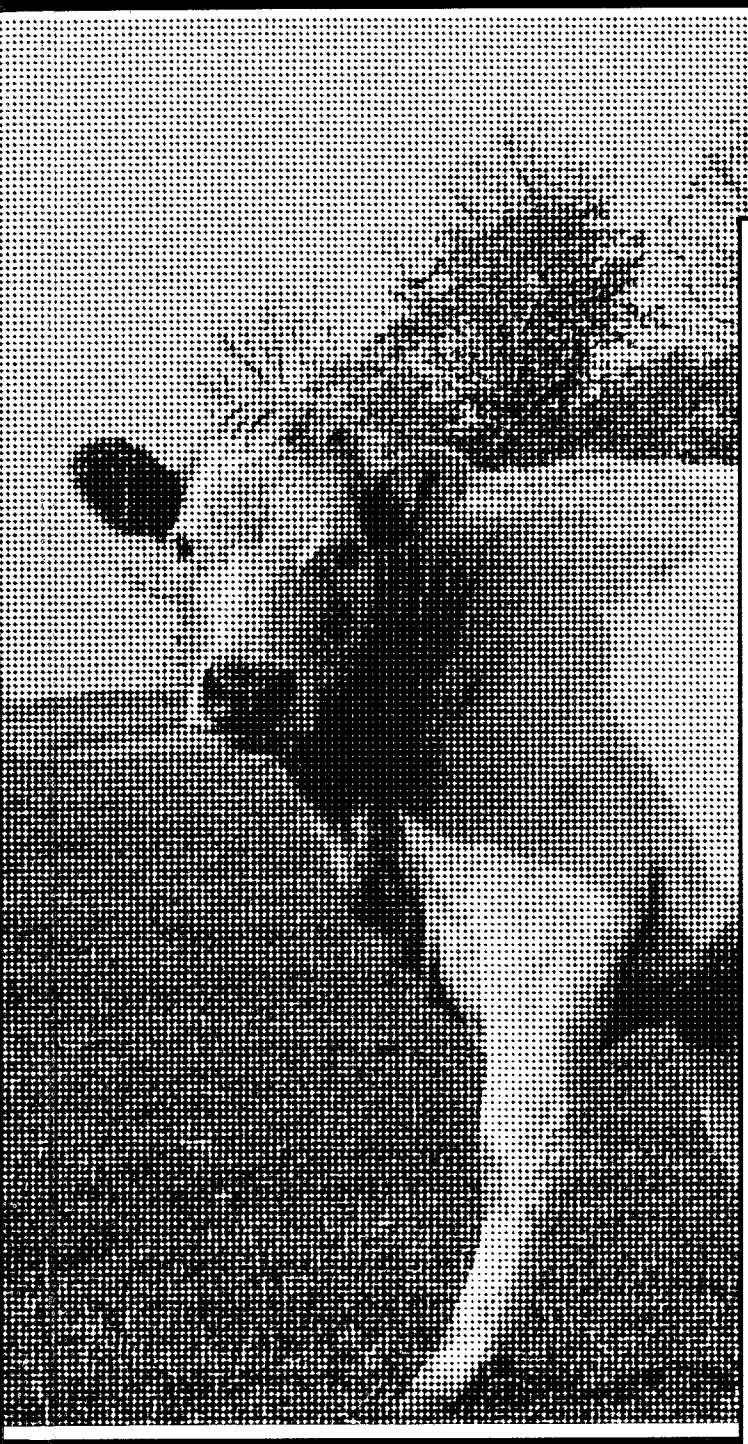
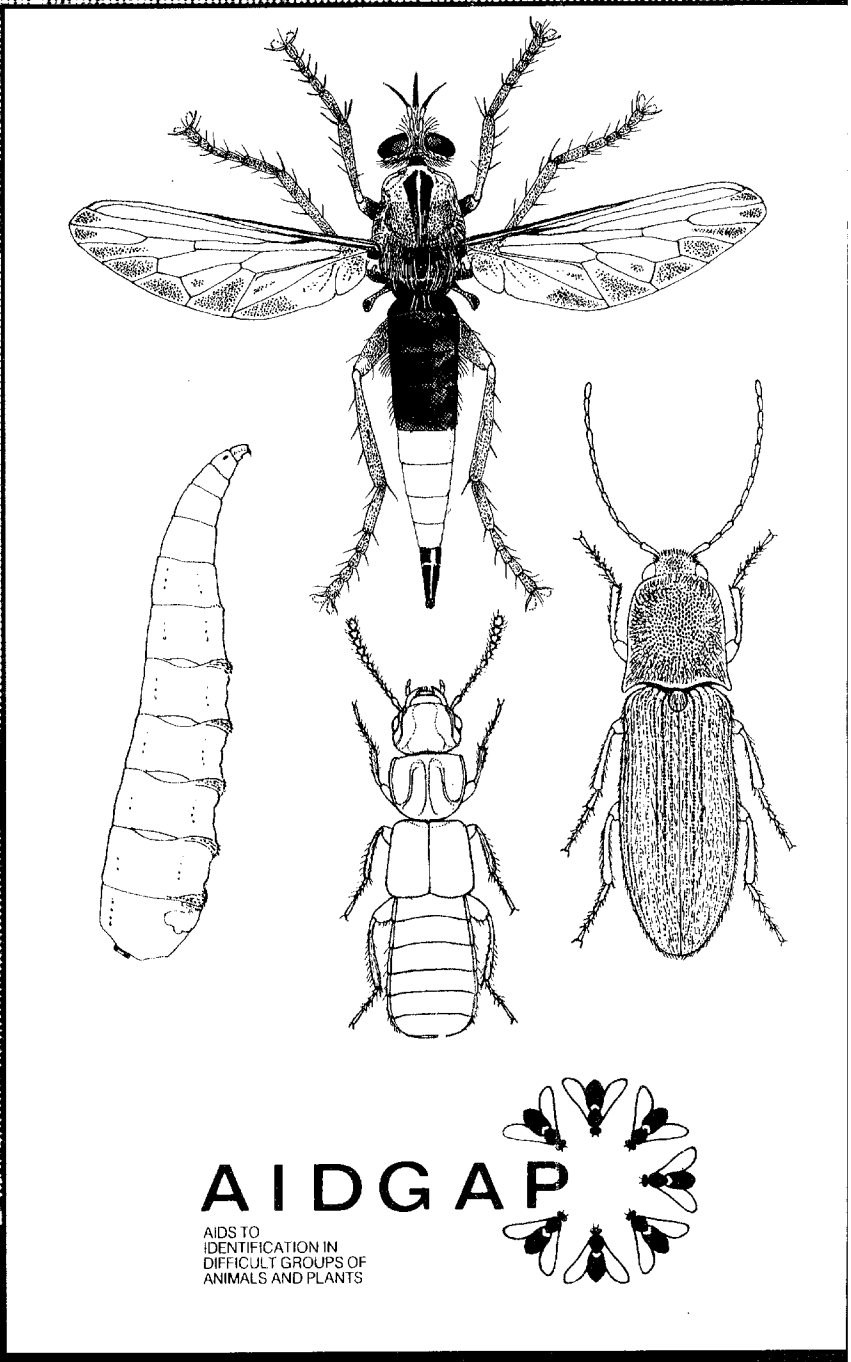
INSECTS
OF THE BRITISH
COW-DUNG COMMUNITY





AIDGAP

AIDS TO IDENTIFICATION IN DIFFICULT GROUPS OF ANIMALS AND PLANTS

By
Peter Skidmore

Field Studies Council

INSECTS OF THE BRITISH COW-DUNG COMMUNITY

By PETER SKIDMORE
Doncaster Museum

CONTENTS

INTRODUCTION

Many animals and plants perform a vital role in the nutrient cycle of pastures, particularly in assisting with the conversion of the cattle dung into humus. The organisms featuring most prominently in this role are insects, mainly flies and beetles, and the group is termed collectively, the "cow-dung community".

The crucial importance of the dung community in agriculture is spectacularly demonstrated in Australia and in other countries where no native *bucoprophilous* (cow-dung loving) fauna exists. In Australia it is estimated that the undegraded dung of 5 cattle removes from production one acre of land per year and considerable expense is being incurred in trying to establish a cow-dung community. The conditions the Australians are seeking to correct are being duplicated in parts of California (Merritt and Anderson, 1977), in the new ranching areas of South America and elsewhere.

An important veterinary aspect of the cow-dung community is the role played by some of its members, notably the face-fly *Musca autumnalis*, in the spread of certain debilitating diseases of cattle, such as Summer Mastitis and the New Forest Disease. The hornfly *Haematobia irritans* may occur in very large populations when their bloodsucking habits cause a considerable reduction in the milk production of affected cattle. Various techniques have been employed to prevent the flies from settling on the cattle. None of these is likely to have serious ecological consequences, but the widespread application of powerful drugs, which are used against a wide range of afflictions of domestic Ungulates, gives major cause for concern. For example, it has been found that the dung of animals treated with one of these drugs was rendered lethal to invertebrates, and, consequently, remained biologically undegraded for up to 3 months (Wall and Strong, 1987). Upon this evidence, the implications for the cow-dung community and the future viability of pastures where the drug is used, are extremely disturbing.

The dung community also provides the biology student with an ideal ecological unit in which to study interspecific relationships, and the effect of external factors. It has been well-researched and considerable amounts of background data are available although much work remains to be done. Reaumur (1738) was the first scientist to study the Diptera which breed in cow-dung and such was the depth of his excellent work that it was 200 years before some of his discoveries were substantiated. The next major worker was Portchinsky who produced several important articles between 1880 and 1913 on the role of predaceous fly larvae. Since then, a considerable literature on the cow-dung community has accumulated. Notable works include: Hammer (1941), the major European study; Mohr (1943), who examines insect succession in cowpats throughout the year; and Merritt and Anderson (1977) who consider the effect of time of deposition and location of cowpats and the effect of these parameters on the rate of degradation.

This book is intended to provide students possessing little or no entomological training with the basic taxonomic ability to begin studies into the cow-dung community. The keys for identification are in two parts and are

followed by two further sections dealing with other important aspects of the subject. Part One keys insects down to family level and should be adequate to give a general picture of the resident insect fauna. Part Two takes the student to species level where appropriate. Detailed studies often show that closely related species have different habits, but valuable pioneer work remains to be done at species level with most of the insects concerned. Part Three describes those families of Diptera (two-winged flies) which are most likely to be encountered as 'casual' visitors to cow-dung. Part Four provides further information on the ecological inter-relationships between the groups and also gives lists of those British species known to the author to have been recorded from the dung of mammalian herbivores. Further work will greatly extend this list but it should serve to illustrate one of Reaumur's important discoveries that different dung types support different insect communities. The list will also serve to illustrate how little is really known and will hopefully stimulate further research. In addition to the list, a simplified food web is included in which trophic categories are given rather than species. These types are coded to correlate with the species list so that the reader can quickly assess the general trophic type to which each species belongs. The latter section of Part Four gives a short list of important titles on *coprophilous* (dung-loving) insects and several of these works provide further valuable lists of references. The more useful taxonomic works are also listed. Finally, a comprehensive glossary and full index are provided.

PREPARATION OF MATERIAL

Hygiene precautions

Since dung consists largely of a living mass of bacteria and other pathogenic organisms, its handling must be undertaken with care. Disposable rubber gloves should be used at all times and there should be immediate access to running water. Obviously, suction pooters should not be used and blow-pooters only with care. Faecal matter must not be allowed to come into contact with the mouthpiece.

Sampling techniques

For comparative studies a number of cowpats of different ages should be gathered, a note being made of the estimated age of the dung in terms of hardness of crust and matrix (*ie.* very fresh, medium or old), light or shade, altitude (if gathered from a range of sites of very different levels), soil conditions (if from a range of different types) and any other parameters which may show a range.

Extraction of organisms from the dung poses many problems since no single process has been devised which will remove all of the individuals from the sample. There are a number of techniques which give partial success:-

(a) Samples are washed out thoroughly under running water through a series of sieves. With older samples it will be necessary initially to break up the matrix by hand, using rubber gloves. Though laborious and messy, this is the quickest method and is the only practical way in which the inactive stages (*eg.* eggs and pupae) can be removed. The great disadvantage is that large quantities of undigested vegetable fragments will remain and the organisms have to be picked out manually. This is best achieved by spreading the detritus

in a thin layer - preferably in a white plastic tray - and looking for the animals under a strong light source (the heat from the light can also increase the animals' activity, thus making them easier to see).

(b) Tullgren or Baermann funnels can be highly efficient for the extraction of active organisms but inactive stages remain *in situ* (see Chalmers & Parker, 1989, for further details of these, and other, sampling techniques).

(c) Methods involving reduction of oxygen supply to the sample, by enclosing in plastic bags or by submerging in water, can be used to induce the more active organisms to leave the dung.

(d) Samples may be placed on damp sand or sawdust in a drying environment. This method may be successful for extracting many beetles and some fly larvae within as little as 24 hours. Modifications of this method extended over a longer period and approximating to field conditions, and allowing for all emergent invertebrates to be trapped can give results which are representative of 'real' field situations. (When approaching time for pupation, many *stercoricolous* (dung-living) insect larvae burrow into the substrate - a detail which must be remembered when gathering samples in the field.)

(e) A useful field method, probably devised by Hammer (1941), consists of placing cones over individual pats and periodically removing the insects from them. The major problem is that of disturbance but, unless the cones widely overlap the edges of the pat, very many insects will escape through the surrounding upper soil or turf. Useful data on succession in dung communities can be obtained by placing cones (of the traffic bollard type) over a number of pats of differing ages.

Murphy (1962) provides a detailed discussion of the relative merits and limitations of a wide range of extraction techniques.

All of the animals will have to be extracted for quantitative work but for many qualitative surveys it is only necessary to retain a range of the animals found. These should then be tipped into a plastic tray and sorted into like groups, each of which is placed in a separate pill box for subsequent identification. It may be necessary to kill one or two examples of each group for examination under a binocular microscope. Larvae are best killed by dropping them in very hot water as this results in maximum extension of the specimen. Adults can be killed in 70% alcohol or with ethyl acetate vapour (but remember that these fumes will attack plastic tubes!). Keep other specimens of the same group alive as their mode of movement may give a valuable aid to identification.

These techniques are likely to work adequately, at least to family level, with the dung of other ungulates.

Many of the invertebrate groups dealt with in this work are covered by Biological Recording Schemes organised by the Biological Records Centre at the Institute of Terrestrial Ecology, Monks Wood Experimental Station, Abbots Ripton, Huntingdon. Up-to-date information on biological and

distributional records are available for a number of the taxonomic groups dealt with in this book.

It must be stressed that the keys are habitat-based and cannot be used for other habitats since other taxa not included here will inevitably occur. Anyone wishing to publish results based upon identifications made with the use of this key alone should have the specimens confirmed by experienced taxonomists. Most of the features mentioned in the keys are clearly visible at magnifications up to x50.

PART ONE
KEYS TO THE MAJOR GROUPS OF ORGANISMS ASSOCIATED WITH THE DUNG OF UNGULATES

A KEY TO THE MAJOR GROUPS OF INVERTEBRATES FOUND IN COW-DUNG

Cow-dung consists of a matrix of undigested plant remains containing recognisable leaf and stem fragments and seeds. Older dung may be permeated by rootlets from surrounding plants and very fine, threadlike fungal hyphae. The fluid component contains vast populations of bacteria, protistans, eggs of parasitic worms, etc., but these are only visible under high magnification and are not dealt with here. They, nevertheless, provide a vital food source for the lowest trophic level of the cow-dung community. Pollen grains, which are usually numerous, are likewise only visible under high magnification, but their ecological importance is probably negligible.

1 Active worm-like animals, round in cross-section and without obvious segmentation (Fig.1)
.....(Phylum NEMATODA)
Nematodes (p.13)

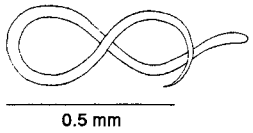


FIG.1.

Note. Slugs (Phylum MOLLUSCA, Class Gastropoda), length: up to 50mm, may be found occasionally, particularly under old dung during the day. This moist environment provides an ideal refuge from sunlight and excessive temperatures (Figs. 2a & 2b).

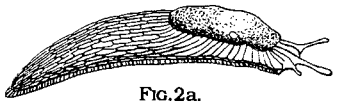


FIG.2a.


FIG.2b.

- Not usually wormlike, but if so then the body is obviously segmented
.....2

2 Animal with three or more pairs of jointed legs
.....(Phylum ARTHROPODA).....3

- Without true jointed legs
.....11

Note. Beware of 'false' legs or prolegs which may be present. These are not obviously jointed.

3 Animal with five or more pairs of jointed legs (one or two pairs on each segment of the body)
.....4

- Animal with, at the most, four pairs of jointed legs
.....6

4 7 pairs of jointed legs (Fig.3)
.....**Woodlice** (Isopoda) (p.15)

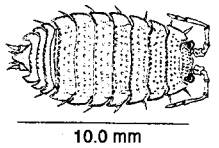


FIG.3.

- More than 7 pairs of jointed legs
.....5

5 1 pair of legs per body segment (Fig. 4a & b)
.....**Centipedes** (Chilopoda) (p14)

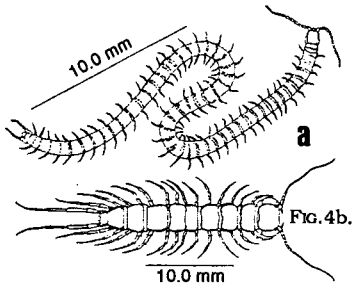


FIG.4b.

- 2 pairs of legs per body segment (Fig. 5a & b)
.....**Millipedes** (Diplopoda) (p.14)

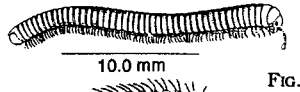


FIG.5a.

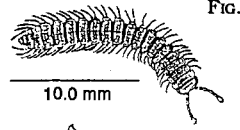


FIG.5b.

6 Animal with four pairs of jointed legs. Body consisting of two major parts at the most ("head" and "body") and sometimes these are completely fused (Fig. 6)
.....**Arachnids** (Arachnida)(p.15)

Note . Spiders, in which the body is composed of two parts as described above, may be found in old cow dung but as casual invaders. Harvestmen have a single body segment but are generally large, very long-legged animals which seldom occur in dung. By far the most important arachnids in dung are mites. These are discussed on page 16.

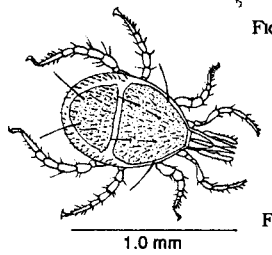


FIG.6.

- Animal with three pairs of jointed legs
.....7

7 Animal with wings (Fig. 7), the first pair may be modified to form hardened covers (elytra; e) over the second pair. If the abdominal segments cannot be seen from above they must be covered by wings. Sometimes the wing cases may be very short so that most of the abdominal segments are visible from above
.....adult **Insects** (Insecta) (p.19)

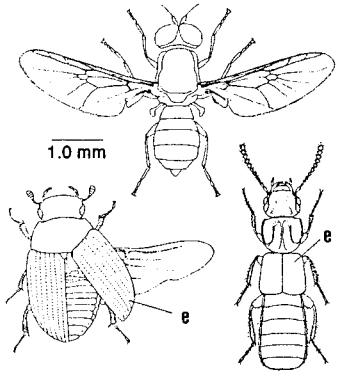


FIG.7.

- Animal without wings
.....8

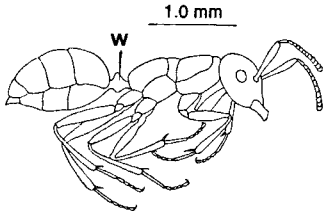


FIG.8.

8 Animal with an obvious "waist" (Fig. 8: w)
.....**Hymenoptera** (Insecta)
(bees, ants & wasps) (p.44)

- Animal without an obvious "waist"
.....9

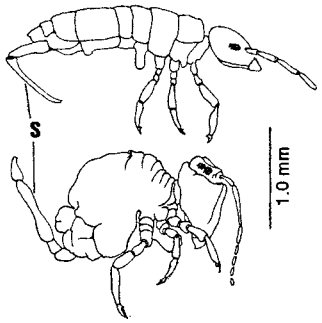


FIG.9.

9 The hind end of the abdomen has two long processes (Fig. 9: s) either bent forwards along the underside of the abdomen or trailing behind. They act as a springing mechanism
.....**Collembola** (Insecta)
(springtails)(p.19)

- Without springing organs as described above
.....10

10 Antennae composed of many (10+) identical rounded segments and the body never with strong bristles. End of the abdomen with a pair of long, single-jointed, rather incurved processes (Fig. 10: f)
.....**Dermaptera** (Insecta)
(Earwig) nymphs (p.20)

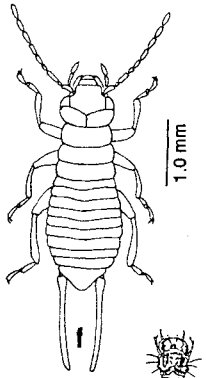


FIG.10.

- Antennae with few (often only two to four), usually cylindrical, segments, and the body often with sparse strong bristles. End of the abdomen with or without processes, but if present these will be multi-jointed (two or more segments) (Fig. 11)
.....**Coleoptera** (Insecta)
(Beetle) larvae (p.25)

FIG.11.

11 Animal obviously segmented
.....12

- Unsegmented structures of spherical to elongate shape
.....13

12 Body composed of 13 segments at the most (see note below), including an obvious head capsule (Fig. 12a: h) or at least a darkened internal skeletal structure which is clearly visible through the body wall (Fig. 12b: s). (It may be necessary to apply pressure to the body wall to see these features clearly). Hind end of the body with a pair of distinct dark spiracles and sometimes with additional processes (Fig. 12a & b)
.....**Diptera** (Insecta)
(Two-winged flies) larvae (p.39)

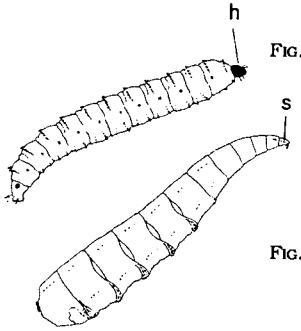


FIG.12a.
FIG.12b.

Note. In some dipterous larvae there may appear to be far more segments but in these cases (*eg.* Anisopodidae) a very distinct head capsule is present.

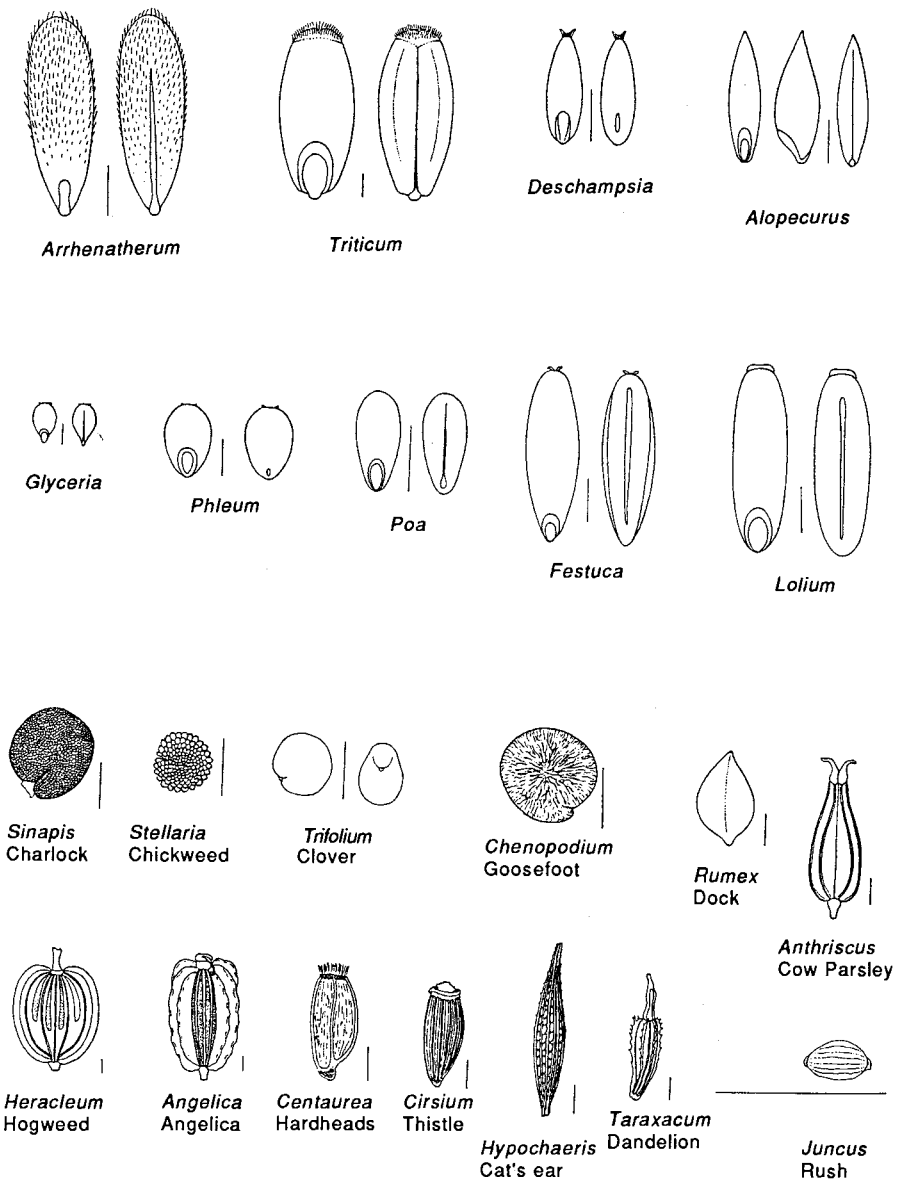


FIG. 13.
A selection of seeds of some common pasture and fodder plants consumed by cattle (scale 1mm). The grass grains (top two rows), showing front and back views, are after Hubbard (1959), remainder after Butcher (1961).

- Body composed of far more segments and without distinct head or internal skeletal structure. Hind end of the body without spiracles or other processes (Fig. 14)
.....(Phylum ANNELIDA)
Oligochaete worms

Note. Earthworms (Class Oligochaeta) commonly invade cow dung, especially when it is ageing and becoming more humidified. Earthworms are regarded by Putman (1983) as being the primary invertebrate decomposers of cow-dung. For the identification of British species, see Sims and Gerard (1985).

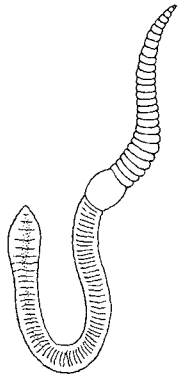


FIG. 14.

13 Generally soft structures whose shells depress when pressure is exerted on them. Shapes ranging from spherical and featureless to elongate, often with pair of dorsal longitudinal ribs or flanges and sometimes with long paired processes at one end. Never with hairs
.....**Insect eggs** (p.17)

- Generally hard structures whose shells do not depress when pressed. Spherical to elongate, often hairy in part; embryo or tubercle-like structure usually visible on one side and one or more longitudinal ribs often present on the other
.....**Seeds** (see below)

PLANTS IN THE DUNG OF UNGULATES

Seeds

The pasture vegetation, upon which the grazing animals feed, varies according to edaphic conditions (the effects of the soil and physical environment) and climate but Fig. 13 shows a selection of the seeds of vascular plants most commonly found in cow dung. Preferred grasses include the genera *Festuca* , *Phleum* and *Lolium* , but *Trifolium* (clovers), *Achillea* (yarrow), *Plantago* (plantains) and *Taraxacum* (dandelions) are also typically present. In wetter pastures *Glyceria* (reed grasses) and *Juncus* (rushes) may be dominant. These seeds are all large enough to be conspicuous at low magnification. Pollen grains are much smaller and require high power examination for their identification.

Fungi

A range of fungi may be found (see Fig.15). Detailed studies will show that a succession of these organisms occurs as the dung ages. According to Ramsbottom (1953) the fungal spores have probably passed through the animal and germinate as the dung reaches the optimum condition for this to happen.

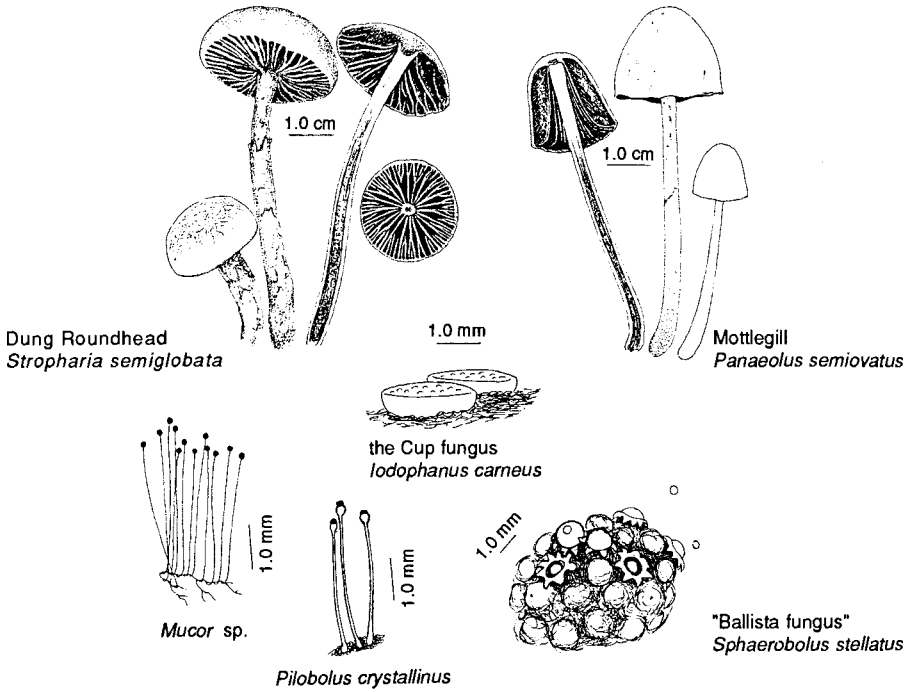


FIG. 15.

Some characteristic fungi frequently found associated with dung

Fruiting bodies of the moulds (Phycomycetes) appear first, followed by the Ascomycetes and finally the toadstools (Basidiomycotina), such as the dung roundhead (*Stropharia semiglobata*) and various species of *Panaeolus*, *Coprinus* and *Conocybe*, etc., and the "ballista fungus" *Sphaerobolus stellatus*. This last-named, like the mould *Pilobolus crystallinus*, has an explosive mechanism for catapulting the spores over 30cm into the surrounding vegetation where, along with any nematode larvae they transport (see below), they may be ingested by grazing animals. Insect activity and wind are also important factors in spore dispersal of other fungi. Within a patch of cowdung it has been shown that the distribution of toadstool species may be strongly governed by pH values. Watling (1978) notes that *Panaeolus semiovatus* and many related species favour alkaline dung in contrast to the acid-loving *Stropharia semiglobata* . Sometimes, black spheres measuring about 7mm in diameter may be found in cow dung. These may prove to be the sclerotia (vegetative "resting" bodies) of ink-cap fungi (*Coprinus* spp.). If kept under ideal growing conditions they may produce the familiar fruiting body. Formerly, they were regarded as an unrelated fungus (*ie.* taxonomically distinct from ink-cap fungi), and described under the name of *Sclerotium stercorarium*. For identification of fungi occurring in dung see Richardson and Watling (1982).

With increasing fungal activity, *fungicolous* (fungus-feeding) insects become more numerous. Characteristic examples are the "feather-wing beetles" (Ptiliidae), the rove-beetles (*Micropeplus* spp.), cryptophagid beetles and fungus-midges (Sciaridae).

Animals in the dung of ungulates

Many of the animals present in fresh dung are unlikely to be seen under low-power (less than x50) binocular microscopes. This microfauna is, therefore, considered beyond the scope of this key, but many of the organisms are of considerable importance to veterinary science. Especially important are the parasitic Platyhelminthes (including the trematodes (flukes) and cestodes (tapeworms)), and the Nematoda (roundworms). These occur as eggs or larvae in dung, awaiting the opportunity to re-infest their hosts which graze on the infested pastures. Some, *Ascaris* for example, do not hatch until they are back inside the host mammal but others hatch either in their host's alimentary tract prior to defaecation, or 'outside' in the dung. Eggs of the nematode *Dictyocaulus viviparus*, adults of which infest the lungs of calves, are coughed up and then swallowed by the host. On passage through the digestive tract the larvae hatch and are passed out with the faeces. The third instar larvae, measuring about 0.3-0.4 mm in length, become negatively geotropic and climb the ripe sporangiophores of the mould *Pilobolus crystallinus*. They are then thown into the surrounding vegetation through the explosive expulsion of the spores, to be swallowed later by their hosts. Larvae of several other nematodes of the suborder Strongylina are thought to feed initially on bacteria before migrating to surrounding vegetation for re-infestation of their hosts. A more complicated life-cycle is found in those nematodes which require a secondary host. Thus in *Habronema* (order Spirurida), which affects the stomach of horses causing gastric habronemiasis, the parasite larvae are swallowed by muscid (two-winged fly) larvae which are feeding in the dung and re-enter the horses through the blood-feeding habits of the adult

flies. In the related nematode order Gongylonema, which inhabits the oesophagus and rumen of cattle, etc., the intermediate hosts are dung beetles (*Aphodius* and *Onthophagus* species) which must be inadvertently swallowed by the cattle for re-infestation by the nematode to take place. In the trematode "liver fluke", *Fasciola hepatica*, the intermediate host is the freshwater snail *Limnaea truncatula* which occurs in wet pastures and shallow ditches.

The largest eggs of parasitic worms are about 0.2 mm across and, therefore, are easily overlooked at lower magnification. However, in the case of tapeworms (Cestoda) the body segments are shed as they become filled with ripe eggs, and these purse-like, usually whitish, structures measure up to 15mm in diameter, and may occasionally be found in dung.

Despite the numerous parasitic forms that occur, most nematodes that are encountered in dung are free-living. The biology of these worms is largely unknown.

In addition to the Insecta, which form the main subject of this work, four other arthropodan groups may occur as casuals under old cow-dung; the Chilopoda (centipedes), Diplopoda (millipedes), Isopoda (woodlice) and Arachnida (spiders, etc.). These are briefly discussed below.

Class CHILOPODA (centipedes)

These highly carnivorous soil organisms commonly invade old cow-dung for prey. There are two main groups, the long-legged surface-hunting Lithobiomorphs (Fig. 16b) and the much more slender Geophilomorphs (Fig. 16a) which hunt in soil litter, grass swards, etc. For further information on the biology and identification see Eason (1964) and Tilling (1987).

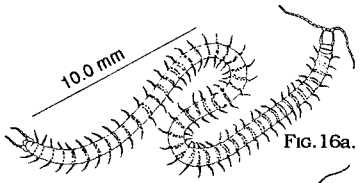


FIG. 16a.

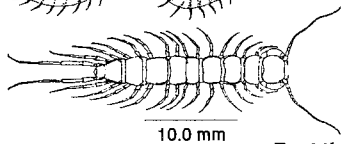


FIG. 16b.

Class DIPLOPODA (millipedes)

Unlike centipedes, the millipedes are associated with decaying plant matter, upon which they feed. Again, two main types may be found occasionally in old cow-dung: the "true" (snake) millipedes like *Tachypodoiulus* spp. (Fig. 17a) and the very different "chain" millipedes including *Polydesmus* spp. (Fig. 17b). A third group - the pill millipedes (*Glomeris* spp.) - may also be found infrequently. These can can be confused with the pill woodlice. For more details on biology and identification see Blower (1985) and Tilling (1987).

FIG. 17a.

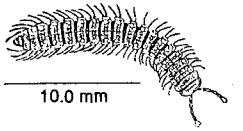


FIG. 17b.

Class CRUSTACEA

Only one crustacean order is likely to be encountered in dung.

Order ISOPODA (woodlice)

Woodlice may be found under old cow-dung where they occur mainly as strays from the surrounding soil (Fig. 18). They feed primarily on decaying vegetable matter and, to a lesser extent, on fungi, bacteria and dung. Sutton (1972), Harding and Sutton (1985) and Hopkin (1991) give detailed accounts of the taxonomy and ecology of the British species.

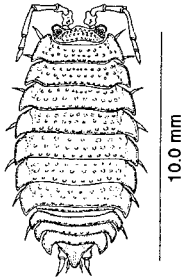


FIG. 18.

Class ARACHNIDA

Four orders are represented in dung.

Order ARANEAE (spiders)

Spiders, being abundant soil animals, are very frequent invaders of cow-dung and many species may be found, although most frequent are perhaps the ground-hunting wolf spiders (*Pardosa* spp. and their relatives)(Fig. 19). For the identification of spiders see Locket and Milledge (1951-53), Locket *et al.* (1974); Jones (1984); Roberts (1985); Jones-Walters (1989).

FIG. 19.

Order OPILIONES (harvestmen)

The harvestmen are generally characterised by their relatively small rounded body and, often extremely long, slender legs. However, many species do not conform to this "norm". Several of the rather shorter-legged forms are common soil animals, and one of them, the pasture-dwelling *Nemastoma bimaculata*, often occurs in old cow-dung. It is very easily recognised by the small size, dull black ground colour and the two white spots on the back (Fig. 20). Harvestmen feed mainly on dead animal matter. For further details on biology and identification see Hillyard and Sankey (1989).

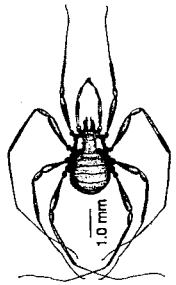
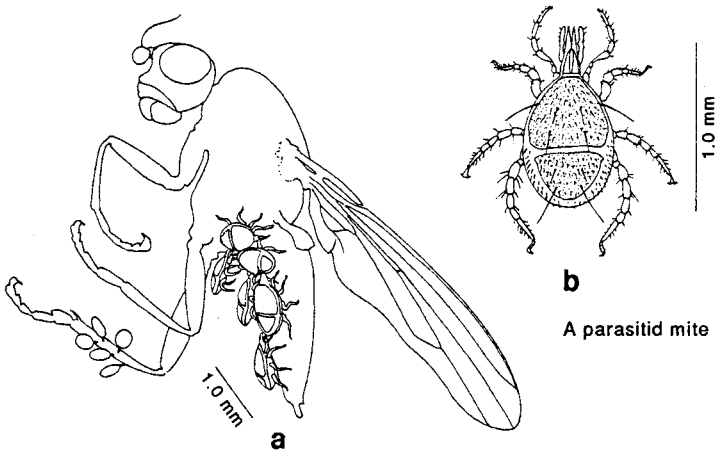


FIG. 20.

Order ACARI (mites)

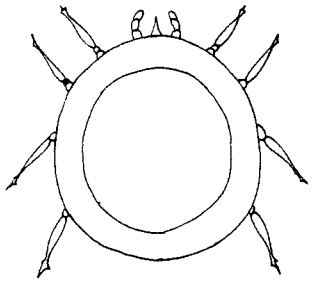
By far the most common arachnids found in dung (and in terrestrial habitats generally) are the mites. All are small or minute (up to about 5 mm long) and their identification is best left to a specialist.

Three main groups are encountered: the Uropodidae, Parasitidae and Oribatidae. Uropodids and parasitids use adult insects for transportation (a process known as *phoresis*) , the former as non-active deutonymphs attached by a thick stem to the insect cuticle (Fig. 21a), the latter as active adults which feed on scraps of food adhering to the insect carriers (Fig. 21b). Whilst the uropodids (Fig. 21c) and oribatids (Fig. 21d) are thought to feed on the dung or on associated fungi, the parasitids (Fig. 21b), as the name suggests, prey on other invertebrates; notably on the eggs and larvae of insects, including those whose adults are used for transportation.



Sphaerocerid fly carrying parasitid mites on abdomen and stalked deutonymphs of uropodid mites on hind tibia

A parasitid mite



A uropodid mite

An oribatid mite

FIG.21.

Mites start to colonise the dung with the first wave of insects, many of which will be carrying the 'hitch-hiking' mites. The parasitid mites are particularly prolific in the earlier days of the cowpat, seeking the eggs and young larvae of their insect "benefactors", and consuming them. At the same time the uropodid deutonymphs will be detaching and starting their free-living existence, and, as the pat ages, increasing numbers of oribatids will be arriving from the surrounding soil. Consequently, a distinct succession of mites works through the dung, with the greatest diversity of parasitids occurring during the early weeks and the majority of oribatids when the old dung is finally becoming humidified.

Order PSEUDOSCORPIONIDA (false scorpions)

This order of very small arachnids is characterised by the greatly enlarged pedipalps which give the scorpion-like appearance (Fig. 22). They feed mainly on mites and small insects and commonly occur in soil and plant litter. A few species have been found in old dung. For identification see Legg and Jones (1988).

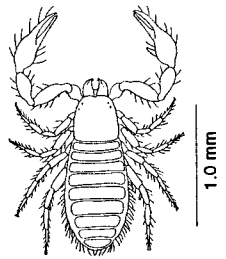


FIG.22.

Class INSECTA

By far the largest class of living things, the insects account for about three-quarters of all known extant species of organisms. Identification problems are compounded by the fact that most insects undergo a complete metamorphosis between larval and adult stages. It is not enough to recognise the adults of species within a habitat under survey, but highly advisable to be able to recognise the immature stages as well. In many cases, however, the larvae have yet to be described in taxonomic publications and in this respect a vast amount of research needs to be done. This book is merely intended to provide some idea of the complexity of insect life in this highly specialised microhabitat and to point the student towards useful pioneer work by emphasising the shortfalls in our present knowledge. It will be clear that some groups are better understood than others, but in very few instances is identification to species possible in the immature stages.

Insect Eggs

Eggs of only two orders of insects are commonly found in dung, namely Coleoptera (beetles) and Diptera (two-winged flies). Coleopteran eggs are usually very smooth and shining, often lacking surface sculpture, with the shapes ranging from rounded to short oval. Dipteran eggs vary in shape from round oval to elongate, their shells usually finely reticulated, often with two dorsal longitudinal ribs or flanges which may project at one end to form long respiratory horns (*ie.* in the Sepsidae and Muscidae). In springtime, batches of eggs of the common earwig (*Forficula auricularia*) are often seen in old cowpats, but these are nearly always tended by the female parent.

Insect larvae

Larvae of only Coleoptera and Diptera are commonly found in dung. The Hymenoptera belonging to the dung community are internal parasites of other insects. Earwig nymphs occur briefly in the springtime but they are insignificant members of the dung fauna. They are easily recognised by their whitish colour, long simple antennae composed of many rounded segments and their long caudal processes. Larvae of Coleoptera and Diptera are distinguished as follows:-

FIG.23a.

1 Head capsule complete and strongly sclerotised with conspicuous mandibles and antennae. Thoracic legs well developed (except in *Cercyon*, in which the body is fleshy and soft and lacks obvious spiracles on the last abdominal segment (Fig. 23a & b)
.....Coleoptera (beetles)(p.25)

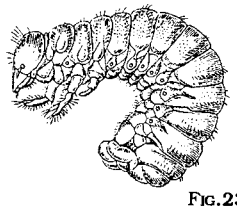


FIG.23b.

FIG.24a.

- Head capsule often absent and legs always absent. Last abdominal segment with distinct anal spiracles, or, if these are hidden (*ie.* family Stratiomyidae), the body rather tough and leathery (Fig. 24a,b & c)
.....Diptera (two-winged flies)(p.39)

FIG.24b.

FIG.24c.

Insect pupae

Only dipteran pupae occur commonly in dung; coleopteran larvae usually pupate in the soil beneath. In many dipteran families the pupa is encased inside the shrunken skin of the final larval instar which retains the essential features of that instar, though in a rather distorted state. In these groups (*eg.* Stratiomyidae and Syrphidae to Muscidae) identification of these "puparia" can be achieved by use of the larval key on p.39. In many species, however, the puparium is more easily identified than the larva owing to certain features appearing only in the former stage (*eg.* the very long pupal horns in *Hydrotaea* puparia). The pupae of more primitive flies (the nematoceran families; see p.29) are less well known at present and have not been keyed out in this book.

Adult Insects

Most adult insects are winged and the vast majority found in the dung (rather than on the surface) are beetles. Springtails, belonging to the order Collembola, sometimes occur in old dung in which fungal colonisation is advanced. These primitive wingless insects possess a characteristic springing mechanism under the end of the abdomen (Fig. 25: s). The other main orders found in dung can be distinguished using the key below.

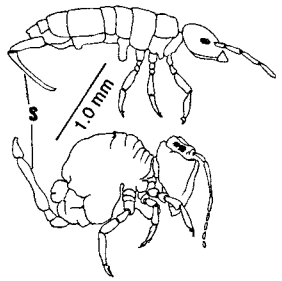


FIG.25.

KEY TO ORDERS OF ADULT INSECTS

Only Coleoptera, Diptera and Hymenoptera include species which normally breed in dung.

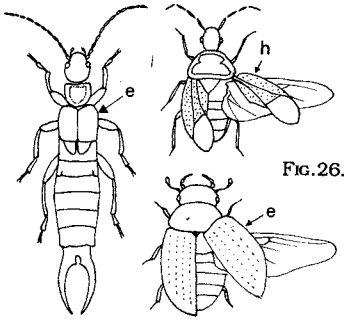


FIG.26.

1 Front pair of wings (Fig. 26: e and h) at least partly leathery, usually closely fitting over the back to protect the delicate hind wings, but sometimes very short
..... 2

- All wings membranous, or wings absent
.....4

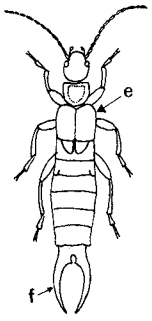


FIG.27.

2 Wing cases (Fig. 27:e) very short, not covering the abdomen which ends in a pair of rigid forceps (Fig. 27:f)
.....DERMAPTERA (earwigs) (p.20)

Note. Beware of rove beetles (Staphylinidae: Fig.28) which also have short wing cases but no abdominal forceps.

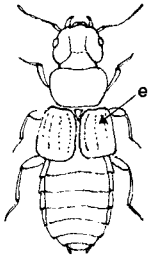


FIG.28.

- End of the abdomen without such forceps, at most with a pair of short 'tails' (cerci); wing cases often cover the abdomen, but they may be short
.....3

3 Front pair of wings membranous at their tips (h); mouthparts of a piercing type (p) (Fig. 29)
.....HEMIPTERA (bugs) (p.21)

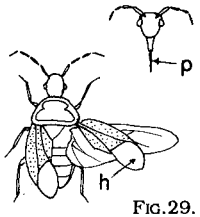


FIG.29.

- Front wings of uniform consistency (e) and the mouthparts of a biting type (b) (Fig. 30)
.....COLEOPTERA (beetles) (p.21)

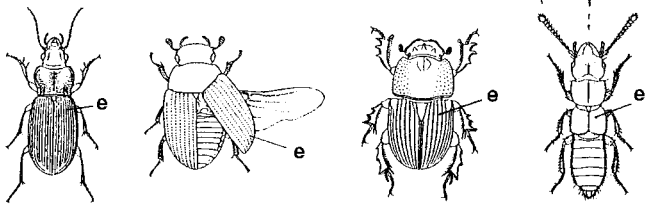


FIG.30.

4 Only one pair of wings (l), the hind pair reduced to form halteres or balancers (b) (Fig. 31). Mandibles (biting jaws) absent
.....DIPTERA
(two-winged flies) (p.27)

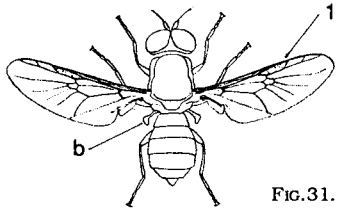


FIG.31.

- Either wingless , or with two pairs of wings (1 and 2) (Fig. 32). Mandibles distinct
.....HYMENOPTERA
(bees, wasps, ants, etc.) (p.44)

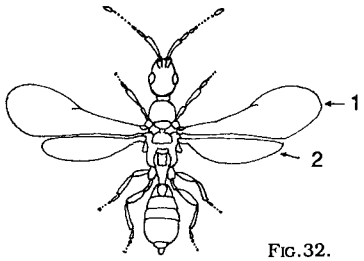


FIG.32.

Order DERMAPTERA (earwigs)

Only two species of earwigs occur commonly in Britain and, whilst neither of these is associated primarily with mammalian dung, both may occur as casuals. The most familiar species is *Forficula auricularia*, and the overwintered females very often utilise overwintered cowpats in springtime for laying their eggs and brooding their young. The creamy coloured eggs are deposited in a group and have no discernible sculpture or ornamentation. They are almost always found with the female, which guards over them.

The other common species, the lesser earwig, *Labia minor*, is a unformly dull brownish-yellow insect, about half as large as the commoner species but morphologically similar. It occurs most commonly in manure heaps.

Young earwigs resemble the adults but are paler and lack wings. The anal forceps are softer and less strongly curved (see Fig. 10, p.9). Earwigs spend winter in the adult state and there is one brood of young annually. See Brindle (1977) for further information on biology and identification.

Order HEMIPTERA (bugs)

A very large order of insects (1500+ British species) but, in Britain, no bug can be regarded as anything other than a casual visitor to mammalian dung. Members of two soil-frequenting families (the Saldidae and Lygaeidae) may be found occasionally in dung where they presumably feed on other insects. The genera most often encountered are shown below (Fig. 33). They are all 3 to 5 mm in length. See Southwood & Leston (1959) for further information on biology and identification.

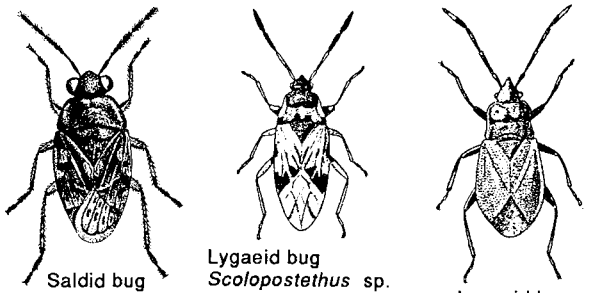


FIG.33.

Examples of ground-living bugs found casually in cow dung

Order COLEOPTERA (beetles)

Although this is, numerically, the largest order of insects (world-wide), the number of families which include exclusively dung-frequenting species (or even species which occur there as frequent casuals) is very small. Indeed only three families are invariably represented: the Staphylinidae (rove-beetles), the Hydrophilidae ('herbivorous' water beetles) and the Scarabaeidae (dung beetles). Geotrupidae (dor beetles) are less numerous in Britain although most species are purely dung insects and several occur commonly. Some Histeridae (carrion beetles) only occur in mammalian dung and are quite common; *Onthophilus striatus* is a characteristic species of horse-dung. Of the other families dealt with here certain Ptiliidae (pygmy beetles) and Cryptophagidae occur in old dung upon which moulds have started to develop, whilst many Carabidae (ground beetles) and the "wireworm" larvae of the family Elateridae (click beetles), being common carnivorous soil insects, frequently invade dung lying on the soil to prey on the inhabitants. Most of the genera dealt with here overwinter in the adult state and lay eggs

in the spring or early summer. Eggs of Coleoptera are generally very featureless, oval or round in shape and, like those of earwigs, devoid of any surface sculpture or ornamentation. The larvae are generally commoner during the summer months but most apparently leave the dung to pupate and, therefore, the pupae are not often encountered in dung but more often in the soil beneath.

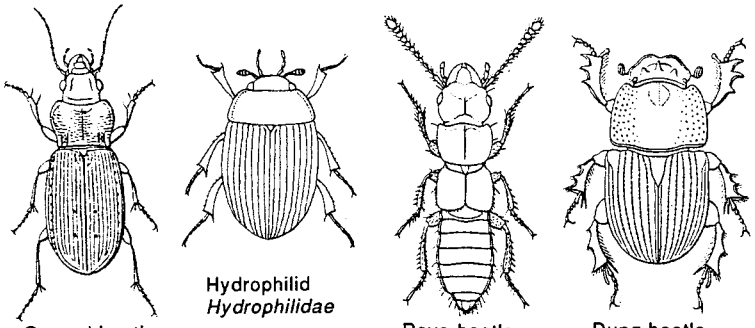


FIG. 34.
Examples of four of the most abundant families of beetles (the three on the right hand side are invariably present).

KEY TO FAMILIES OF COLEOPTERA OCCURRING IN COW-DUNG (ADULTS)

Note. Remember that this is a habitat-based key. Some families may occur as casuals. If in doubt, refer to one of the comprehensive identification texts listed in the bibliography (p.154)

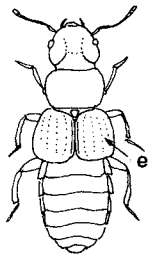


FIG.35.

1 Elytra (wing cases: Fig. 35; e) are much shorter than the abdomen; more than three abdominal segments visible from above. Wings (under elytra) never feather-like
.....STAPHYLINIDAE
(rove-beetles) (p.58)

- Elytra covering all of, or most of, the abdomen; at most with one or two abdominal segments visible from above.
..... 2

Note. In preserved specimens, the abdomen may be distended so that it projects beyond the elytral apices. Be careful. In some Ptiliidae, more abdominal segments may be visible but these beetles are 1.2mm long at the most and the wings (under the elytra) are feather-like)

2 Antennae are long, 11 jointed, and with all joints of about equal length (Fig. 36)
.....CARABIDAE
(ground beetles) (p.49)

Note: Be careful here. Remember the possibility of encountering 'casuals' - see note on the opposite page.

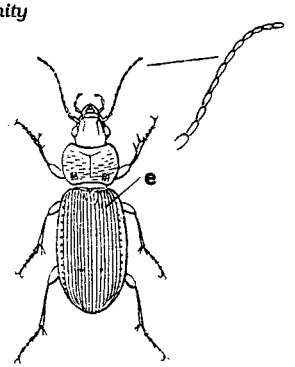


FIG.36.

- Antennae are not as described above; sometimes very abruptly thickened or clubbed towards the apex
.....3

Note . In some of these families, in which the antennae are short, difficulty may be experienced in distinguishing the antennae (a) from the maxillary palpi (p) (Fig. 37); the latter never have more than 5 joints, the former never fewer than 6. The palps never have a segmented club.

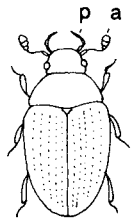


FIG.37.

3 Antennae with a long basal joint followed by 4-7 very short ones and ending in a 3-4 jointed club (Fig. 38). Body sizes various; up to 24mm
.....4

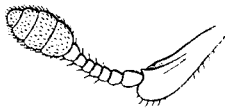


FIG.38.

- Antennae with the basal joint relatively short, not nearly as long as the following 4-7 joints together (Fig. 39). Always very small beetles (up to about 3 mm long)
.....7

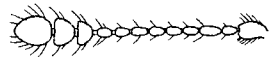


FIG.39.

4 Apical antennal joints making up the club joined in the midline so that the club is symmetrical (Fig. 40)
..... 5

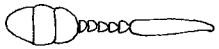


FIG.40.

- Apical antennal joints making up the club are joined on the outer side so that the club is strongly asymmetrical (Fig. 41)
.....6

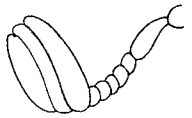


FIG.41.

5 Palpi (p) as long as the antennae (a), or nearly so, and the elytra rounded at the apex, entirely covering the abdomen (Fig. 42)
.....*HYDROPHILIDAE
(hydrophilid beetles) (p.49)

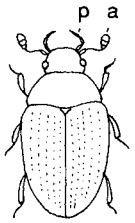


FIG.42.

- Palpi much shorter than the antennae, with the last abdominal segment exposed. The truncate (square-ended) elytra only reaching the base of the preapical (second-from-last) abdominal segment (Fig. 43)
.....HISTERIDAE
(histerid beetles) (p.54)

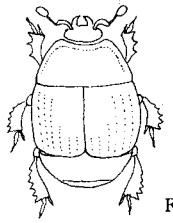


FIG.43.

6 Length 14-22 mm. Blue black beetles with metallic blue or green undersides (Fig. 44a & b)
.....GEOTRUPIDAE
(dor beetles) (p.82)

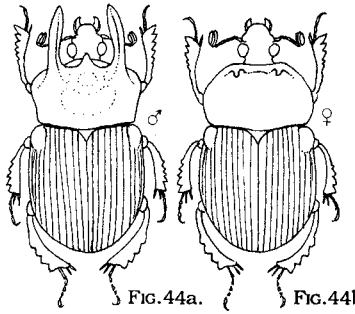


FIG.44a. FIG.44b.

- Length 3-13 mm. Colouration not as above (Fig. 45)
.....*SCARABAEIDAE
(dung beetles) (p.84)

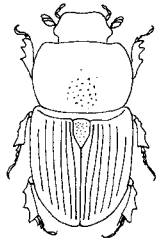


FIG.45.

7 Minute (length up to 1.2mm). Uniformly black or dark brown beetles with feather-like hind wings (w) and antennae of very characteristic shape having the first two segments stout, segment 3 onwards very thin, and a loose 3-segmented club (Fig. 46)
.....PTILIIDAE
(pygmy- or featherwing beetles) (p.56)

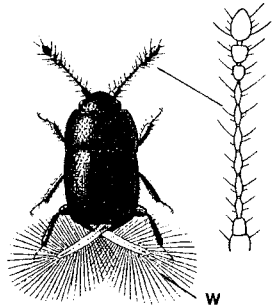


FIG.46.

- Length about 1-3 mm. Often partly reddish and blackish beetles with hind wings and antennae not as described above (Fig. 47)
.....CRYPTOPHAGIDAE (p.93)

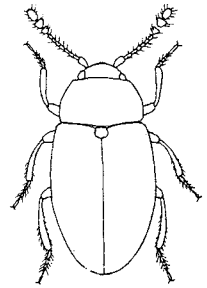


FIG.47.

Note. Families marked with an asterisk (*) above are invariably present and often include several species. Histeridae are much less frequent and Cryptophagidae and Ptiliidae are only common when rich fungal growth is developing. At such times they may be joined by *Euplectus* (Pselaphidae) and *Monotoma* (Rhizophagidae) (both are illustrated below: Fig.48). *Euplectus* spp. (Fig. 48a) look like small rove beetles but have distinctive depressions on the head, pronotum and basal abdominal tergites. *Monotoma* spp. (Fig. 48b) are of unmistakable shape. Pselaphids and rhizophagids are at least partly predatory, some of the former family preying on mites and springtails.

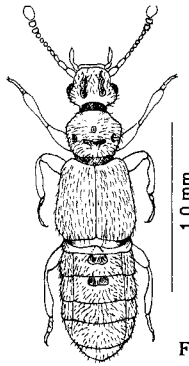


FIG.48a.
Euplectus sp.

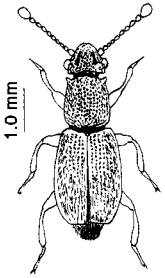


FIG.48b.
Monotoma sp.

KEY TO FAMILIES OF COLEOPTERA OCCURRING IN COW-DUNG (LARVAE)

1 Legs with 5 segments, including a separate tarsal segment (t)(Fig. 49)
.....CARABIDAE
(ground beetles) (p.49)

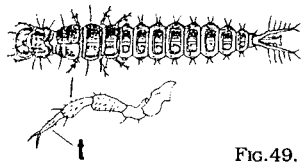


FIG.49.

- Legs with at most 4 segments (the tarsus being fused with the tibia)
.....2

2 Larvae of a characteristic "scarabaeiform" form (**C** shaped - Fig. 50)
.....7


FIG.50.

- Larval form otherwise
.....3

3 Legs and cerci (c) long (Fig. 51)
.....STAPHYLINIDAE
(rove beetles) (p.58)

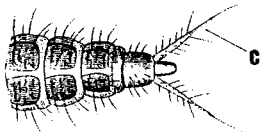


FIG.51.

- Legs and cerci very short or absent
.....4

4 Body hard and waxy to touch owing to heavy sclerotisation of the body wall (Fig. 52a & b)
.....ELATERIDAE
(wireworms) (p.93)

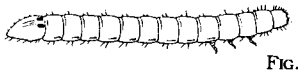


FIG.52a.


FIG.52b.

- Body soft
.....5

5 Body with 12 segments (excluding the head) (Fig. 53)
.....HISTERIDAE
(histerid or carrion beetles) (p.54)

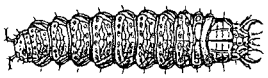


FIG.53.

- Body with 11 or fewer segments (Fig. 54)
.....6

6 Body with 11 segments (excluding the head) (Fig. 54)
.....HYDROPHILIDAE (p.49)


FIG.54.

- Body otherwise
.....*Larvae of other families merely occurring as casuals.*

7 Last abdominal segment rather flattened or concave and the third pair of legs often much shorter than the two preceding pairs (Fig. 55). 3 antennal segments
.....GEOTRUPIDAE
(dor beetles) (p.82)

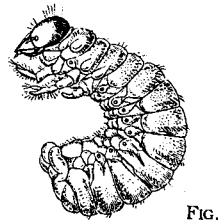


FIG.55.

- Last abdominal segment rounded, convex, and all legs of equal length (Fig.56). 4 or 5 antennal segments
.....SCARABAEIDAE
(dung beetles) (p.84)

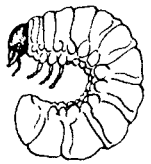
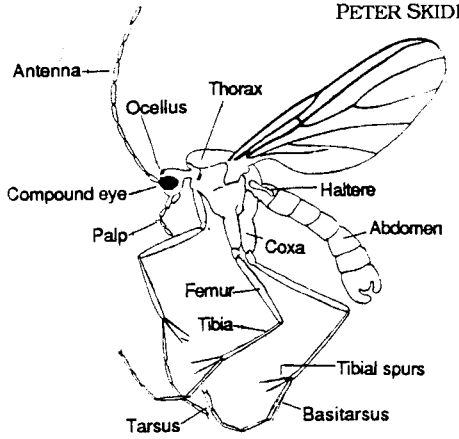


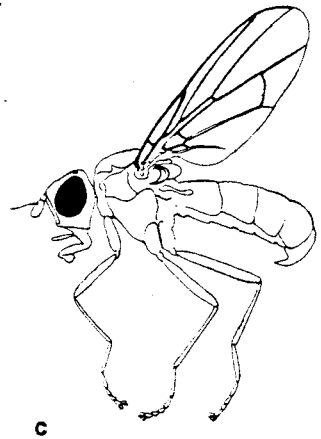
FIG.56.

Order DIPTERA (two-winged flies)

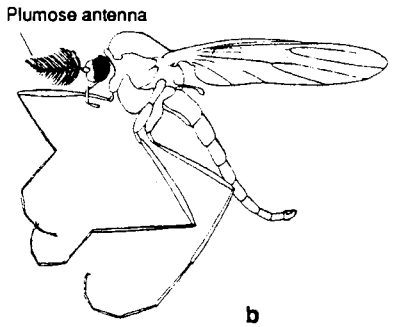
This vast order of insects, surpassed only by the Hymenoptera in numbers of British species, is very well represented in the cow-dung community. Unlike the beetles (Coleoptera), many dipteran families occur commonly in the larval stage in cow-dung whereas the adult flies seldom penetrate the dung. Consequently, although fly larvae usually predominate in samples of dung which are being examined in the laboratory, coleopteran adults invariably outnumber dipteran adults. Another problem arises from the fact that very many adult Diptera will be found casually on cow-dung - visiting the fresh dung either to suck the moisture or to prey on other visitors. These are not regarded as in any way belonging to the cow-dung community but their occurrence means that flies which will not key out to family in the following guide can be expected. These can either be ignored, as casuals, or, if needed, they should be identified by using relevant keys listed in the Bibliography. For keys to families of British Diptera see Colyer and Hammond (1968) and Unwin (1983). Smith (1989) provides a comprehensive key to diptera larvae.



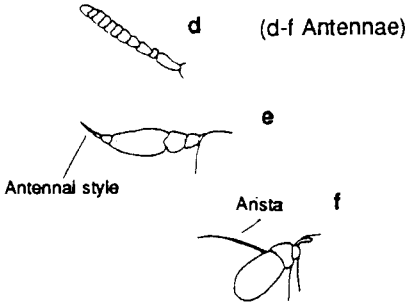
a
Hypothetical nematoceran



c
Hypothetical calypterate



b
Male chironomid midge



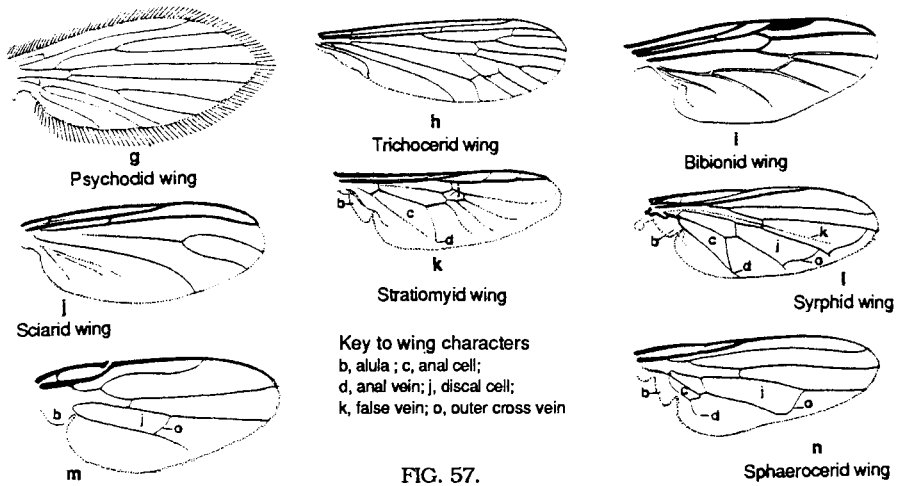


FIG. 57.
"Typical" adult two-winged fly (Diptera) features

The external structure of adult Diptera ranges from the primitive cranefly type, characteristic of the sub-order Nematocera, to the advanced 'calypterate' type of which the house-fly is typical. See Colyer & Hammond (1968) for a detailed explanation of the taxonomy of the two-winged flies. In brief, the Diptera are separated into 3 sub-orders: the Nematocera, the Brachycera and the Cyclorrapha (of which the acalypterates and calypterates form major groups).

Figure 57 illustrates (in a stylistic form) the main anatomical characters used in the following keys.

Most Diptera overwinter in the larval stage (unlike the Coleoptera), pupating in late-winter or early-spring. Eggs of many flies, especially of the more advanced families, are of a rather distinctive appearance, sometimes with long apical processes which are called respiratory horns. Some Diptera have several generations throughout the warmer months so two-winged fly larvae can be found in cow-dung at any time of the year. Many species pupate in the old cowpats. In the more primitive families of flies, the larva, when fully grown, sheds its skin to form the pupa (just as in beetles or Lepidoptera, etc.). In the more advanced families, however, the final larval skin is not shed but merely contracts to form a 'puparium', inside which the true pupa forms. It is possible, particularly with puparia approaching time for adult emergence, to extract the pupa by carefully cutting open the puparium. When the fly has emerged from the puparium, the pupal case remains as a very flimsy translucent or whitish skin visible inside the puparium.

KEY TO FAMILIES OF DIPTERA COMMONLY OCCURRING IN COW-DUNG (ADULTS)

This key includes those families which frequently occur in cow-dung, but others may be found. See the key to 'casuals' on p.36 if the specimen does not conform to descriptions given in this key.

Note . All terms referred to in this key are labelled in Fig.57 (opposite).

1 Wing with a long, usually closed, anal cell (a), extending at least 2/3 way to the wing margin (Fig. 58)
.....2

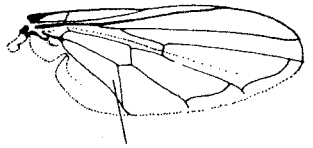


FIG.58.

- Anal cell short or absent (posterior veins may diverge towards the wing margin)
.....5

2 Wing with 2 outer cross veins (x) running parallel with the hind margin. A false vein (v) passing through the discal cross-vein (Fig. 59)
.....SYRPHIDAE (p.109)

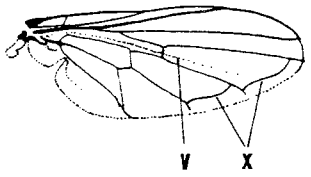


FIG.59.

- Wing without 2 outer cross veins running parallel with hind margin
.....3

3 Apical tarsal joint of the legs with two pads between the claws (Fig. 60)
.....ASILIDAE (p.107)

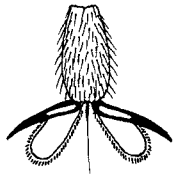


FIG.60.

- Apical tarsal joint of the legs with three pads between the claws (Fig. 61)
.....4

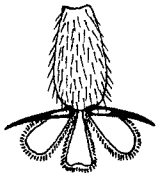


FIG.61.

4 At most, 4 veins reaching wing margin between the wingtip and the anal cell (a), but often none, as the long veins fade out before reaching the margin (Fig. 62). Usually very colourful, metallic green or coppery flies
.....STRATIOMYIDAE (p.103)

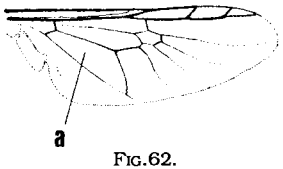


FIG.62.

- 5 veins clearly reaching the hind margin of the wing between the wingtip and the anal cell (Fig. 63: a). Dull flies, never brightly metallic; usually greyish and/or yellowish
.....RHAGIONIDAE (p.107)

FIG.63.

5 Antennae with 3 segments, the third with an apical style or dorsal arista (Fig. 64a & b)
.....6

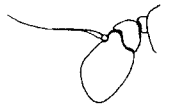


FIG.64a.


FIG.64b.

- Antennae with at least 5 segments, often long and threadlike, sometimes plumed (Fig. 65a & b)
.....7


FIG.65a.

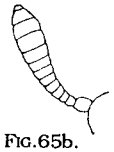


FIG.65b.

6 Alula (wing lobe) present (al) (Fig. 66)
.....15

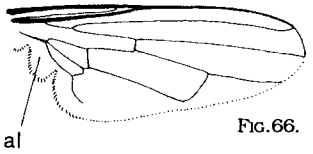


FIG.66.

- Alula absent (Fig. 67)
.....Superfamily EMPIDOIDEA(p.107)
(includes families Hybotidae, Empididae & Dolichopodidae)

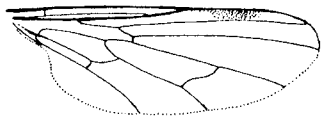


FIG.67.

7 Top of the thorax with a V-shaped suture (s) (Fig. 68)
.....8

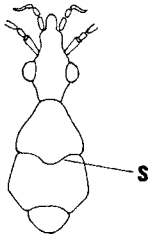


FIG.68.

- Top of the thorax smoothly domed, without a V-shaped suture
.....9

FIG.69a.

8 Anal vein short (Fig. 69b:n); ocelli present (Fig. 69a: o)
.....TRICHOCERIDAE (p.94)

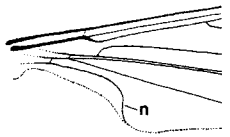


FIG.69b.

- Anal vein long (n) (Fig. 70); ocelli absent
.....TIPULIDAE (p.95)

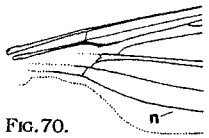


FIG.70.

9 Small, moth-like flies with pointed wings; 10-11 veins reach wing margin (Fig.71).
.....PSYCHODIDAE (p.96)

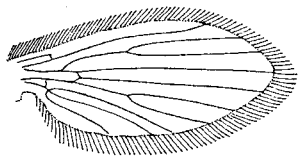


FIG.71.

- Wings rounded; with less than 10 veins reaching the wing margin
.....10

10 Tibiae (t) of the front legs ending in a long strong spine or a circlet of spines (Fig. 72)
.....BIBIONIDAE (p.100)

FIG.72.

- Tibiae of the front legs simple, having at the most fine bristles; without a long strong spine or circlet of spines
.....11

11 Wing with a conspicuous central discal cell (Fig.73:d)
.....ANISOPODIDAE (p.99)

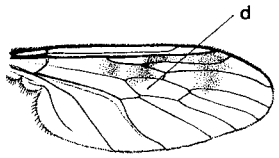


FIG. 73.

- Wing without a discal cell
.....12

12 Antennae short and compact; ocelli present (o) (Fig. 74)
.....SCATOPSIDAE (p.101)

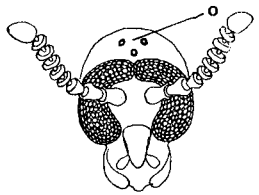


FIG.74.

- Antennae long and fine - not as illustrated above; ocelli present or absent
.....13

13 Eyes meeting on top of the head, above the antennae. Ocelli present (as in Fig. 74)
.....SCIARIDAE (p.100)

- Eyes not meeting on top of the head. Ocelli absent
.....14

Note. If the eyes do not meet on top of the head but ocelli are present, see Mycetophilidae, p.137.

14 Vein 4 forked (Fig. 75)
..CERATOPOGONIDAE (p.96)

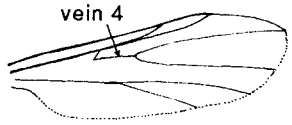


FIG.75.

- Vein 4 not forked (Fig. 76)
.....CHIRONOMIDAE (p.98)

Note. In these two families, 6 veins reach the wing margins. If only 4 or 5 reach the margin, see Cecidomyiidae, p.137.

FIG.76.

15 Hind tibiae with strong bristles (at least as long as the thickness of the tibia) in the basal 4/5 of their length (remember that the base is located at the body end)
.....16

- Hind tibiae without strong bristles in the basal 4/5 (but can have strong bristles in the apical fifth of the length)
.....20

16 Anal vein (Fig.77: n) not reaching the wing margin and the discal vein (Fig. 77: v) sometimes bending forwards towards the wing tip
.....17

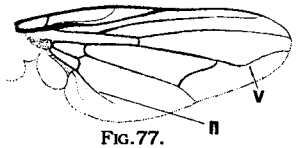


FIG.77.

- Anal vein (Fig. 78: n) reaches the wing margin and the discal vein (Fig. 78: v) always runs straight to the margin
.....19

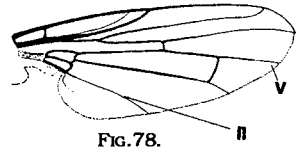


FIG.78.

17 Hypopleuron (h) with a conspicuous fan of bristles (Fig. 79b) and the discal vein (v) always angularly bent forwards towards the wing tip (Fig. 79a)
.....18

- Hypopleuron (h) without distinct bristles, usually quite bare (Fig. 80) and the discal vein usually runs straight to the wing margin (except in a few genera in which it curves forwards towards the wing tip, usually in a gentle sweep)
.....MUSCIDAE (p.118)

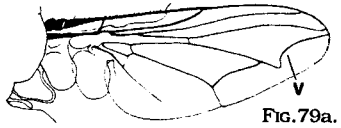


FIG.79a.

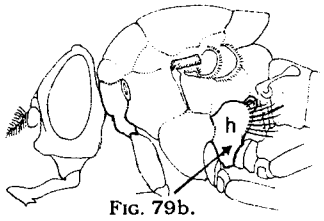


FIG. 79b.

FIG.80.

Note. In the Fanniidae (p.117) the anal vein (n) is very short, its projected course intersected by the strongly curved auxiliary vein (Fig. 81a: av). In the Muscidae these veins are more nearly parallel (Fig. 81b).

FIG. 81a.

FIG. 81b.

18 Propleural depression bare (Fig. 82: p). Black and grey flies with the abdomen conspicuously chequered (never partly metallic blue or green)
.....SARCOPHAGIDAE
(a 'casual', p.140)

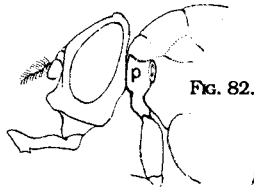


FIG. 82.

- Propleural depression (Fig. 83: p) hairy. Partly metallic green or blue flies
.....CALLIPHORIDAE
(a 'casual', p.140)

FIG. 83.

19 Thoracic squama (ts) reduced to a strip (Fig. 84). Often yellowish or greenish flies, the males clothed in long silky golden hair
...SCATHOPHAGIDAE (p.114)

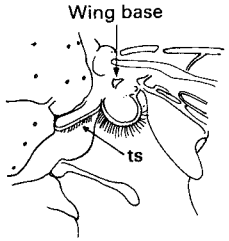


FIG.84.

- Thoracic squama (ts) an obvious membranous lobe (Fig. 85). Usually greyish or blackish flies, never clothed in long golden hairs
.....ANTHOMYIIDAE (p.115)

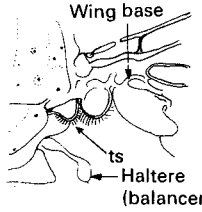


FIG.85.

20 Basal segment of the hind tarsi shorter than the next (second) segment, and often swollen. Wing never with a dark subapical spot
...SPHAEROCERIDAE (p.111)

- Basal segment of the hind tarsi longer than the second segment. Wing sometimes (but not always) with a dark subapical spot
.....21

FIG.86a.

21 Wing often with dark spot at the apex (s) but otherwise unmarked (Fig. 86a). Basal abdominal segment narrowed at the base (t) and the head of a characteristic spherical shape (in combination, they give an 'ant-like' appearance). Front legs of the male (sometimes other legs also) with teeth, spines, or other secondary sexual ornamentations (Fig. 86b). Mostly shining blackish flies
.....SEPSIDAE (p.109)

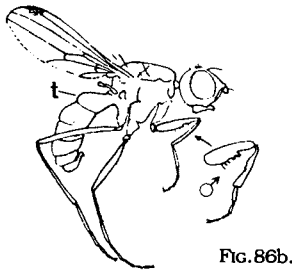


FIG.86b.

- Not agreeing with the above description
...see the *Key to Acalypterate families occurring as casuals* (p.36)

KEY TO ACALYPTERATE DIPTERAN FAMILIES OCCURRING AS CASUALS IN COW-DUNG (ADULTS)

The only acalypterate families that include species which normally develop in the dung of ungulates are the Sphaeroceridae and Sepsidae which are dealt with in the main key above. However, some of the families included in the following key may be encountered as 'casuals'. For example, grass-feeding flies will often drop onto the surface of cow-dung lying in pastures.

This key includes the families which are most likely to be encountered.

1 Anal cell extended along the anal vein into a point (Fig. 87: n)
.....OTITIDAE (p.139)

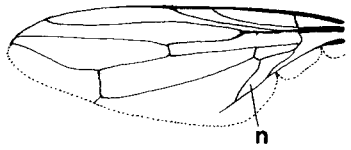


FIG.87.

- Anal cell not extended along the anal vein but with the outer edge rounded or straight; or the anal cell absent
.....2

2 Tibiae with a dorsal bristle just before the apex (Fig. 88: b)
.....3

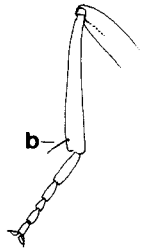


FIG.88.

- Tibiae without a dorsal preapical bristle
.....6

3 Length 5-10 mm. Yellow to deep reddish orange flies with an anal vein reaching the wing margin (Fig. 89: n)
.....DRYOMYZIDAE (p.139)

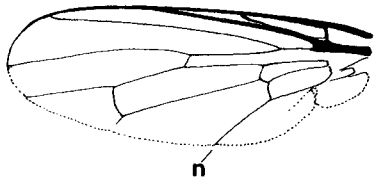


FIG.89.

- At most 5 mm in length or if slightly more then at least the thorax dark greyish and dull. Anal vein not reaching the wing margin
.....4

4 Front edge of the wing armed with long spines (Fig. 90). Very small flies, length 2-3 mm
.....TRIXOSCELIDAE (p.139)

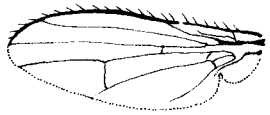


FIG.90.

Note. Members of the Heleomyzidae also have strong costal spines but are generally larger (mainly about 3-6 mm). Several genera (*eg. Aecothea* , *Tephrochlamys* and *Heleomyza*) breed in poultry manure, cess pits, etc., but have not been recorded from the dung of ungulates.

- Front edge of the wing without such long spines. Length 2-5mm
.....5

5 Costal vein (along the front edge of the wing) with two breaks in the basal half (Fig. 91a: *) and the antennal arista always with long hairs of which the apical pair form a very distinctive fork (Fig. 91b: f). Length 2-4 mm
.....DROSOPHILIDAE (p.139)

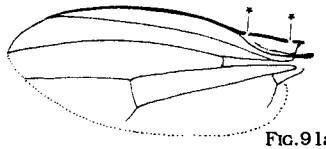


FIG.91a.

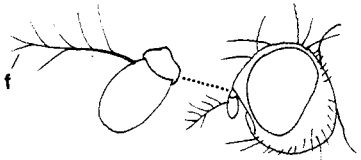


FIG.91b.

- Costal vein without any breaks and the antennal arista often bare, but if with long hairs then there is no obvious apical fork. Length 2-5 mm
.....LAUXANIIDAE (p.138)

6 No anal cell (Fig. 92)
.....7

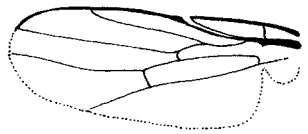


FIG.92.

- Anal cell present
.....8

7 Antennal arista with long hairs on the upper side (Fig. 93: h). Ocellar triangle not particularly large. Length mainly 2-5 mm
.....EPHYDRIDAE (p.138)

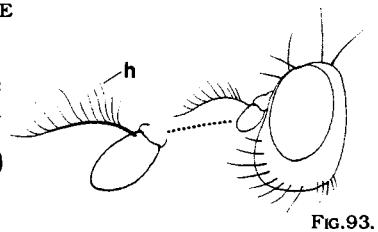


FIG.93.

- Antennal arista without long hairs. Ocellar triangle very large and conspicuous (Fig. 94: o). Length mainly 1-4 mm
.....CHLOROPIDAE (p.138)

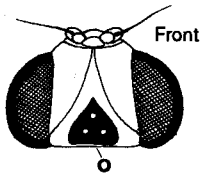


FIG.94.
Top view of head

8 Front femur with a conspicuous ventral spine which is obviously stouter than any other femoral hairs (Fig. 95: v). Length mainly 2-3 mm
.....ANTHOMYZIDAE (p.139)

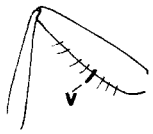


FIG.95.

- Front femur without such a spine. Length 2-5mm
.....9

9 Wings clear, unmarked
.....10

- Wings with dark clouds over at least the discal cross vein, the wing tip and part of the front edge (Fig. 96 a & b). Length mainly 2-4 mm
.....OPOMYZIDAE (p.138)

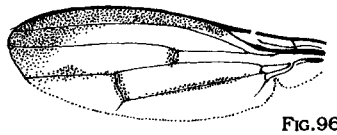


FIG.96a.

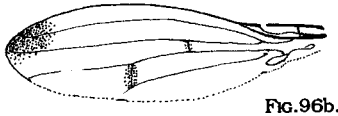


FIG.96b.

10 Always shining blue-black flies with discal cross vein (Fig. 97: d) often located in the outer half of the wing (but not always) and separated from the wing margin by (at the most) its own length. Generally larger flies, mainly 3-5 mm in length
.....LONCHAEIDAE (p.138)

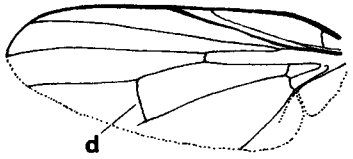


FIG.97.

- Colour very variable, yellow or grey to black. Discal cross vein sometimes absent (Fig. 99); when present, often before the middle of the wing, separated from the wing margin by more than its own length (Fig. 98: d). Generally smaller flies, mainly 2-3 mm in length
.....AGROMYZIDAE (p.138)

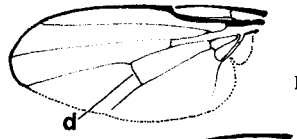


FIG.98.

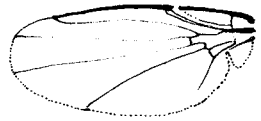


FIG.99.

KEY TO FAMILIES OF DIPTERA OCCURRING IN COW-DUNG (LARVAE)

Note. In all of the illustrations in this key the heads point to the left.

1 Dull, heavily sclerotised, flattened larvae with a conspicuous, non-retractile head capsule. Anal spiracles in a fissure on the anal segment. Body with many conspicuous bristles and often distinctly marked (Fig. 100)
.....STRATIOMYIDAE (p.103)

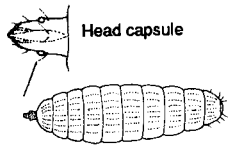


FIG.100.

- Never with the combination of characters described above
.....2

2 Head capsule complete (totally hardened - usually darkly pigmented), sometimes retractile; mandibles strike horizontally
.....3

- Head capsule usually incomplete (some parts appearing soft and fleshy) and retractile; mandibles strike vertically
.....11

3 Head capsule retractile (if uncertain watch a live specimen). Large larvae (up to 25 mm) (Fig. 101) ..TIPULIDAE (leatherjackets) (p.95)


FIG.101.

- Head capsule not retractile. Small larvae, less than 15 mm
.....4

4 False (pro-) legs on the prothorax (the first segment behind the head) and on the anal segment. Very small larvae; less than 5mm long
.....5

- False (pro-) legs absent; larvae sometimes longer than 5mm (but not always)
.....6

5 Body quite smooth **and** thoracic prolegs present (Fig. 102: p)
.....CHIRONOMIDAE (p.98)

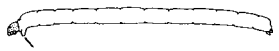


FIG. 102.

- Body with conspicuous bristly hairs on all segments (in which case thoracic prolegs may be present: Fig. 103) **or** body smooth and thoracic prolegs are absent
..CERATOPOGONIDAE (p.96)

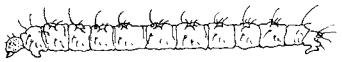


FIG. 103.

6 10 pairs of spiracles, the anal ones not on paired processes (Fig. 104)
.....BIBIONIDAE (p.100)

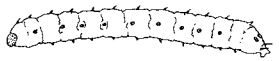


FIG. 104.

- With less than 10 pairs of spiracles, or the anal ones on paired lobes
.....7

7 Very small rather hairy inactive larvae with anal spiracles on cylindrical processes (Fig. 105). Length up to 5 mm
.....SCATOPSIDAE (p.101)


FIG. 105.

- Not with the combination of characters described above
.....8

8 Anal segment with a short non-retractile respiratory tube and the body usually with distinct darkened plates on each segment (Fig. 106). Length up to about 5 mm
.....PSYCHODIDAE (p.96)


FIG. 106.

- Without the combination of characters described above
.....9

9 Abdominal segments divided into three approximately equal parts by transverse furrows. Anal segment in posterior view (pv) with 4 lobes around the anal spiracle (Fig. 107)
.....TRICHOCERIDAE (p.94)

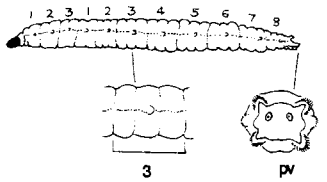


FIG. 107.

- Without the combination of characters described above
.....10

10 Abdominal segments 2-6 divided by transverse furrows into 2 unequal parts each, and the anal spiracular area of the last segment (pv) with 5 lobes. Very slender worm-like larvae (Fig. 108)
.....ANISOPODIDAE (p.99)

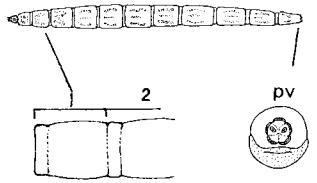


FIG. 108.

- Abdominal segments not as above and the anal spiracular region without lobes (Fig. 109)
.....SCIARIDAE (p.100)


FIG. 109.

Note. If the specimen is very slender and worm-like with a circlet of long hairs on the last segment, see *Culicoides* (Ceratopogonidae, p.96).

11 Head distinct, sclerotised at least above and with well developed, though often very short, antennae
.....12

- 'Acephalous' (headless) larvae, with the sclerotised parts of the head being restricted to the internal mouthparts
.....13

12 Anal segment with spiracles in a deep concavity surrounded by 5 processes (Fig. 110)
.....RHAGIONIDAE (p.107)

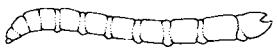


FIG. 110.

- Anal segment rounded behind though usually with longitudinal fluting on the sides (Fig. 111)
.....Superfamily EMPIDOIDEA (p.107)

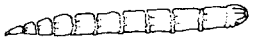


FIG. 111.

13 Anal spiracles (a) on processes which are fused and the body with numerous plumed spines at the hind end (Fig. 112)
.....SYRPHIDAE
(*Rhingia campestris*) (p.109)

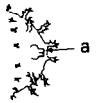


FIG. 112.

- Not as described above
.....14

14 Body rather flattened dorsoventrally (top-to-bottom) with long plumed or branched spines arranged in longitudinal rows (Fig. 113)
.....FANNIIDAE (p.116)


FIG. 113.

- Body never with such spines
.....15

15 Anal spiracles (a) on long and divergent processes (Fig. 114)
.....SEPSIDAE (p.109)

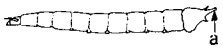


FIG. 114.

- Anal spiracles either without processes or on short processes at the most
.....16

16 Larval mouthparts with oral bars (o), or, if the oral bars are absent, then anal spiracles have snake-like slits (Fig. 115: s). No peripheral lobes around the anal spiracular field
.....MUSCIDAE (p.118)

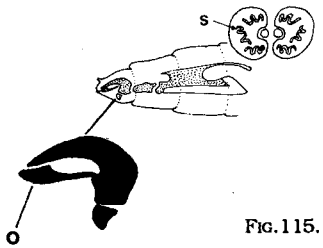


FIG. 115.

- Oral bars absent. Anal spiracular slits never snake-like. Anal segment often with lobes (1) (see Fig. 116 below) around the anal spiracular field
.....17

17 Without lobes in the region of the anal spiracular field. Length up to 6 mm
...SPHAEROCERIDAE (p.111)

- Larvae with conspicuous peripheral lobes around the anal spiracular field (Fig. 116: 1). Length sometimes greater than 6mm
.....18

18 Body covered in conspicuous tiny black spines giving a blackish tinge to the skin when viewed with the naked eye (Fig. 116).
..SCATHOPHAGIDAE (p.114)

- Body never covered in such black spines though much finer pale ones may be present
.....ANTHOMYIIDAE (p.115)

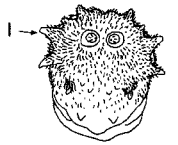


FIG. 116.

Note Larvae, or more often puparia, of Oestridae (Fig. 118) and Gasterophilidae (Fig. 117) may occasionally be found in dung, the latter family only in horse-dung. The larvae are internal parasites which may drop to the ground during defaecation by the host. Although spectacular in appearance, their presence is purely by chance and they play no obvious part in the cow-dung community (see pp. 113 & 114).


FIG. 117.


FIG. 118.

Order HYMENOPTERA (wasps and ants)

The Hymenoptera which are primarily associated with dung are those whose larvae are parasitic on the immature stages of coprophilous insects. However, foraging Hymenoptera, seeking provisions for their young, commonly visit dung and one sphecid (or digger) wasp (*Mellinus arvensis* , see couplet 4 below) is a very familiar attendant on cowpats for this purpose. Ants (Formicidae) are also very often seen in old cowpats.

KEY TO FAMILIES OF HYMENOPTERA (ADULTS)

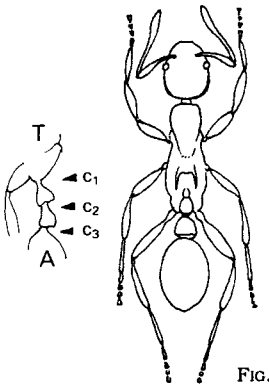


FIG. 119.

1 "Waist" with 2 or 3 deep constrictions (c) between the thorax (T) and the abdomen (A) (Fig. 119). Usually wingless
..FORMICIDAE (ants) (p.129)

Note. The terms "thorax" and "abdomen" used here for locating the "waist" are used for convenience only. The correct terms in Hymenoptera are *alitrunk*, *gaster* and *petiole* respectively.

- "Waist" (between the thorax and the abdomen) never with more than one deep constriction. Normally winged, but the females can be wingless - see below
.....2

2 Wingless insects
.....*Not keyed out here*
(see the note below)

Note . Wingless females are very difficult to identify. Only the males, and winged females can be named using this key.

- Winged insects
.....3

3 Hind wing with an anal lobe (an) (Fig. 120). Robust, conspicuously marked black and yellow species with wing venation as shown in Fig. 120. Antennae with at most 13 segments
.....4

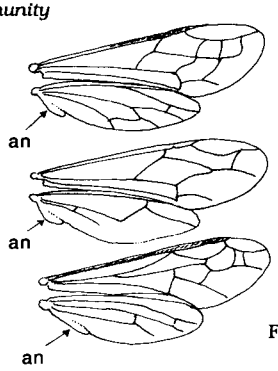


FIG. 120.

- Hind wing without an anal lobe or antennae with more than 13 segments (usually far more) Usually small, more slender insects of various colours (often brownish or blackish). Wing venation usually simple
.....5

4 Wing venation as shown opposite (Fig. 121a). Abdomen abruptly widened after waist (Fig. 121b)
.....VESPIDAE
(social wasps) (p.129)

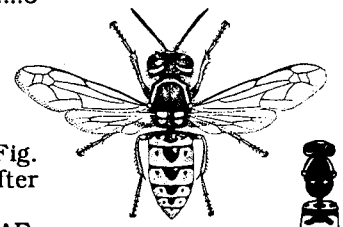


FIG. 121a.

FIG. 121b.

- Wing venation as shown below (Fig. 122 a & b). Abdomen gently widening after waist (Fig. 122c)
.....SPHECIDAE
(digger wasps) (p.130)


FIG. 122c.

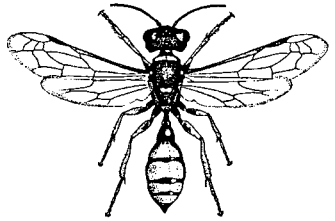


FIG. 122a.

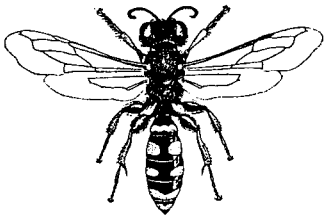


FIG. 122b.

5 Wing venation complex, covering most of the forewing. Hind wing with distinct veins
.....6

- Wing venation simple, with veins mainly restricted to the front margin of the forewing, or absent; hind wings with, at the most, very faint veins
.....7

FIG. 123.

6 Two discoidal cross-veins on the forewing (d) (Fig. 123)
....ICHNEUMONIDAE (p.130)

- One discoidal cross-vein on the forewing (Fig. 124: d)
.....BRACONIDAE (p.131)

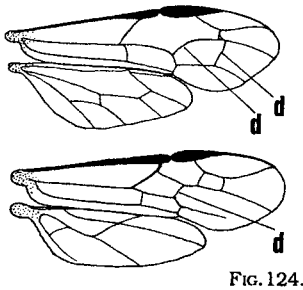


FIG. 124.

7 Wing venation as shown in Fig. 125. Body often metallic
.....PTEROMALIDAE (p.133)

FIG. 125.

- Wing venation otherwise. Body never metallic
.....8

8 Forewing with a large radial cell (Fig. 126: r)
.....9

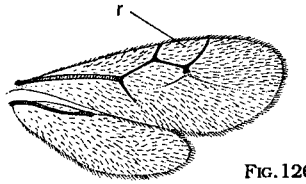


FIG. 126.

- Forewing with a minute radial cell (Fig. 127: r), or radial cell missing completely
.....10

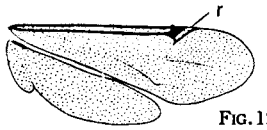


FIG. 127.

9 Scutellum (s) with a cup-like or plate-like structure on the upper surface. (The scutellum is on the upper hind edge of the thorax, before the waist) (Fig. 128)
.....EUCOILIDAE (p.121)

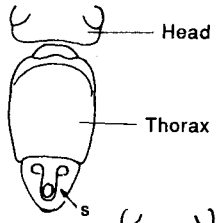


FIG. 128.

- Scutellum (Fig. 129: s) without such a structure
.....FIGITIDAE (p.135)

FIG. 129.

10 Forewings with a minute radial cell (r) which is, at the most, as long as the stigma (s) (Fig. 130)
...PROCTOTRUPIDAE (p.136)

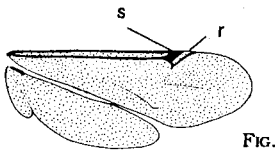


FIG. 130.

- Forewings without a radial cell and often without any obvious venation
.....DIAPRIIDAE (p.136)

NOTES
(Key continued opposite)

PART TWO

KEYS TO GENERA AND SPECIES OF INSECTS ASSOCIATED WITH THE DUNG OF UNGULATES

Note. Users of this habitat-based key must recognise the distinct possibility that other families/genera/species may occur as casuals. These could not all be predicted during the preparation of this work and must be identified by means of the standard taxonomic works in the list of References.

ORDER COLEOPTERA

Family CARABIDAE (ground beetles)

A large family of very active predatory soil insects of which several species have been recorded from the dung of herbivorous mammals. None, however, belongs to the dung community being merely casual marauders from adjacent biotopes. Both larvae and adults (*eg.* Fig. 131a & b) may occur in dung. See Lindroth (1974) and Forsythe (1987) for further details of biology and identification.

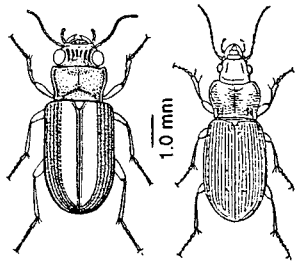


FIG. 131.

Family HYDROPHILIDAE

A large family of mainly aquatic beetles. Four genera commonly occur in dung. These include some of the most abundant dung insects. Both larvae and adults of *Sphaeridium* and *Cercyon* may be found.

Table 1 (p.54) gives the size ranges of dung-frequenting adults of the Hydrophilidae; this can be used if a precise means of measuring (*eg.* microscope graticules, etc.) is available.

Key to genera of dung-frequenting Hydrophilidae (adults)

Note. Having identified the specimen using the following key, refer to the confirmatory descriptions in the following sections.

1 Generally larger species; length 4-7.5 mm. Without elytral striae (*ie.* no orderly series of punctures extending the full length of the elytra) (Fig. 132)
.....*Sphaeridium* (p.50)

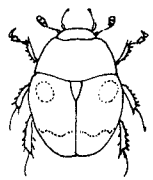


FIG. 132.

- Generally smaller species; length 1-4.5 mm. With distinct elytral striae
.....2

2 Front tibiae (t) deeply notched in the apical half (Fig.133). Very small; length 1.5-2mm
.....*Megasternum* (p.51)

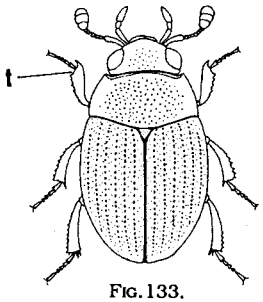


FIG. 133.

- Front tibiae not notched as above
.....3

3 Upper surface of body covered with very short fine hairs. Length 1.6-2.2 mm (Fig. 134)
.....*Cryptopleurum* (p.51)

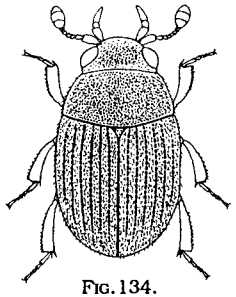


FIG. 134.

- Upper surface of body entirely without hairs. Length 1-4.5 mm
.....*Cercyon* (p.51)

Genus *Sphaeridium*
The largest dung-frequenting Hydrophilidae found in Britain belong in this genus; these are unmistakable because of the strongly contrasting pale elytral apices and usually conspicuous red elytral spots although one species (*S. lunatum*) often lacks these. The predaceous larvae are very maggot-like, except for their short thoracic legs and strong mandibles (Fig. 135). *S. scarabaeoides* is generally the most abundant of the three British species, the adults of which are distinguished as follows:


FIG. 135.

FIG. 136.

1 Hind edge of the pronotum strongly curved (view from directly above) (Fig. 136)
.....*S. bipustulatum*

- Hind edge of the pronotum slightly curved (Fig. 137)
.....2

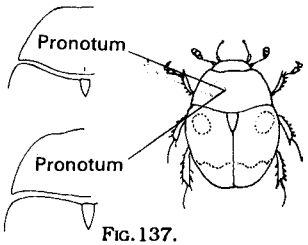


FIG. 137.

2 Side margins of the pronotum entirely black. Elytra often without reddish patches towards the base
.....*S. lunatum*

- Side margins of the pronotum at least partly reddish. Elytra always with reddish patches near the base
.....*S. scarabaeoides*

Genus *Megasternum*
The single British species, *M. obscurum* , is a very small, rather shiny blackish or dark reddish beetle closely resembling a small *Cercyon* but with the front tibiae (t) characteristically notched (Fig. 138). It often occurs in great profusion with *Cerycon* species and has a very similar biology. However, it is by no means restricted to dung, occurring in all manner of decaying vegetable matter. Size 1.5-2mm.

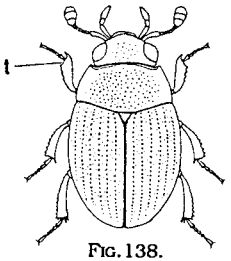
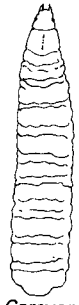


FIG. 138.

Genus *Cryptopleurum*
Very small blackish to reddish beetles of very similar shape and appearance to *Cerycon* and *Megasternum* but much duller due to a dense covering of short hairs. *C. minutum* is usually mainly or entirely black and rather smaller than the much less common *C. crenatum*. *C. subtile* , a generally dull reddish species, is perhaps merely a casual invader of cow-dung. Size 1.6-2.2mm.

Genus *Cercyon*
Very small to medium sized black or partly reddish or yellowish, convex beetles, some of which are amongst the commonest beetles occurring in dung. The larvae resemble those of *Sphaeridium* but are legless (Fig. 139). The species keyed out below are those generally associated with dung (as their primary habitat) but it is possible that others may occur as casuals.


Cercyon larva
FIG. 139.

1 Palpi (p) entirely black and the elytral interstices (the areas between the longitudinal series of punctures or striae) are clearly punctured (i) (Fig. 140). Length 2.5-4.2 mm
.....2

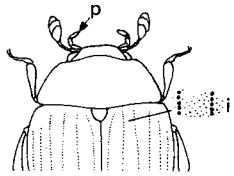


FIG. 140.

- Palpi at least partly pale; if mainly blackish then the elytral interstices are hardly punctured. Length 1.2-3.2 mm
.....5

2 Elytra evenly rounded at the sides (Fig. 141). Black species, sometimes paler towards the elytral apex. Length 3.5-4.2 mm
.....*C. lugubris*

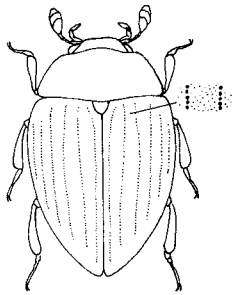


FIG. 141.

- Elytra not evenly rounded at the sides. Mainly black and reddish species. Length 2.5-4 mm
.....3

3 Base of the pronotum with a very short, weak central groove (g). Elytra widest near the base. Black with the elytral apex reddish, or elytra reddish with vague blackish suffusion over the scutellum (s) (Fig. 142). Length 3-4 mm
.....*C. atomarius*

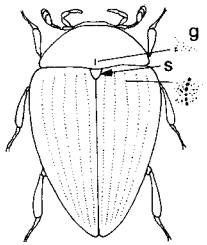


FIG. 142.

- Base of the pronotum without such a groove. Elytra widest nearer the middle. Elytra can be reddish or blackish. Length 2.5-3.2 mm
.....4

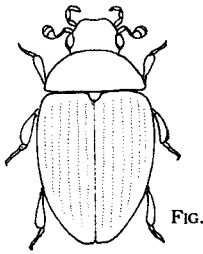


FIG. 143.

4 Elytral epipleura (extreme outer edge of the elytra) pale. Elytra all blackish or the apex slightly reddish; rarely entirely reddish (Fig. 143)
.....*C. haemorrhoidalis*

- Elytral epipleura dark. Elytra mainly reddish with a triangular black patch over the scutellar area (Fig. 144)
.....*C. melanocephalus*

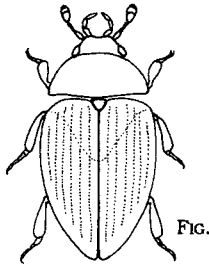


FIG. 144.

5 Elytra pointed towards the apex and blackish in the basal half or more; elytral interstices with very fine cross-reticulations (best seen when illuminated from in front) (Fig. 145). Length 1.7-2.4 mm
.....*C. analis*

- Not as above
.....6

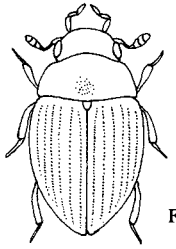


FIG. 145.

6 Pronotum entirely black and the elytra with, at the most, the hindmost half reddish. Pronotum finely punctured. Length 1.2-1.7 mm (Fig. 146)
.....*C. pygmaeus*

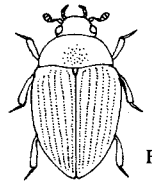


FIG. 146.

- Pronotum at least partially reddish along the sides and finely or densely punctured. Length 1.3-3.2 mm
.....7

7 Length 1.3-1.7 mm. Pronotum finely punctured
.....*C. atricapillus*

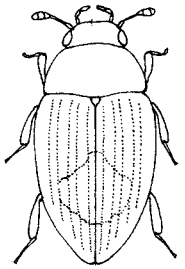
- Length 1.7-3.2 mm. Pronotum densely punctured
.....8

8 Length 1.7-2.0 mm
.....*C. terminatus*

- Length 2.1-3.2 mm
.....9

9 Elytra clear yellowish in contrast to the mainly black pronotum. Length 1.9-2.6 mm
.....*C. quisquilius*

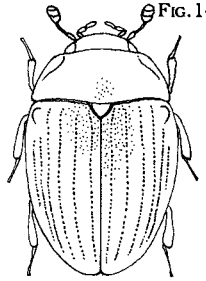
FIG. 147.



- Elytra rarely entirely clear yellowish. Length 2.4-3.2mm
.....10

10 Elytra yellowish with a dark central patch (Fig. 147)
.....*C. unipunctatus*

FIG. 148.

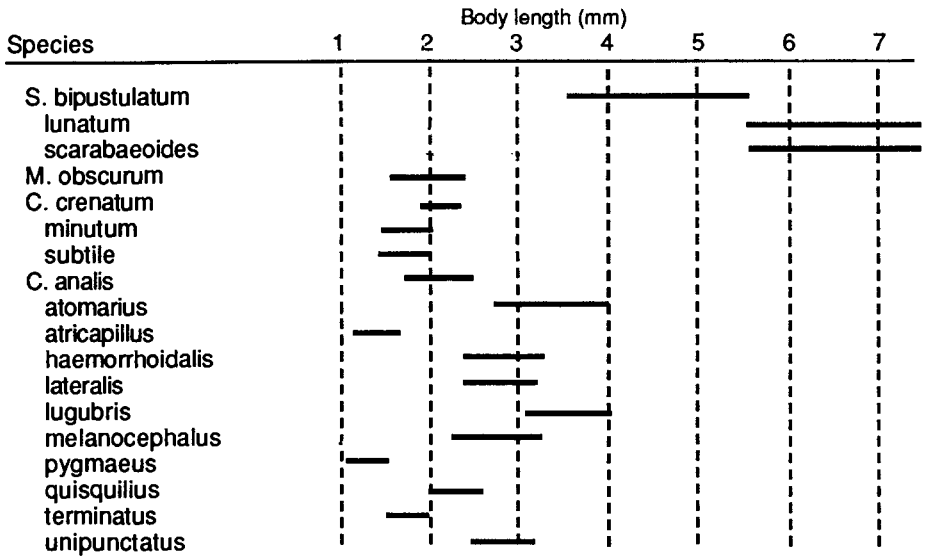


- Elytra dark reddish, paler apically; pronotal sides gradually paler (Fig. 148)
.....*C. lateralis*

Note . The most generally abundant species in cow-dung are *atomarius*, *haemorrhoidalis*, and *melanocephalus*. The last named is generally distinguished by the conspicuous red elytra with the black triangular patch at the base. The other two are typically rather larger and more uniform in colour. The basal pronotal groove in *atomarius* is usually very short and fine but fairly clear. *C. unipunctatus* is usually very distinct because of the red elytra with the one central dark spot, whilst *C. quisquilius* is usually unmistakable because of the pale yellow rather than reddish elytra, contrasting with the black pronotum.

Table 1 gives size ranges for the dung-frequenting members of the Hydrophilidae. It should help in their identification if graticules or other fairly precise means of measuring are available.

TABLE 1. Size ranges in dung-frequenting Hydrophilidae (adults)



Family HISTERIDAE (histerid beetles)

In Britain the members of this family which occur in herbivore dung are insufficiently common to play anything more than a very minimal part in the dung community. Both adults and larvae are predatory on the larvae of flies and beetles. Five British genera contain species which may be found in herbivore dung; adults can be distinguished using the following key. For identification of British species see Halstead (1963).

1 Length 1.8-2.4 mm. Dull, entirely heavily sculptured (Fig. 149)
.....*Onthophilus* (p.55)

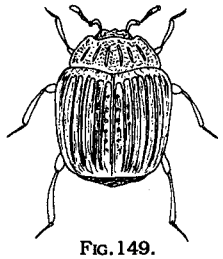
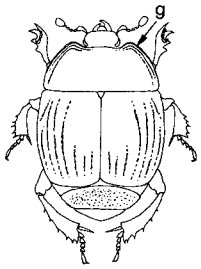


Fig. 149.

- Length 3.5-11mm. Shiny
.....2



2 Front angle of the pronotum with 3 grooves (Fig. 150: g). Often much larger species, length 3.5-11 mm
.....*Hister* (see below)

- Front angle of the pronotum with one or two grooves. Length 3.5-6mm
.....3

Fig. 150.

3 Front margin of the pronotum with only one complete groove (*ie.* running parallel to the actual front edge as in *Hister*). Length 4-6mm.
.....*Paralister* (p.56)

- Front margin of the pronotum with 2 complete grooves running parallel with the actual front edge. Length 3.5-4.5mm
.....4

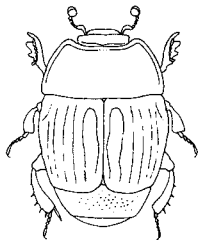


Fig. 151.

4 Entirely black (Fig. 151)
.....*Atholus* (p.56)

- Black with a red spot on each elytron
.....*Peranus* (p.56)

Genus *Onthophilus*
O. striatus is a small dull black beetle of quite unmistakable appearance due to its distinctive form and very characteristic sculpture (Fig.152). It is fairly common in horse-dung but not known from other dung types. Length 1.8-2.4mm. The smallest British dung-frequenting histerid.

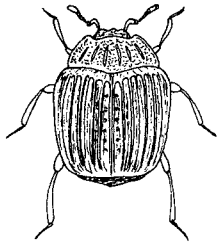


Fig. 152.

Genus *Hister*
Included here are the largest members of the family and the three species which are recorded from herbivore dung can be distinguished using the key below.

1 Length 3.5-6.5mm
.....*H. bissexstriatus*

- Length 8-11mm
.....2

2 Entirely black (Fig. 153)
.....*H. unicolor*

- Elytra with bright red spots
.....*H. quadrimaculatus*

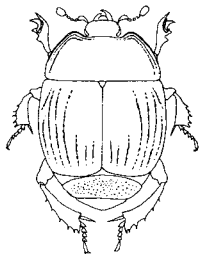


FIG. 153.

Note. *H. quadrimaculatus*, our most spectacular British histerid, is extremely rare.

Genus *Paralister*
P. carbonarius closely resembles *H. bissexstriatus* but has only 2 grooves by the front pronotal angle. In both species the elytra are entirely black, but in *P. purpurescens* - a second species found in cow-dung - the elytra may be reddish centrally. Length 4-6mm.

Genus *Atholus*
A. duodecimstriatus is an entirely black species with 6 distinct complete longitudinal striae on each elytron (*ie.* 12 altogether, hence the name 'duodecimstriatus') (Fig. 154). Length 3.5-4.5mm.

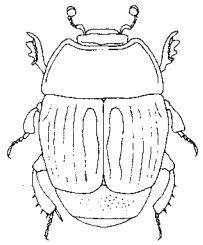


FIG. 154.

Genus *Peranus*
P. bimaculatus resembles *A. duodecimstriatus* in general form and appearance but there is a red spot on each elytron. Length 3.5-4.5mm.

Family PTILIIDAE (feather-wing or pygmy beetles)

This family is usually represented only in older dung in which moulds and other fungi are developing. The beetles are characterised by their minute size, ranging from about 0.5-1.2 mm, and feather-like wings. They include our smallest Coleoptera. The genera recorded from dung should be distinguishable from one another by reference to the illustrations below although the more critical ones require specialist examination at high magnification and excellent illumination. The most distinctive genera are *Ptenidium* and *Acrotrichis*, and they are also by far the most frequently encountered. Identification to species level is only possible in these genera by reference to genitalic characters and is best left to the specialist. For details of extraction of spermathecae see under *Atheta* and related genera, p.78.

Genus *Ptenidium*
Members of this genus are characterised by the 4 large pores (p) along the base of the pronotum (Fig. 155). *P. pusillum* (0.9-1.2mm) is larger than *P. nitidum* (0.7-0.8mm) and has a tiny longitudinal keel between the middle pair of pronotal pores. Both species are shiny black, slightly paler towards the elytral apex, and are quite common in old cow-dung.

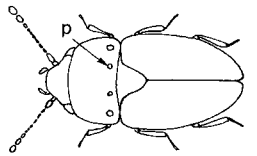


FIG. 155.

Genus *Ptiliola*
P. kunzei is a minute dark brown beetle with a pale outer margin to the elytra and a very tiny tooth on the front outer angle of the elytra (Fig. 156). Length 0.50-0.55 mm.

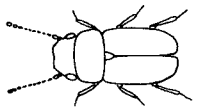


FIG. 156.

Genus *Ptiliolum*
P. fuscum is rather like the preceding species but is larger and lacks the tooth on the outer front angle of the elytra (Fig.157). Length 0.60-0.65 mm.

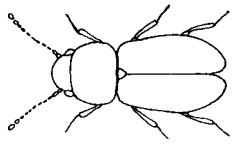


FIG. 157.

Genus *Nephanes*
N. titan is usually regarded as our smallest beetle. The elytra are more truncate (*ie.* appearing to be cut short), than in the preceding genera (Fig. 158). Length, 0.5 mm maximum.

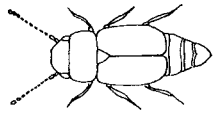


FIG. 158.

Genus *Baeocrara*
B. variolosa resembles the next genus (*ie. Acrotrichis*) but is punctured and the hind angles of the pronotum are right-angular, not acute. Length 0.75-0.80 mm. Scarce.

Genus *Acrotrichis*
A large genus including some of the commonest members of the family; closely resembling each other in the very characteristic shape, but differing in the structure of the female spermathecae (Fig.159a). In life, the last 3 to 4 abdominal segments project beyond the elytral apices (Fig. 159b). Length 0.65-1.12 mm.

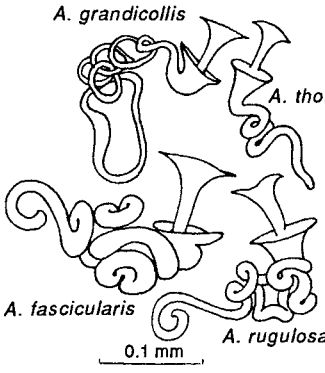


FIG. 159a.
Spermathecae

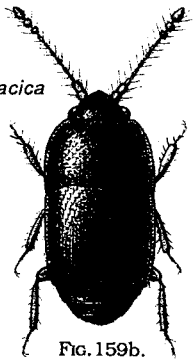


FIG. 159b.

Family STAPHYLINIDAE (rove beetles)

A large and very important family of predatory beetles including some of the most abundant members of the dung community. The identification of many of the genera, notably those belonging to the subfamily Aleocharinae, is best left to the specialist. Ecologically, the genus *Aleochara* is particularly interesting in that the larvae are internal parasites of dipteran puparia.

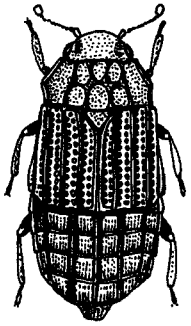


FIG. 160.

1 Head, pronotum, elytra and abdominal tergites very heavily sculptured (Fig. 160). Length 2.5-3mm.
.....(subfamily Micropeplinae: Genus *Micropeplus*) p.63

- Never with heavy sculpturation on **all** of the body structures listed above
.....2

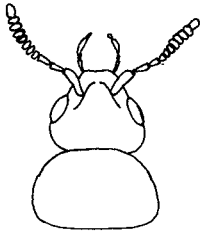


FIG. 161.

2 When the head is viewed from directly above, the antennae are seen to arise from behind the front margin of the head, level with (and between) the front margins of the eyes (Fig. 161). Length usually less than 5 mm, and never over 8 mm
.....(subfamily Aleocharinae).....19

- When the head is viewed from directly above, the antennae are seen to arise from either between the outer basal corners of the mandibles or from the sides of the head in front of the eyes (see Figs. 162 & 163 opposite). Pronotum often with longitudinal furrows running its entire length or with a series of large paired punctures down the middle. Length 1.5-28 mm
.....3

3 When viewed from directly above, the antennae arise from the sides of the head, outside the outer basal corners of the mandibles (Fig. 162). Length 1.5-9.0 mm
.....4

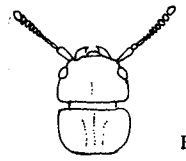


FIG. 162.

- When viewed from directly above, the antennae arise from between the inner basal corners of the mandibles (Fig. 163). Length 2-28 mm
.....12

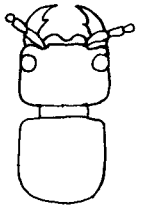


FIG. 163.

4 Vertex of the head (between the hind inner corners of the eyes when viewed from above) with a pair of ocelli (Fig. 164: o). Length 2-3 mm
.....(subfamily Omaliinae).....5

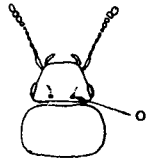


FIG. 164.

- Vertex without ocelli
..... 7

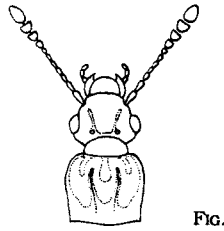


FIG. 165.

5 Pronotum with 2 deep longitudinal furrows (Fig. 165) . Length 2.5-3.5mm
.....*Omalium* (p.64)

- Pronotum without such impressions
.....6

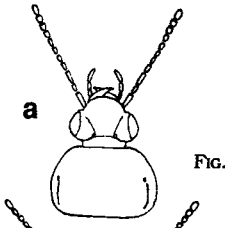


FIG. 166.

6 Pronotum with a pore near the middle of each side margin and a slight impression in each hind angle (Fig. 166). Length 3 mm
.....*Deliphrum* (p.64)

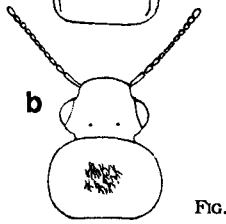


FIG. 167.

- Pronotum without such pores and impressions but with highly characteristic sculpture (Fig. 167). Length 2 mm
.....*Acrolocha* (p.64)

7 Last abdominal segment armed with strong pointed teeth (Fig. 168). Length 5-9 mm
.....(subfamily Tachyporinae)
Tachinus (p.73)


Fig.168.

- Last abdominal segment without such teeth
.....8

8 Hind angles of the pronotum incised (Fig. 169)
.....(subfamily Proteininae)
Megarthrus (p.63)

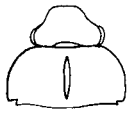


Fig.169.

- Hind pronotal angles not incised
.....(subfamily Oxytelinae)..... 9

9 Pronotum with one deep central longitudinal furrow (Fig. 170)
.....*Platystethus* (p.65)

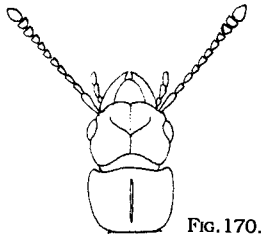


Fig.170.

- Pronotum with at least 2 longitudinal impressions
.....10

10 Pronotum with 2 short impressions near the middle (Fig. 171)
.....*Aploderus* (p.64)

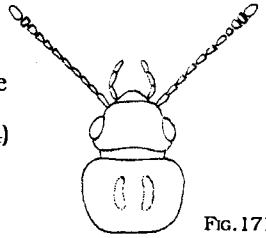


Fig.171.

- Pronotum with 3-5 long impressions (Fig. 172)
.....11

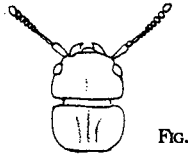


Fig. 172.

11 Basal antennal segment strongly narrowed before the apex (Fig. 173)
.....*Oxytelus* (p.66)

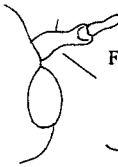


Fig.173.

- Basal antennal segment not narrowed before the apex (Fig. 174)
.....*Anotylus* (p.65)

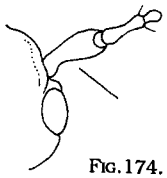


Fig.174.

12 Distance between the antennal bases less than between one of them and adjacent eye margin (Fig. 175)
.....(subfamily Xantholininae)..... 13

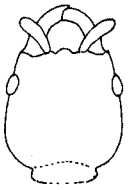


Fig.175.

- Distance between the antennal bases greater than between one of them and adjacent eye margin (Fig. 176)
.....(subfamily Staphylininae) 15

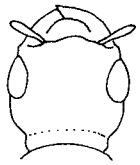


Fig.176.

13 Length 4-5 mm. With a characteristic transverse shagreenation (microsculpture) on the pronotum. Neck only as wide as the length of the basal antennal segment (Fig. 177)
.....*Leptacinus* (p.66)

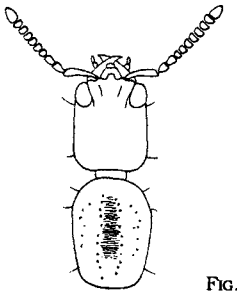


Fig.177.

- Length 5-14 mm. Neck obviously wider than the basal antennal segment
.....14

14 Length 10-14 mm. Shining black species with bright orange elytra
.....*Xantholinus* (p.67)

- Length 5-8 mm. Mainly blackish
.....*Gyrohypnus* (p.66)

15 Upper surface with sparser hairs never forming a pattern. Length 5-16 mm
.....16

- Upper surface covered with dense short hairs giving a spectacular pattern and largely hiding the cuticle; beautifully marked species. Length 10-28mm
.....17

16 Length 5-16 mm. Head not longer than broad and the pronotum with **either** less than 6 **or** more than 6 pairs of punctures down the middle.
.....*Philonthus* (p.67)

- Length 4.5-5 mm. Head distinctly longer than broad and the pronotum with 6 pairs of punctures down the middle.
.....*Gabrius* (p.72)

17 Very spectacular black species with the head, most of the pronotum and the apical half of the abdomen covered in dense long golden hair and the elytra patterned with light grey "fur" (Fig. 178). Length 18-28 mm
.....*Emus* (p.73)

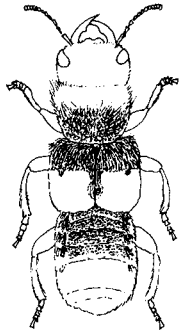


FIG. 178.

- Never patterned as above. Length 12-19mm
.....18

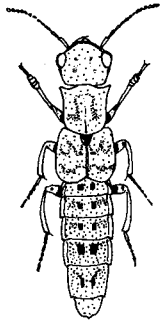


FIG. 179.

18 Pronotum with sharply pointed front angles (Fig. 179). Length 14-19 mm
.....*Ontholestes* (p.72)

- Pronotum with bluntly rounded front angles (Fig. 180). Length 12-17 mm
.....*Platydracus* (p.73)

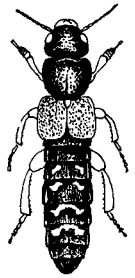


FIG. 180.

19 Highly characteristic shape, having a globular head, narrow neck and distinct waist between both the pronotum and the elytra and between the elytra and the abdomen (Fig. 181). Length 1.5-2.5 mm
.....*Autalia* (p.75)

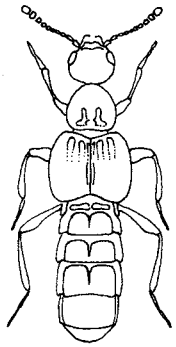


FIG. 181.

- Shape and sculpture never as above
.....20

20 All tarsi with 5 segments. The front- and mid-tibiae with numerous tiny spines (Fig. 182a: o) and the metapleurae (Fig. 182a: m)(thoracic side plates - see the glossary, p.157) projecting beyond the hind angles of the elytra when viewed from above (Fig. 182b: e). In life, the head is slightly retracted into the pronotum and therefore its hind edge is not visible when viewed from above
.....*Aleochara*
(and *Tinotus morion*)(p.76)

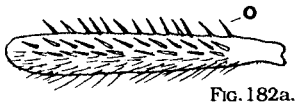


FIG. 182a.

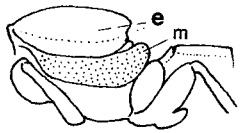


FIG. 182b.

- Not as above; tibiae without stout spines (though they may have bristles (Fig. 183a: o). Metapleurae (Fig. 183b: m) not projecting beyond the hind angle of the elytra (Fig. 183b: e)
.....*Atheta*
and related genera (p.78)

FIG. 183a.

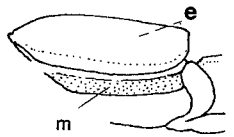


FIG. 183b.

Genus *Micropeplus*
A small genus of beetles of unmistakable appearance and dull brownish to blackish colour. They feed on fungal mycelia in rotting compost, manure, etc. *M. porcatus* has been recorded from the dung of unspecified ungulates.

Genus *Megarthrus*
The beetles of this genus are unmistakable due to the highly characteristic shape of the pronotum in which the hind angles are incised (*ie.* it looks as if a tiny piece has been cut out of each hind corner). No other British beetles share this peculiar feature. Of the 5 British species, 2 occur commonly in dung; they are distinguished as follows:-

1 Dark beetles. The basal segment of the antennae dark. Coarse pronotal scupture. Male hind tibia with a peculiar incurved apical outer process (Fig. 184: p)
.....*M. depressus*

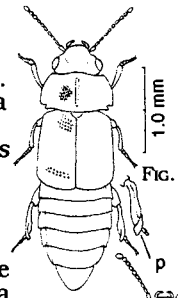


Fig. 184.

- Extensively reddish beetles. The basal segment of the antennae red. Fine pronotal sculpture. Male hind tibia without an apical process as described above but with a preapical constriction instead (Fig. 185: c)
.....*M. denticollis*

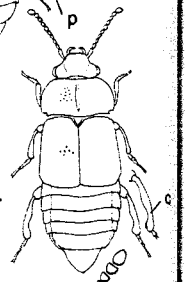


Fig. 185.

Genus *Omalium*
O. rivulare, the commonest of the thirteen British species, occurs in a wide variety of decaying plant and animal material and has been recorded (rarely) from ungulate dung (Fig. 186).

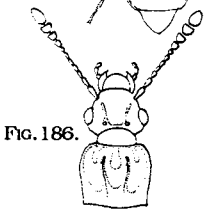


Fig. 186.

Genus *Deliphrum*
D. tectum, our only species, is a small, very shiny black beetle with yellowish pronotal sides, elytra and legs. Easily recognised by the pronotal sculpture (*ie.* pore close to the middle of the side margin, and the shallow impression in the hind angle) (Fig. 187). Length about 3 mm. Generally uncommon.

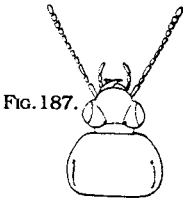


Fig. 187.

Genus *Acrolocha*
A. sulcula is a very small blackish species with yellowish legs and bases of the antennae. Elytra dark brown. A useful identification feature is the very unusual pronotal and elytral sculpture plus the general shape of the body (Fig. 188). Length about 2 mm. Not generally a common species. The inset figure opposite shows the pronotal sculpture enlarged.

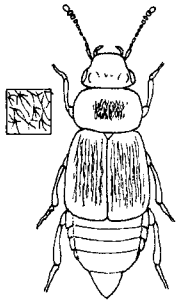


Fig. 188.

Genus *Aploderus*
A. caelatus is a blackish species with yellowish legs and elytra. The pronotum does not have a deep central groove but has a short longitudinal impression on each side of the middle (Fig. 189). Front tibiae are abruptly narrowed before their tips. Length 3.5-5 mm.

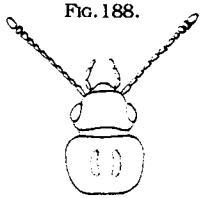


Fig. 189.

Genus *Platystethus*
Adult *P. arenarius* are mainly blackish, easily recognised by the strong central pronotal groove and the angular contraction of the head behind the eyes (Fig. 190b). The only member of the genus found in the dung of herbivores. Length 3-5 mm. A larva is illustrated in Fig. 190a.

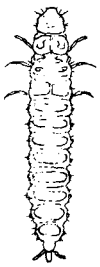


Fig. 190a.

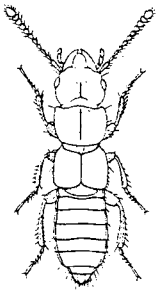


Fig. 190b.

Genus *Anotylus*
These rove beetles are easily recognised by the very distinct pronotal grooves and the absence of an impressed line by the outer elytral edge (Fig. 191). Amongst the most abundant rove beetles found in dung, the 5 species recorded from the medium are distinguished as follows.

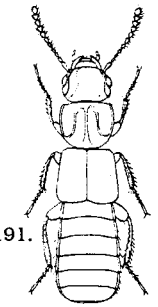


Fig. 191.

1 Front tibiae not abruptly narrowed just before the apex on the outer side (Fig. 192). Length 1.7-2.2 mm
.....*A. tetracarinatus*

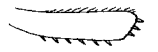


Fig. 192.

- Front tibiae abruptly narrowed just before the apex on the outer side (Fig. 193). Length 1.2-3.6mm
.....2


Fig. 193.

2 Head and pronotum distinctly shining between the sculpturing. Length 3-3.5 mm.....*A. sculpturatus*

- Head and pronotum completely dull. Length 1.2-3.6mm
.....3

3 Length 2.9-3.6 mm. Fine longitudinal keels running parallel to the inner margin of the eyes
.....*A. complanatus*

- Length 1.2-2.1 mm. Without a longitudinal keel
.....4

4 Length 1.2-1.8 mm
.....*A hamatus*

- Length 1.7-2.1 mm
.....*A fairmairei*

Note. Specimens in the overlapping area of this size range can only be distinguished in the male. In *A. hamatus* there is a single central tooth on sternite 6, whilst in *A. fairmairei* there are two such teeth.

Genus *Oxytelus*
These beetles closely resemble *Anotylus* but have the basal antennal joint narrowed apically and have an impressed line along the elytral outer edge. Two species are recorded from dung, *O. laqueatus* being a very common species (Fig. 194). The second species, *O. piceus* is much rarer and distinguishable only on the relatively smaller size of the eyes. The separation of the two species requires expert identification.

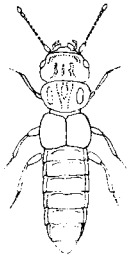


FIG. 194.

Genus *Leptacinus*
L. batychrus is the only species recorded from dung. A rather small dark brownish species with paler elytra and characteristic transverse pronotal shagreenation between the 2 inner rows of 10-14 pronotal punctures (Fig. 195). Length 4-5 mm.

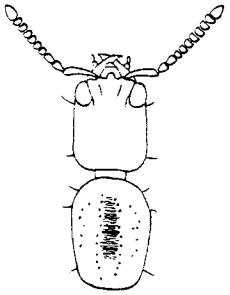


FIG. 195.

Genus *Gyrohypnus*
Three of the four British species have been recorded from dung. As in *Xantholinus* the elytra overlap along the suture.

1 Length 5.5-7.0 mm. Elytra, legs and the apices of the abdominal segments paler
.....*G. angustatus*

- Length 7.0-9.0 mm. Mainly black
.....2

2 Head with an almost round, puncture-free, area above and behind the eyes; angular behind (Fig. 196)
.....*G. fracticornis*

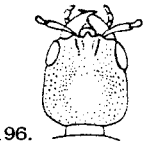


FIG. 196.

- Head with a narrow, puncture-free area above and behind the eyes; rounded behind (Fig. 197)
.....*G. punctulatus*

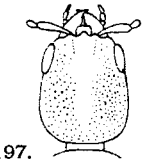


FIG. 197.

Genus *Xantholinus*
X. glabratus is the only species known to occur in dung. A very striking mainly black species with bright orange elytra (Fig. 198: a- larva; b-adult). Length 10-14 mm.

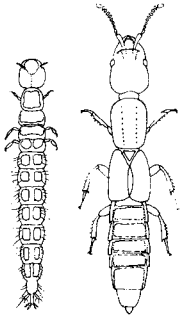


FIG. 198a. FIG. 198b.

Genus *Philonthus*
A large genus; mainly black, or partly metallic or reddish rove beetles varying in size from small to fairly large; length 5-16 mm. Front parts usually smooth and shining, often with a double series of large pores down the centre of the pronotum. The partly metallic species cannot be confused with other dung-frequenting rove beetles and some of these are amongst the commonest beetles found in dung (Fig. 199: a- larva; b-adult). Eighteen British species have been recorded from dung of herbivores and can be distinguished using the key below, but several others may also occur less regularly. In some species positive identification is only possible on male genitalic characters (see couplet 11).

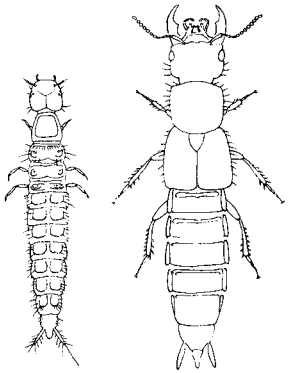


FIG. 199a. Adult FIG. 199b.

1 Pronotum without a double series of pores down the middle (see Fig. 199b above)
.....2

- Pronotum with at least 4 pairs of pores down the middle (Fig. 200)
.....3

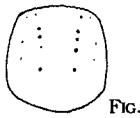


FIG. 200.

2 Only the elytra metallic (*ie.* with blue or green reflections). Length 10-16 mm (often the largest *Philonthus*) (see Fig. 199b above)
.....*P. splendens*

- Head, pronotum and elytra metallic. Length 8-11 mm
.....*P. intermedius*

Note. In *P. laminatus* , which is doubtfully recorded from cow-dung, the pronotum is completely and evenly rounded at the sides.

3 Pronotum with the side margins broadly yellowish throughout their length. Length 7-9 mm
.....*P. marginatus*

- Pronotal side margins dark throughout. Lengths various; 5-14mm
.....4

4 Pronotum with 4 pairs of pores down the middle (Fig. 201).
.....5

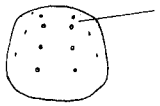


Fig.201.

- Pronotum with 5 or more pairs of pores down the middle (Fig. 202)
.....12

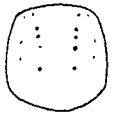


Fig.202.

5 Joint 1 of hind tarsus is longer than joint 5 **and** as long as 2, 3 and 4 together (Fig. 203). Length 10-14 mm
.....6

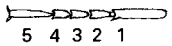


Fig.203.

- Joint 1 of hind tarsus is both shorter than joint 5, **and** 2, 3 and 4 together (Fig. 204). Length 5-8 mm
.....9

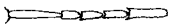


Fig.204.

6 Base of visible abdominal tergite 2 (seen from above) with the interspiracular line straight (as on segment 1) (Fig. 205)
.....*P. carbonarius*

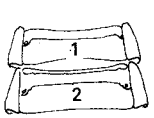


Fig.205.

- Base of visible abdominal segment 2 (seen from above) with the interspiracular line dipped in the middle (unlike that on segment 1 which is straight) (Fig. 206)
.....7

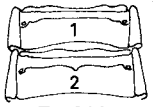


Fig.206.

7 Subapical antennal joint not obviously wider than long (Fig. 207)
.....*P. addendus*


Fig.207.

- Subapical antennal joint (*ie.* next to the last one) obviously wider than long (Fig. 208)
.....8


Fig.208.

8 Abdominal tergites much more finely punctured than the elytra, and both are black-haired. Temples less densely and closely punctured
.....*P. succicola*

- Abdominal tergites about as closely punctured as the elytra and both are dark brown haired. Temples with fine to coarse puncturation, which is either widely or closely spaced
.....*P. politus*

9 Head with the 4 pores between the eyes (view from above) evenly spaced (Fig. 209)
.....10

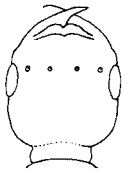


Fig.209.

- Head with the 4 pores between the eyes unevenly spaced (Fig. 210)
.....11

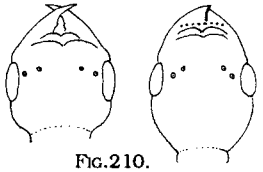


Fig.210.

10 Metallic. Length 7-8 mm
.....*P. cephalotes*

- Blackish. Length 5.5-7.5 mm
.....*P. nigriventris*

11 Pronotum roughly parallel-sided; not metallic. Length 5.5-7 mm . Male genitalia (lower view) as in Fig. 211a - see the note below
.....*P. fimetarius*

- Pronotum broadest in the posterior (hindmost) third, strongly narrowing towards the front; brownish with a metallic shine. Length 5-6 mm
.....*P. albipes* and *P. alpinus*

Note: These two species are only distinguishable on the shape of the male genitalia; the organ often projects beyond the apical (hindmost) abdominal segments; or in freshly killed specimens it can be forced out by pressing the middle of the abdomen. *P. albipes*, Fig. 211b; *P. alpinus*, Fig. 211c.

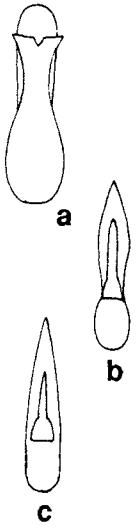


FIG.211.

12 Pronotum with two irregular rows of pores each comprising numerous pores down the middle (Fig. 212). Length 7.5-8.5 mm
.....*P. puella*

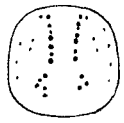


FIG.212.

- Pronotum with 5 pairs of pores down the middle (Fig. 213). Length 5.5-9mm
.....13

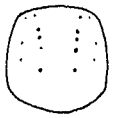


FIG.213.

13 Base of the second visible abdominal segment (viewed from above) with the interspiracular line dipped in middle (Fig. 214). Length 6.5-9 mm
.....*P. rectangulus*

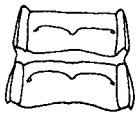


FIG.214.

- Base of the second abdominal segment with the interspiracular line straight (Fig. 215). Length 5.5-9mm
.....14


FIG.215.

14 Dorsal (upper) surface of the basal (foremost) abdominal segments with hairs dense and short (Fig. 216). Length 7-8 mm
.....*P. sanguinolentus*


FIG.216.

- Dorsal surface of the basal abdominal segments with hairs long and sparse (Fig. 217). Length 5.5-9.0mm
.....15


FIG.217.

15 Eyes longer than the temples. Length 6.5-8.0 mm
.....*P. longicornis*

- Eyes shorter than the temples. Length 5.5-9.0mm
.....16

16 Elytra black. Head broad and round-oval. Front coxae at most very slightly paler internally. Length 6-8 mm
.....*P. jurgans*

- Elytra usually with extensive, though ill-defined, reddish suffusion, or front coxae clearly mainly yellowish. Head narrow, more elongate-oval. Length 5.5-9.0mm
.....17

17 Elytra with a large reddish patch which does not reach the side or hind margins or, if entirely black, then the front coxae also black throughout. Length 7-9 mm
.....*P. cruentatus*

Note. *P. ebeninus* , a black species with metallic shine, otherwise resembling *P.cruentatus*, has been recorded (doubtfully) from cow-dung.

- Elytra with a reddish suffusion reaching the side or hind margins or, if entirely black, then the front coxae at least partly yellowish on the front side. Length 5.5-8mm
.....18

18 Head broad, round-oval. Elytra almost always entirely black. Front coxae only obscurely yellowish in front. Length 6-8 mm
.....*P. furgans*

- Head narrow, elongate oval. Elytra almost always with reddish suffusion running diagonally from scutellar region towards hind outer angle. Front coxae distinctly yellowish in front. Length 5.5-7.5 mm
.....*P. varians*

Genus *Gabrius*
G. piliger is the only member of the genus which has been recorded from dung. Very like a small *Philonthus* but with 6 pairs of pores down the middle of the pronotum. Black, which metallic elytra. Length 4.5 mm.

Genus *Ontholestes*
Both British species are recorded from dung and are of spectacular appearance, being clothed with dense golden and blackish hair forming a very distinctive pattern. They are, however, not generally common.

1 Length 14-19 mm, with legs and antennal bases partly pale, small eyes and pronotum narrowed towards base
.....*O. tessellatus*

- Length 10-15 mm, with entirely dark legs, large eyes and pronotum almost parallel-sided (Fig. 219)
.....*O. murinus*

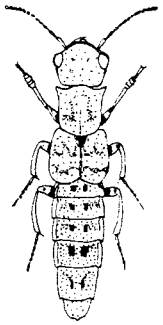


FIG.219.

Genus *Emus*
The single British species (*E. hirtus*) is an extremely spectacular but, unfortunately, very rare beetle; densely clothed in golden fur on the head, front of the pronotum and apical half of the abdomen. Rest of the body is black except the elytra which are mainly grey (Fig. 220). Length 15-25 mm.

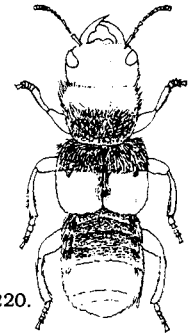


FIG.220.

Genus *Platydracus*
Three of the British species are recorded from dung; like the two preceding genera they are beautifully marked, large rove beetles. All three are generally scarce, *P. fulvipes* being decidedly rare. Length 12-17 mm.

1 Elytra bright red. Head, pronotum and abdomen black with patches of bright golden hair (Fig. 221)
.....*P. stercorarius*

- Elytra black
.....2

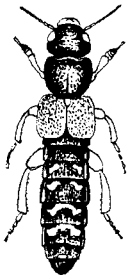


FIG.221.

2 Body entirely blackish but covered with dense patches of blackish and golden hair giving a variegated pattern. Very similar to *Ontholestes*
.....*P. pubescens*

- Body blue-black, covered with blackish hairs except on the visible abdominal tergites 5 and 6, each of which has a basal (front-end) transverse band of golden hairs
.....*P. fulvipes*

Genus *Tachinus*
A genus of unmistakable dark reddish to blackish, rather flattened rove beetles in which the apical abdominal segment is very strongly toothed. The form of these tergites can be used to confirm identification - see Fig. 225). Length 3-9 mm. A *Tachinus* larva is illustrated in Fig. 222 (scale 1mm)

Adults of the dung-frequenting species can be identified using the key below.

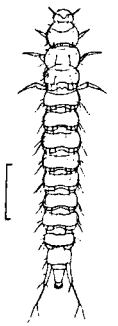


FIG.222.

1 Elytra with strong surface shagreenation (microscopic wrinkles) making them dull
.....2

- Elytra shining
.....5

2 Elongate elytra, considered together they are longer than wide. Elytra red. Small diagonal dust-patches on the first three visible abdominal tergites. Pronotum and elytra equally strongly punctured. Length 6-9 mm
..... 3

- Elytra together about as long as wide; usually more or less distinctly reddish. Only the first two visible tergites with paired diagonal dust-patches. Length 5-7 mm
.....4

3 Pronotal front, side and hind margins with equally broad reddish markings and the surface of the pronotum between punctures smooth and shining. Abdominal tergites as illustrated in Fig. 225a. Length 6-9 mm
.....*T. humeralis*

- Pronotum with side margins more broadly reddish than front and hind margins, and pronotal surface between the punctures distinctly shagreened (*ie.* corrugated or wrinkled). Abdominal tergites as illustrated in Fig. 225b. Length 6-8 mm
.....*T. proximus*

4 Pronotum usually with only the hind margin narrowly paler. Abdominal tergites: Fig. 225c-female; Fig. 225g-male
.....*T. signatus*

- Pronotum with the side margins broadly paler. Abdominal tergites: Fig. 225d-female; Fig. 225h -male
.....*T. pallipes*

Note. These two can be extremely similar since specimens of *T. signatus* may occasionally have the widely pale pronotal side-margins of *T. pallipes* . The only certain way to distinguish the two species is by means of the male genitalia and the apical tergite of the female (see Fig.225 overleaf).

5 Pronotum nearly twice as wide as long, and wider than the elytra at the 'shoulders' (Fig. 223). Abdominal tergite; Fig. 225e.
.....*T. laticollis*

FIG.223.

- Pronotum at most 1.5 times wider than long and no wider than the elytra at the 'shoulders' (Fig. 224). Abdominal tergite; Fig. 225f.
.....*T. marginellus*

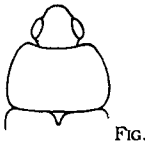
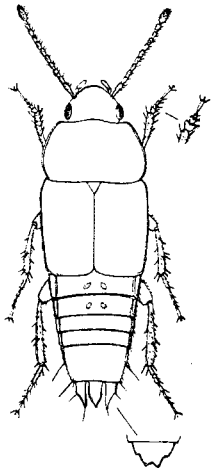


FIG.224.



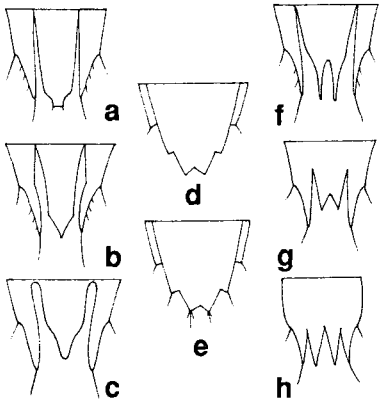


FIG.225.

Genus *Autalia*
Very small rove beetles of a very distinctive shape. Length 1.7-2.5 mm.

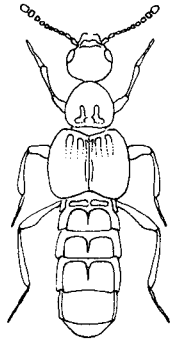


FIG.226.

1 Length 1.7-2.1 mm. Pronotal puncturation barely discernible and the middle longitudinal furrow reaching back to the basal (hind end) transverse groove (Fig. 226)
.....*A. rivularis*

- Length 2.1-2.6 mm. Distinct pronotal puncturation and the middle furrow restricted to the front half.
.....*A. puncticollis*

Genus *Aleochara* (but including *Tinotus*)
A very interesting genus of small rove beetles (length 1.7-2.1mm) of rather distinctive appearance due to the extremely short elytra and projecting metapleurae (Fig. 227). Their larvae are internal parasites of dipteran larvae. They complete their larval stage and then pupate inside the host's puparium. When the beetle emerges it chews a jagged hole through the wall of the puparium (unlike the neat round one so characteristic of hymenopteran parasites). Of the 8 British species of *Aleochara* recorded from dung, *A. lanuginosa* is by far the commonest.

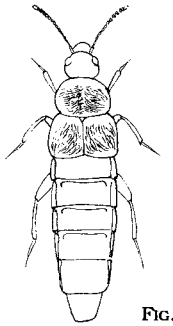


FIG.227.

Key to dung-frequenting species of *Aleochara* and *Tinotus*

Note : In the illustrations below, one side shows the pronotal puncturation and the elytral colour pattern whilst the other side shows the pronotal and elytral hair orientation.

1 Length 1.5-2.6 mm. Black species
.....*T. morion*

- Length 2-8 mm. Often partly reddish
..... 2

2 Pronotum with rows of large pores down the middle (*eg.* Fig. 228)
.....3

- Pronotum without such pores (*eg.* Fig. 229)
.....4

3 Elytra black with, at most, the hind edge reddish. Length 2.2-5.5 mm
.....*A. bilineata*

- Elytra obviously extensively reddish in the apical half (Fig. 228). Length 2-4.5 mm
.....*A. intricata*

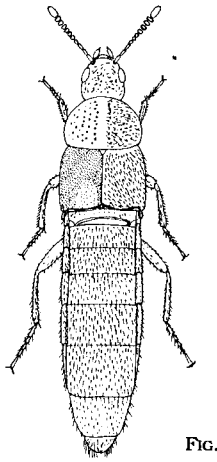


FIG.228.

4 Elytra very coarsely punctured, with the spaces between the punctures almost as wide as punctures themselves. Black with elytra reddish towards the hind angles. Length 3.5-5 mm
.....*A. bipustulata*

- Elytra with interspaces larger than the punctures. Length 3-7mm
.....5

5 Elytra black, with, at most, the extreme apical margins very slightly reddish (Fig. 229). Length 3-5.5 mm. By far the commonest British *Aleochara*
.....*A. lanuginosa*

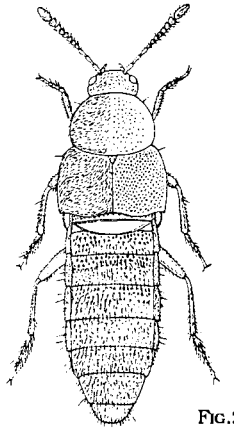


FIG.229.

- Elytra extensively reddish. Length 3-7mm. Very rare species
..... 6

6 Basal abdominal segments sparsely punctured and the abdomen more narrowed behind. Elytra blackish with the reddish central patch. Length 5-7 mm
.....*A. discipennis*

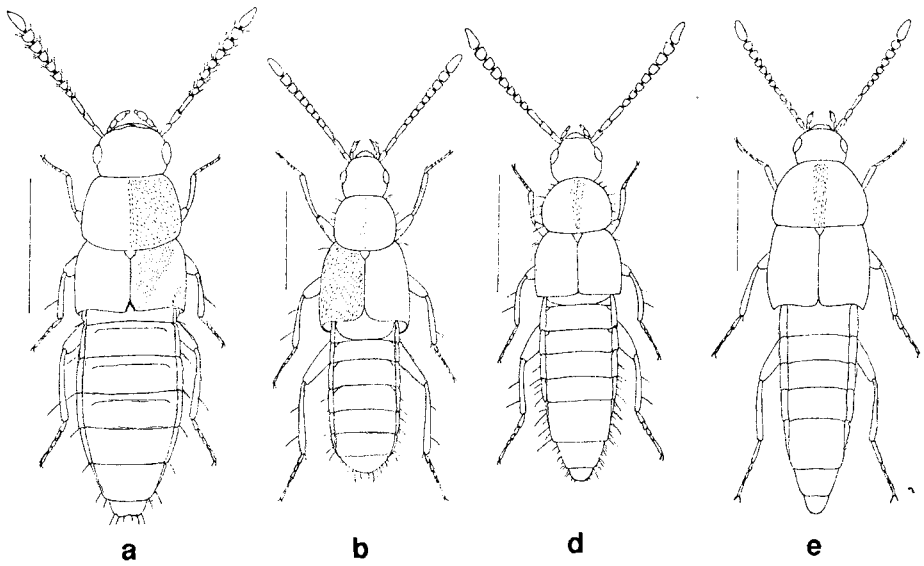
- Basal abdominal segments very densely punctured and the abdomen almost parallel sided. Length 3-6mm
.....7

7 Basal abdominal segments more densely punctured than the apical ones. Length 4.5-6.0 mm
.....*A. tristis*

- Basal abdominal segments as finely and densely punctured as the apical ones. Length 3-5 mm
.....*A. moesta*

Atheta and related genera

A very large group of small, often abundant, rove beetles, the identification of which requires specialist experience. Specific identification relies on genitalic characters and details of the underside; mouthparts, pubescence patterns, number and relative lengths of tarsal segments, etc., many of which are frequently very difficult to ascertain. Most species are blackish, often with elytra and legs yellowish and of undistinguished appearance. Very little is known of the biology and habits of these beetles but *Atheta (Dimetrota) atramentaria* is an important predator of free-living nematodes.



a. *Atheta (Coprothassa) melanaria*
(showing only the right hand side of pronotum and elytra). Tibial hairs long.

b. *A. (Dimetrota) marcida*
Showing arrangement of hairs along the median pronotal line and the normal arrangement of elytral hairs (left elyton only). Tibial hairs long.

c. *A. (D.) atramentaria*
Characteristic wavy arrangement of hairs in the central part of the elytron - compare with Fig. 230b.

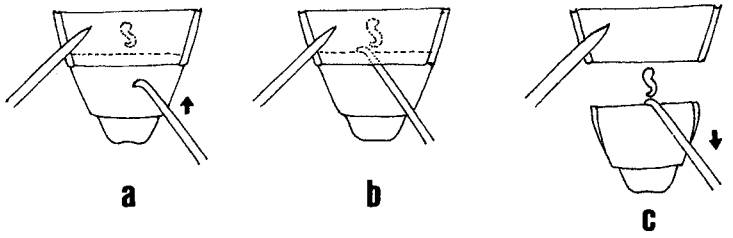
d. *Chaetida longicornis*
Showing arrangement of hairs along the median pronotal line. Tibial hairs long.

e. *Oxypoda opaca*
Showing arrangement of hairs along the median pronotal line. Tibial hairs short.

FIG. 230.
Pronotal and tibial hairs, and elytral markings (scales 1mm)

Table 2 provides a lateral key which should assist in distinguishing the 26 species of the *Atheta* group listed on p.81, but the provisional identifications should be confirmed by specialists because (a) only gross artificial characters have been used here, and (b) many more species are likely to occur regularly. The genus *Atheta* alone contains over 130 British species! The arrangement of pronotal hairs and elytral markings are useful characters for identification in this group. Figure 230 shows the arrangements in some species– others are illustrated in Figs. 234 and 236 on page 80.

The key uses characters which are reasonably easy to appreciate but for confirmatory purposes the spermathecae of the females are figured. The male genitalia are not included as their structure is more complicated. The extraction of the spermathecae is a simple procedure (see Fig. 231 a-c below). The specimen is placed in a petri dish containing spirit under a magnification of at least x50. Using a pin or forceps to hold the specimen with one hand, a fine pin, whose point has been bent by pressure against a hard surface, is inserted between the visible tergites 5 and 6 as shown in Fig. 231a and b, then gently pulled backwards (Fig. 231c), so that the apical part of the abdomen is detached. Often the spermathecae will be clearly seen, attached by a clear viscera to the detached segment, but if not it will be found inside the abdomen. Obviously, some dissected specimens will prove to be males; here the genitalia are usually much larger, often occupying the whole interior of the apical part of the abdomen and appearing as a basically tripartite (three-part) structure. The spermathecae vary in size according to species but will be clearly recognisable by their very characteristic form and generally sub-opaque yellowish colour (see Figs. 238a-y overleaf).



Extraction of females' spermathecae

FIG.231.

Body length is given in column 9 since this can also provide some supportive evidence of identity. Note that of the species recorded here *Atheta (Microdota) inquinula* is the smallest, measuring only 1.1-1.2 mm, whilst *Oxypoda nigricornis* and *O. opaca* may attain 4.5 mm. Few of these beetles are readily recognisable on gross external characters but of those listed on page 81, *Atheta (Dimetrota) atramentaria* is characterised by *inter alia* the peculiar alignment of hairs on the elytra which centrally trace an S-shape (Fig. 230c).

TABLE 2. Lateral key to 26 species of rove -beetles belonging to the *Atheta* group

The characters used in the lateral key are given below. Choose the characters that are appropriate for the specimen under examination and compare these with the species' character lists given in the table opposite (see Tilling, 1984, for further details of how to use lateral keys - including the manufacture of scanning strips, etc.).

1 Relative lengths of antennal joints 2 and 3 (Fig.232a-c)
a 2 longer than 3
b 2 as long as 3
c 2 shorter than 3
d species varying from a to b

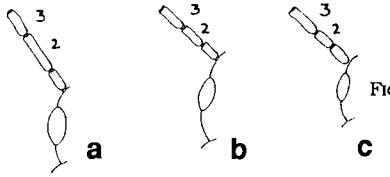


FIG.232.

2 Shape of the subapical antennal segment (Fig.233a & b)
a wider than long
b not wider than long

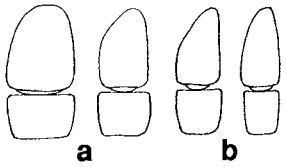


FIG.233.

3 Orientation of hairs down the centre of the pronotum (Fig.234)
a all pointing forwards
b all pointing backwards
c pointing forwards in front half and backwards in back half

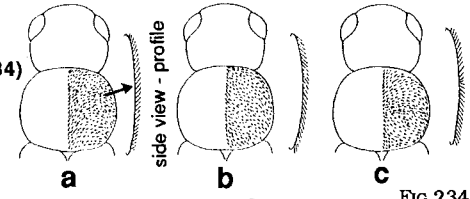


FIG.234.

4 Tibial bristles (Fig. 235 a & b)
a not obviously longer than tibial diameter
b obviously longer than tibial diameter

FIG.235.

5 Elytra (Fig. 236a)
a darkened towards base (and often towards apex) (Fig.236)
b unicolourous
c varying from a to b

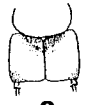
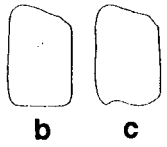


FIG.236.

6 Elytral apical margin (Fig.236 b & c)
a straight (Fig. 236b)
b wavy (Fig. 236c)



7 Abdomen (Fig.237 a & b)
a parallel-sided
b gradually narrowing behind
c varying or inconclusive

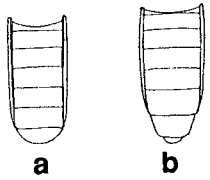


FIG.237.

8 Female spermathecae (see Fig.238 a-y) (After Freude, Harde & Lohse, 1974)
Note: that the shape of the spermatheca in *Atheta (Dimetrota) picipennis* varies considerably, three variants being shown here (Fig. q).

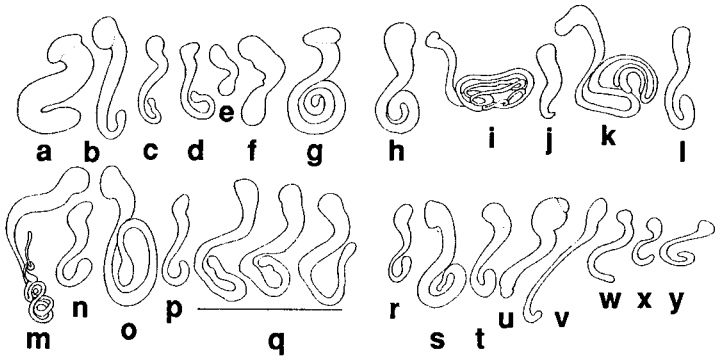
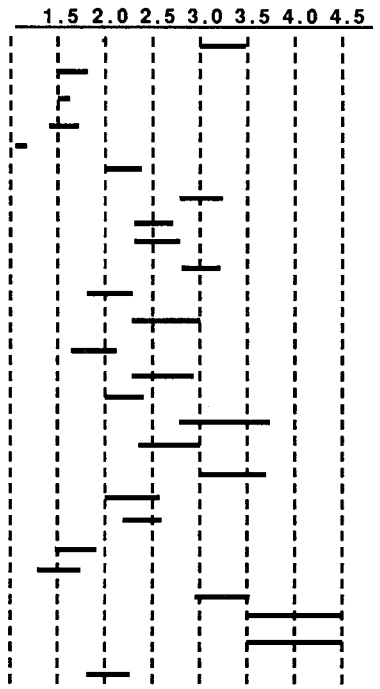


FIG.238.

SPECIES	CHARACTERS 1 2 3 4 5 6 7 8
N. sordida	c b b a a b b a
A.(M). atricolor	a a a a b a a b
excelsa	a a a a b a a c
glabricula	a a b a b a a d
inquinula	a a a a b a a e
subtilis	a a a a b a a f
A.(C).melanaria	c b b b a b b g
A.(A).aterrima	b b c b b a b h
benicki	b b c b b a b -
A.(D).atramentaria*	b b a b a a c i
cauta	a b a b a a c j
cinnamoptera	b b a b c a c k
ischnocera	a a a b b a c l
laevana	b a a b a a c m
macrocera	b b a b c a c n
marcida	b b a b b a c o
nigripes	d a a b b b c p
picipennis	b b a b b a c q
puncticollis	b a a b c a c r
setigera	d a a b b a c s
A.(P).cribrata	a a b a b a b t
A.(D).sordidula	a a a a b a b u
C.longicornis	c b a b a a b v
O.nigricornis	c b b a c b b w
opaca	c b b a c b b x
sericea	b a b a c b b y
	1 2 3 4 5 6 7 8



* **Note also the characteristic arrangement of the elytral hairs (Fig. 230c, p. 78)**

Family GEOTRUPIDAE (dor beetles)

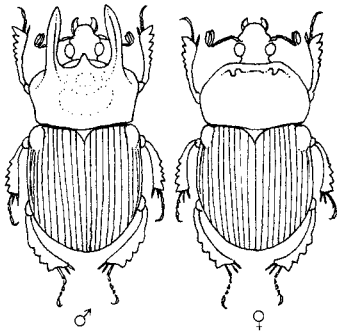
These are large blue-black beetles which burrow into the soil beneath the dung, taking stores of dung with them. Consequently, they are seldom found in the dung itself but their burrows are very conspicuous. Immature stages are spent in the burrows during winter. The larvae are of characteristic scarabaeiform (**C**-shaped) type but differ from immatures of the family Scarabaeidae (p.84) in having only 3 antennal segments.

Key to dung-frequenting genera of Geotrupidae (larvae and adults)

1 Pronotum of the adults broadest at or before the middle, with either two very long horns or a pair of small wart-like tubercles near the front margin (see Fig. 239a & b). Larvae with all three pairs of legs almost equally long
.....Genus *Typhaeus* (see below)

- Pronotum of adults broadest in the basal half, without horns or tubercles; quite smooth (see Fig. 240b.) Larvae with the third pair of legs much shorter than the others (Fig. 240a.)
..... Genus *Geotrupes* (see below)

Genus *Typhaeus*
The minotaur beetle, *T. typhoeus*, cannot be confused with any other British insect, especially the male which has conspicuous horns on the pronotum (Fig. 239a). In the female the corresponding area is roughened and a pair of small, though distinct, tubercles replaces the horns (Fig. 239b). Locally frequent from central Scotland southwards, in sandy areas. Length 14-22 mm.



a FIG.239. **b**

Genus *Geotrupes* (Dor beetles)
The six British species are all mainly, or exclusively, associated with herbivore dung. Apart from *Typhaeus* and *Copris* there are no British beetles which could be confused with *Geotrupes* in size and general appearance. Burrows of dor beetles under herbivore dung are a common sight but the beetles are mainly encountered in flight on warm evenings (Fig. 240a & b). Adults can be identified using the key on p.83.

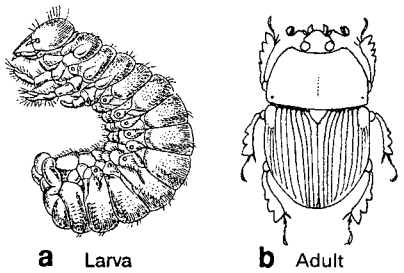

a Larva **b** Adult

FIG.240.

1 Elytra without longitudinal striae (Fig. 241). Length 12-20 mm
.....2

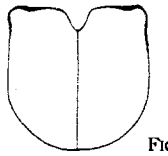


FIG.241.

- Elytra with obvious longitudinal striae (Fig. 242). Length 12-26mm
.....3

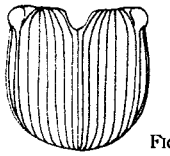


FIG.242.

2 Ventral (lower) surface of the abdomen with very sparse punctures and hairs in the middle, denser towards the sides. Large punctures on the pronotum very sparse. (A very local species in southern England)
.....*G. pyrenaeus*

- Ventral surface of the abdomen uniformly punctured and hairy. Large dense pronotal punctures. (Widely scattered throughout Britain, often in mountainous areas)
.....*G. vernalis*

3 Each elytron with nine striae, between the suture and the "shoulder" (Fig. 243). (Found in southern England and Wales.) Length 16-24 mm
.....*G. mutator*

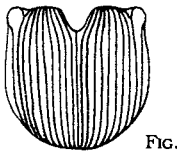


FIG.243.

- Each elytron with seven striae between the suture and the "shoulder" (Fig. 244)
.....4

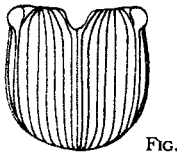


FIG.244.

4 Elytral striae weak and narrow (Fig. 245). Generally small, length 12-19 mm. (Common, especially in wooded, hilly areas, or open moorland)
.....*G. stercorosus*


FIG.245.

- Elytral striae deep and broad (Fig. 246). Generally large species, length 16-26 mm. (Common and widespread)
.....5


FIG.246.

5 Ventral (lower) surface of the abdomen uniformly punctured and hairy. Hind tibiae with two complete ridges on the outer side (Fig. 247)
.....*G. stercorarius*

- Ventral surface of the abdomen with hairs and punctures sparse along the middle. Hind tibiae with three complete ridges on the outer side (Fig. 248)
.....*G. spiniger*


FIG.247.


FIG.248.

Family SCARABAEIDAE (dung beetles)

This family includes the true "dung beetles" which spend most of their life in dung, only leaving to find fresh supplies, or to pupate in the underlying soil on completion of their larval stage. The larvae are of the usual scarabaeiform type (**C** shaped: *eg.* Fig. 240a) and are often abundant in old cowdung. By far the commonest species belong to the genus *Aphodius*. Certain species of these are invariably present in herbivore dung. For the identification of British species see Jessop (1986).

Partial keys are presented here. In addition to the dichotomous keys (pp.84-87), a tabular key for the genera *Aphodius* , *Heptaulacus* and *Euheptaulacus* is given in Table 3 on pages 88 and 89.

Key to the genera of dung-frequenting Scarabaeidae (adults)

1 Hind tibiae with 2 long apical spurs (Fig. 249a). Scutellum present (Fig. 249b). Head and pronotum never with horns
.....2


FIG. 249a.

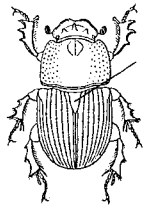


FIG. 249b.

- Hind tibiae with 1 long spur (Fig. 250). Head and pronotum often without horns
.....3


FIG.250.

2 Elytral striae (*) generally narrower than interstices (i) and usually with large punctures (Fig. 251). Hind margin of the pronotum and elytral interstices never with conspicuous pale hairs. Length 2.5-13.0mm
.....*Aphodius* (see below)

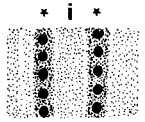


FIG.251.

- Elytral striae (*) at least as wide as the interstices (i) and without large punctures (Fig. 252). Hind margin of the pronotum with a fringe of pale hairs and elytral interstices with two conspicuous rows of convergent pale hairs. Length 3-5mm
.....*Heptaulacus & Euheptaulacus* (p.91)

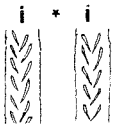


FIG.252.

3 Pronotum smooth, without conspicuous horns or tubercles (Fig. 253). Colour entirely dull black to extensively pale yellowish or greenish metallic. Length 4-13mm
.....*Onthophagus* (p.91)

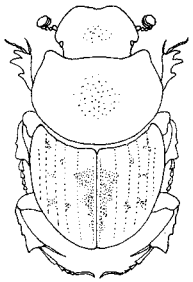


FIG.253.

- Pronotum with conspicuous horns (male: Fig. 254a) or tubercles (female: Fig. 254b). Entirely shiny black or dark brown. Large species; length 17-23mm
.....*Copris* (p.91)

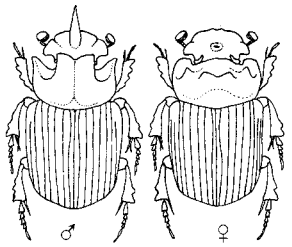


FIG.254.

Genus *Aphodius*
Included in this genus are the commonest dung beetles, some of them being ubiquitous in herbivore dung although several exhibit a distinct tendency to favour particular dung types. Jessop (1986) provides a comprehensive identification key for members of this large genus. The following key, however, should help in the correct identification of some of the commonest species. See also the lateral key on pages 88 and 89.

1 Scutellum (s) is obviously longer than wide, 1/2-1/5 as long as the elytra (Fig. 255). Length 3.5-13.0 mm
.....2

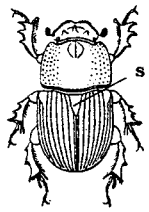


FIG. 255.

- Scutellum short; no longer than its basal width. Length 2.5-13.0 mm
.....5

2 Small beetles (length 3.0-5.5 mm). Elytra mainly black with apex broadly reddish. (Common in lowland areas of Britain)
.....*A. haemorrhoidalis*

- Large beetles (length 6-12 mm) with elytra entirely black, dull reddish or yellowish brown
.....3

3 Elytra **dull**, mainly reddish to entirely black or yellowish brown. Length 6-9 mm. (Mainly southern distribution in Britain, commonest in Southwest England)
.....*A. erraticus*

- Elytra **shining** black. Length 6-12mm
.....4

4 Length 6.0-7.5 mm. (Not recorded in Britain for 40 years)
.....*A . subterraneus*

- Length 9-12 mm. (Common and widespread but less ubiquitous than some other *Aphodius* species)
.....*A. fossor*

5 Length 11-13 mm. Dark reddish beetles
.....*A. rufipes*

- At most 9 mm long. Various colours
..... 6

6 Pronotum shiny black with front angles broadly orange (Fig. 256). Elytra very bright orange red, unmarked. Length 5.5-8.0 mm
.....7

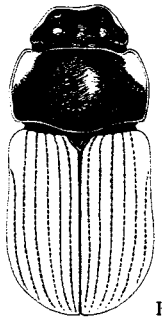


FIG.256.

- Above colour combination not applicable
.....8

7 Abdomen orange beneath
.....*A. foetens*

- Abdomen black beneath. (One of our commonest and most distinctive species)
.....*A. fimetarius*

8 The sides of the pronotum (which is mainly blackish with a strong metallic shine) have a complete fringe of long yellow stiff hairs (Fig. 257). Length 5-6.5 mm. Elytra are dull yellowish with small dark diagonal marks in the middle of each. (Adults of this species occur from September into October, often in huge numbers, and habitually greatly enlarge the surface of the cow-pats, or other dung patches, in which they feed.)
.....*A. contaminatus*

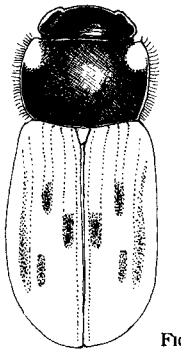


FIG.257.

- The sides of the pronotum without a fringe of stiff yellow hair. Length 4-7mm. Various colour combinations, but not as described above
.....9

9 Entirely dark reddish with, at most, the centre of the pronotum faintly darker; legs and antenna reddish. Length 5-7 mm.
.....(The commonest species which answers this description is *A. rufus* .)

- Either entirely black or the elytra are extensively yellowish and the pronotum mainly black
.....10 (page 90)

TABLE 3

Lateral key to the commonest species in the genera *Aphodius, Heptaulacus* and *Euheptaulacus*. The table is intended to act as a tabular key to clearly visible, artificial characters (pronotal and elytral colours and markings, and body length), but it also incorporates information on general distribution and status of the species in Britain and the times of activity of adults. When using the key there should always be an assumption that species taken in samples are most likely to be common species. Always confirm your identification using Jessop (1986).

The columns in Table 3 are explained below.

Column A. Relative length of scutellum:-
- a long (as in Fig.255)
- b short (as in Fig.256-7)

Column B. Colour of Pronotum:-
- a unicolourous: blackish, dark reddish or dark brownish
- b dark with just front angles pale
- c dark with side margins and front angles pale
- d hind margin pale (and often side and front margins too)
- e pronotum pale throughout

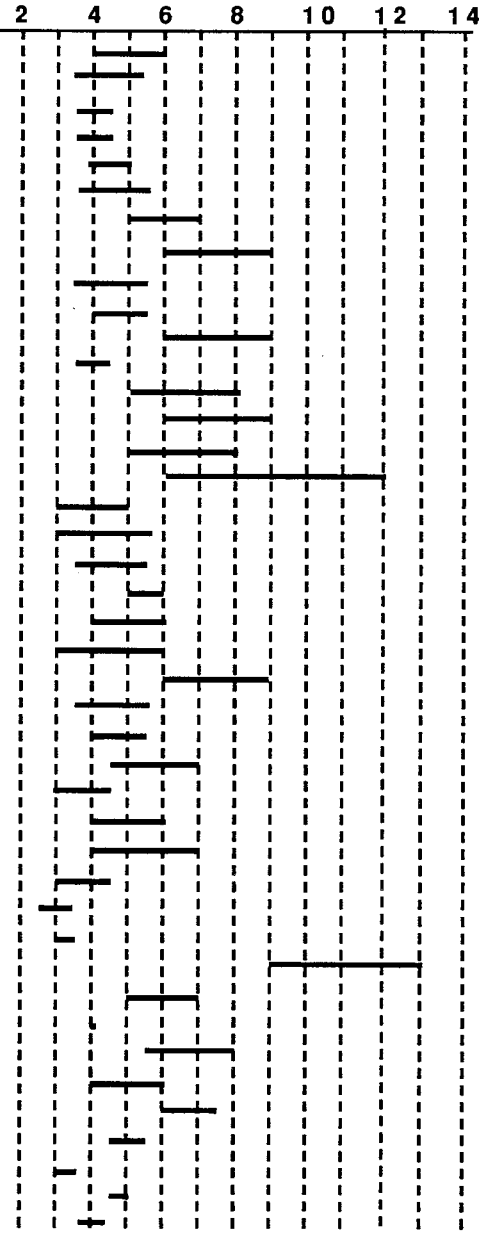
Column C. Colour of elytra:-
- a unicolourous dark reddish to black
- b dark with paler apex (sometimes clearly defined apical patch
- c dark with paler patches or suffusions at base and apex
- d entirely pale yellowish or bright orange red (Fig.256)
- e yellowish with dark sutural streak
- f yellowish with dark suffusion in posterior half (Fig. 259)
- g yellowish with dark spots on interstices (Figs. 257, 258 & 261)
- h dark with pale spots on interstices

Column D. National Distribution:-
- a throughout Britain
- b extending as far north as southern Scotland
- c extending as far north as northern England
- d extending as far north as Midlands and North
- e South Wales and southern England
- f southern England only
- g northern and western species, rare or absent in southern England

Column E. Status:-
- a generally abundant
- b locally numerous
- c very local species
- d one or two sites or records only, or species not seen for many years.

Column F. Adults flight period
- a all year round
- b mainly summer months
- c mainly late winter and spring
- d autumnal species
- e autumn to spring

SPECIES	A	B	C	D	E	F
A. ater	b	a	a	a	a	a
A. borealis	b	b	a	a	b	b
A. brevis	b	a	a	g	d	?
A. coenosus	b	a	a	d	d	c
A. conspurcatus	b	d	g	b	c	a
A. consputus	b	c	f	e	c	c
A. contaminatus	b	d	g	a	a	d
A. depressus	b	a	a	d	b	b
A. distinctus	b	c	g	b	c	b
A. equestris	b	d	g	d	b	b
A. erraticus	a	a	e	b	b	b
A. fasciatus	b	b	c	g	c	d
A. fimetarius	b	b	d	a	a	a
A. foetans	b	b	d	a	b	b
A. foetidus	b	a	f	b	b	b
A. fossor	a	a	a	b	a	a
A. granarius	b	a	a	c	b	c
A. haemorrhoidalis	a	a	b	c	b	b
A. ictericus	b	a	d	b	c	b
A. constans	b	a	a	a	b	c
A. lapponum	b	a	a	g	b	b
A. lividus	b	d	e	c	d	?
A. luridus	b	a	g	a	c	e
A. merdarius	b	c	e	a	b	b
A. nemoralis	b	a	a	g	c	e
A. obliteratus	b	d	g	b	c	d
A. paykulli	b	c	g	a	c	c
A. porcus	b	a	a	a	c	d
A. prodromus	b	c	f	a	a	c
A. pusillus	b	a	a	a	b	a
A. putridus	b	a	a	e	b	?
A. quadrimaculatus	b	a	c	b	d	c
A. rufipes	b	a	a	a	a	b
A. rufus	b	a	a	a	a	d
A. scrofa	b	a	a	b	d	?
A. sordidus	b	d	f	b	c	b
A. sphacelatus	b	d	f	a	a	e
A. subterraneus	a	a	a	d	d	b
A. zenkeri	b	c	a	c	c	b
H. testudinarius	b	a	h	c	d	c
E. sus	b	a	g	c	d	?
E. villosus	b	e	d	a	c	b



10 Entirely black or dark brown, length 5-6.5 mm
.....The commonest entirely black species is *A. ater* but in upland areas it may be partly replaced by *A. lapponum* and *A. depressus*, though the latter is larger (length 6-9 mm).

- Elytra largely or entirely yellowish
.....11

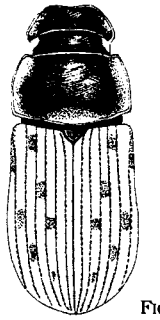


Fig.258.

11 Elytra with distinct, though small, black spots (Fig. 258)
.....Several species, of which *A. luridus* is the only species which can be regarded as being not uncommon.

- Elytra without distinct dark spots but often with the apical two-thirds or more suffused with black. Length 4-7 mm
.....12

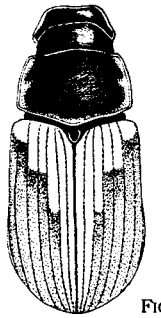


Fig.259.

12 Much of the elytra, except about the basal quarter or third, with a dirty suffusion, the front margin of which may appear as a fairly distinct inwardly diagonal mark forming a V (Fig. 259).
.....The commonest species having this colouration of the elytra are *A. prodromus* and *A. sphacelatus* ; the former is often very abundant and almost ubiquitous, the latter rather less so. In *sphacelatus* the hind margin of the pronotum is usually very narrow though distinctly paler whilst in *prodromus* it is black

- Elytra clear unicolourous yellowish.
..... One of the more frequent of our *Aphodius* with clear orange elytra is the small *A. merdarius* which is mainly found in horse dung; length 4-5 mm.

Note. The above key is only intended to give pointers to possible identity and students are recommended to consult the key by Jessop (1986) should they require specific identifications.

Genus *Heptaulacus*
The single British species, *H. testudinarius*, is easily distinguished from *Euheptaulacus* spp. by the black, very coarsely punctured pronotum. The colour of the elytra varies from light to dark brownish, the darker specimens with pale irregular spots. The example shown here (Fig. 260) is exceptionally pale. Length 3-5 mm. See also the tabular key, pages 88 and 89.

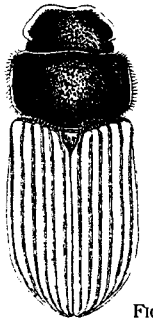


Fig.260.

Genus *Euheptaulacus*
The pronotum in the two British species is much more finely punctured than in *H. testudinarius*. In *E. villosus* the colour is uniformally pale brownish while in *E. sus* the pronotum is darker brownish and there are scattered dark elytral patches (Fig. 261). Length 3-5 mm. See also the lateral key, Table 3, pages 88 and 89.

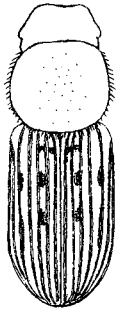


Fig.261.

Genus *Copris*
C. lunaris is our largest dung-frequenting scarabaeid and cannot be confused with any other beetle Fig. 262a & b). In size and habits it closely resembles one of the Geotrupidae. A very scarce and extremely local species known from a few places in southern England only but not recorded since the 1950s. Length 17-23mm.

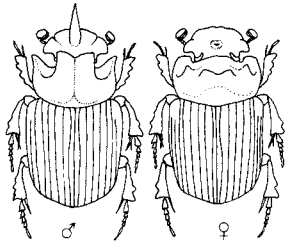


Fig.262.

Genus *Onthophagus*

Very distinctive blackish or greenish beetles in which the elytra are often yellow or pale brown with darker markings. They all have a southern distribution in Britain, being virtually absent north of the English midlands. Even in southern England several are very rare. Length 17-23mm.

1 Entirely dull black
.....2

- Elytra yellowish
..... 4

2 Front pronotal angles produced (extended forwards) (Fig. 263a). Length 7-10 mm. (Not recorded in Britain for 60 years)
.....*O. nutans*

- Front pronotal angles rounded (Fig. 263b). Length 4.0-11.5mm
.....3

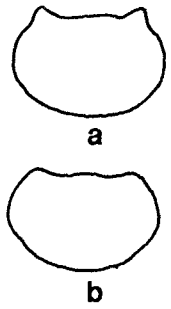


FIG.263.

3 Length 4-6 mm. Pale hairs on the elytra. (The commonest British *Onthophagus* occurring from North Wales and North Midlands southwards)
.....*O. joannae*

- Length 6-11.5 mm. Without pale hairs on the elytra. (Not recorded in Britain for 120 years)
.....*O. taurus*

4 Front angles of the pronotum rounded
.....5

- Front angles of the pronotum produced (extended forwards)
.....6

5 Darker parts dark green. Dark elytral markings not extending to elytral base. Length 7-13 mm. (Southern England, local)
.....*O. vacca*

- Darker parts blackish. Dark elytral margins on elytral interstice 5 reaching the elytral base (*ie.* the front end). Length 6-9 mm. (Southern England, very local)
.....*O. nuchicornis*

6 Head and pronotum very obviously greenish; elytra uniformly yellowish or with faint dark patches. Length 6-10 mm. (Southern England, local)
.....*O. coenobita*

- Head and pronotum blackish; elytra yellowish but always with darker markings. Length 4-7 mm. (Distribution as in *O. joannae* and fairly common in southern parts of England and Wales) (Fig. 264)
.....*O. similis*

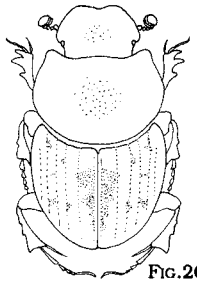


FIG.264.

Family CRYPTOPHAGIDAE

Members of this family sometimes occur in large numbers in old dung in which fungal colonisation is advanced, both adults and larvae feeding on fungal mycelia and spores. All cryptophagids are small; in some genera (*eg. Cryptophagus*) the sides of the pronotum are distinctly toothed.

1 Very broadly rounded with the pronotum widest across the hind angles (see Fig. 265 below). Length about 2 mm
.....Genus *Ootypus* (see below)

- Narrow species in which the pronotum is usually widest before the hind angles (see Fig. 266 below). Length 1.0-2.5 mm
.....Genus *Atomaria* (see below)

Genus *Ootypus*
O. globosus , the only British species, is a shining black or partly reddish beetle of distinctive shape which is fairly common in old dung (Fig. 265). Length approximately 2mm.

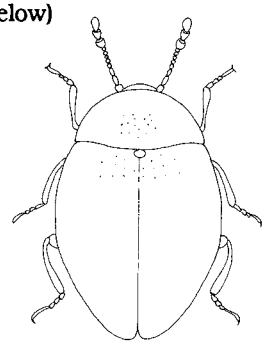


FIG.265.

Genus *Atomaria*
A large genus of reddish to blackish beetles, the identification of which is best left to the specialist. They are of fairly easily recognisable appearance, due in part to the closely spaced antennal insertions on the rather prominently rounded frons (front of the head - see the glossary) (Fig. 266). Some species are somewhat broader than that shown in Fig. 266 but a few others are narrower. Though more often found in manure or compost, several species have been recorded from old dung. Length 1.0-2.5mm.

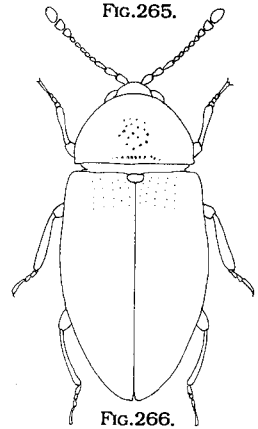


FIG.266.

Family ELATERIDAE (click beetles)

Amongst the common soil-frequenting insects which invade cow-dung in search of prey are the semi-carnivorous larvae of several click beetles. The common name for the adults refers to their habit of clicking when held, or of flicking themselves into the

air if they land on their backs. This is done by a special mechanism under the thorax. The larvae are the familiar "wireworms" - hard, smooth, waxy grubs usually of a rich yellowish colour but sometimes marked with brown - which feed mainly on plant roots, often causing great damage to crops. They are frequently found in old cow-dung, especially in springtime, and are quite unmistakable. Larval identification relies mainly on the shape of the last segment. In *Agriotes* it is pointed (Fig. 267b), but in other soil frequenting genera it is flattened and armed with two processes of varying shapes (Fig. 267c). The adults rarely occur under dung but they have a characteristic shape (Fig. 267a). They range from the small dull *Hypnoides riparius* (about 5 mm long) to the metallic purple or green *Ctenicera* and the large, attractively patterned *Lacon murinus* (about 18 mm long).

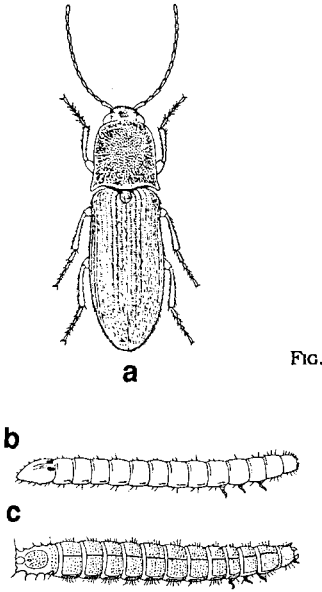


Fig.267.

ORDER DIPTERA

Insofar as the cow-dung community in Britain is concerned, this is an even more important order than the Coleoptera since fly larvae will always be found in samples and many more families include species which are exclusively coprophilous. They also appear to form the main prey of marauding carnivores, which may include other flies, beetles, soil arthropods or vertebrates. Some have been shown to be involved in the transmission of bovine diseases. Unlike the Coleoptera, however, adults are seldom found in samples unless the insects are netted over the dung before it is collected.

Note. Users of this habitat-based key must recognise the likelihood that other families/genera/species may occur as casuals. These could not all be predicted during the preparation of this work and must be identified by means of the standard taxonomic works in the list of References. However, the preliminary key to 'casuals' (p.36) and the notes in Part Three of this book (p.137) should help in identifying those families which are most likely to be encountered.

Family TRICHOCERIDAE (winter gnats)

A very small family of small flies differing from crane flies in having a much shorter anal vein (Fig. 268a). As their name suggests, these fly mainly in winter, often in large swarms in mild weather. Sometimes they may be found sheltering under debris on the ground (including old cow-pats).

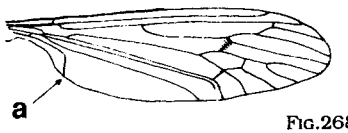


Fig.268.

The larvae somewhat resemble small tipulid larvae (Fig. 268b) but the head capsule with the distinct black 'A' beneath (Fig. 268d), and the four rounded lobes around the perispiracular field should distinguish them (Fig. 268c). They may be found occasionally in numbers in old cow-pats but are merely casuals; they belong to the soil fauna.

The larvae are not yet identifiable to species with any degree of certainty but the abundant species *Trichocera regalationis* is easily recognised in the adult state by the dull greyish colour and the faint clouding over the cross veins.

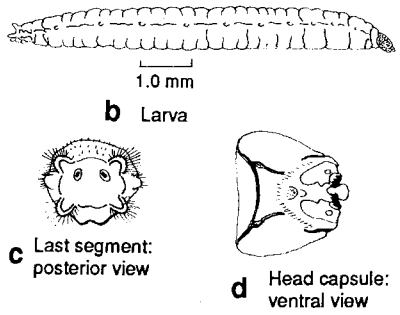
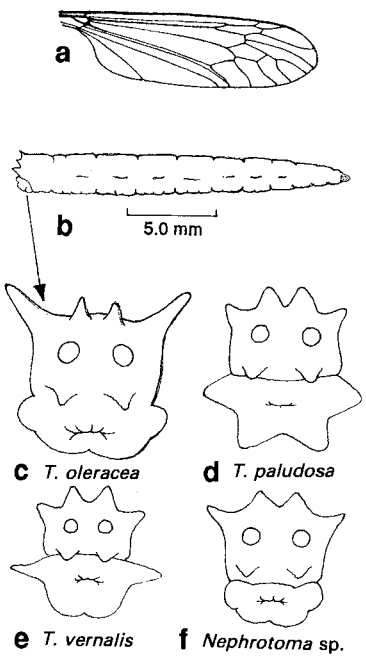


Fig.268.

Family TIPULIDAE (crane flies, or daddy long-legs)

Owing to their large size and widespread distribution the crane flies are familiar to us all. An example of the 'typical' wing venation is shown in Fig. 269a. Many crane flies enter houses at night, attracted by the lights, and several breed in profusion in pastures. The larvae, known as 'leatherjackets', of some of these pasture species may be found in cow-dung though they really belong to the soil fauna (Fig. 269b). The identification of many of the larger leatherjackets is fairly easy, being based mainly on the lobes around the anus and perispiracular field. These should be viewed from directly behind after the larva has been killed by immersion in very hot water. The relative size of the lobes can then be seen easily. The lobes of the four most ubiquitous pasture tipulid larvae are shown here (Fig. 269c,d,e & f). These larger leatherjackets are unlikely to be mistaken for any other insect larvae. The thick skin, retractile head (very obvious in live specimens) and the characteristic lobes just mentioned give them a distinctive appearance. The adults are probably never found in cow-dung and are, therefore, beyond the scope of this book.



anal lobes of larva

Fig.269.

Family PSYCHODIDAE (moth flies)

A large family of tiny flies which, though often extremely abundant, are overlooked by most people. As the name implies the adults are rather like very small moths - their wings, which are often prettily patterned with scale-like hairs, are held at rest in a delta-shape like moths (Fig. 270a).

Psychodid larvae, often numerous in cow-pats, are easily recognised by the apparently multiple-segmented body with its sparse hair tufts, the rather triangular head capsule (Fig. 270c) and the pointed last abdominal segment. Fig. 270b shows a typical *Psychoda* larva in dorsal view. Fig. 270d shows a pupa of *Psychoda* sp. Psychodid larvae have been insufficiently studied at present to permit specific identification. For identification of the adults of British species see Coe *et al.* (1950) and Withers (1989).

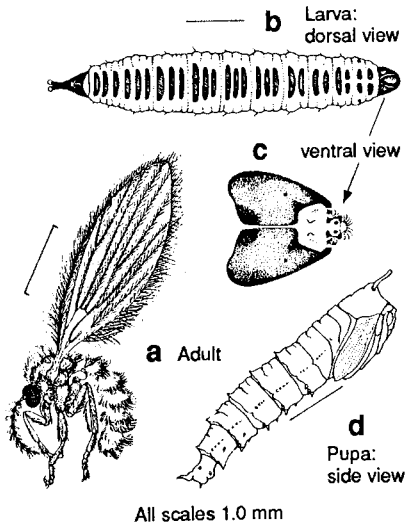


FIG.270.

Family CERATOPOGONIDAE (biting midges)

A large family of mostly very small midges, some of which are extremely troublesome bloodsuckers, especially in northern hilly areas. However, *Forcipomyia* species, two of which breed commonly in cow-dung, are inoffensive to man. Like others in this genus they probably suck the blood of larger insects. Two species of *Culicoides* are recorded also from cow-dung but, unlike many others in this large genus (which includes all of the notorious bloodsuckers), they are not known to attack man. Though very small, these flies are rather distinctive (Fig. 271a & b). In the males the antennae are plumed but unlike those of the following family (the Chironomidae), the hairs arising from the antenna itself are pointed very obviously forwards so that the plume appears quite narrow (Fig. 271b). In *Forcipomyia* the body and wings are clothed with dark hairs, those on the wings being densest along the front margin which, therefore, appears broadly darkened except for a pale spot about the middle and a fading out towards the tip. Vein 4 is forked (Fig. 271c)

Forcipomyia larvae (Fig. 271d) cannot be mistaken for any other fly larvae owing to their covering of long bristly hairs which arise in distinct clusters from small tubercles; often globules of fluid adhere to these hairs giving a most bizarre, frosted appearance to these larvae. Their movements are very slow.

Culicoides larvae (Fig. 271e) are totally different, being extremely active 'wrigglers', very closely resembling small worms in their movements and in the total absence of any false legs. However, the last segment has a circlet of stout hairs and there is a very distinct head capsule.

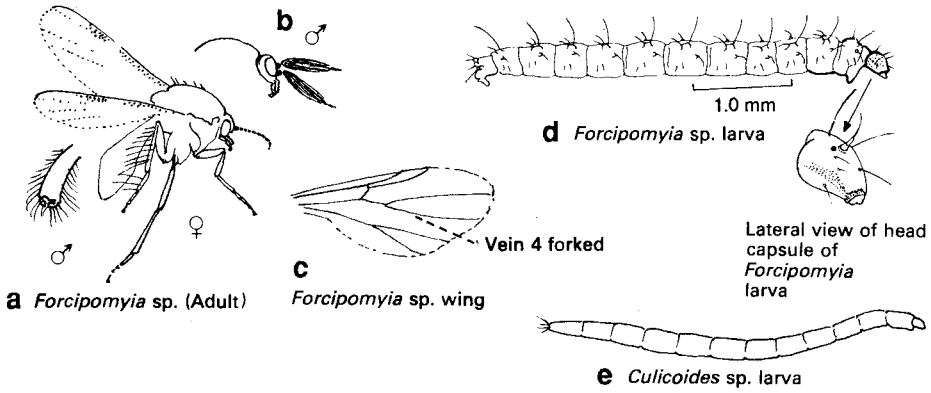


FIG.271.

Key to the genera of dung-frequenting Ceratopogonidae (larvae)

1 Body clothed with numerous long stout bristles arising from tubercles and the prothorax (*ie.* the segment immediately behind the head) with an obvious false leg. (See Fig. 271d above)
.....Genus *Forcipomyia*

- Body entirely without hairs except on the terminal (hindmost) segment. Prothorax without a false leg. (See Fig. 271e above)
.....Genus *Culicoides*

Key to dung-frequenting Ceratopogonidae (adults)

1 Wings with dense clothing of dark hairs, especially towards the front edge but with the clear patch about the middle and paler towards the tip. Body clothed in dense bristly hairs
.....Genus *Forcipomyia* 2

- Wings practically clear, with only microscopical hairs towards the tips. Body much less bristly
.....Genus *Culicoides*

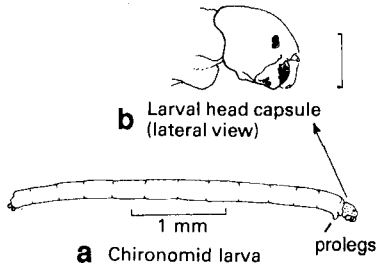
Note. In *Culicoides* species breeding in other situations the wings are usually patterned with light and dark patches.

2 Body very dark, clothed in black hairs
.....*F. brevipennis*

- Body clothed in dull brown hairs
.....*F. bipunctata*

Family CHIRONOMIDAE (midges)

The vast majority of species of this large family of flies breed in water, some being notable for their ability to survive in strongly de-oxygenated water. It is, therefore, not surprising that a few species breed in cow-dung. The adults of these species are very small black midges often with milky whitish wings. Frequently, the strongly plumed antennae of the males are also whitish. They can readily be distinguished from the biting midges mentioned above (family Ceratopogonidae) by the absence of a fork in vein 4 of the wings, the strongly projecting front edge of the thorax and much bushier antennal plumes of the males (Fig. 272c).



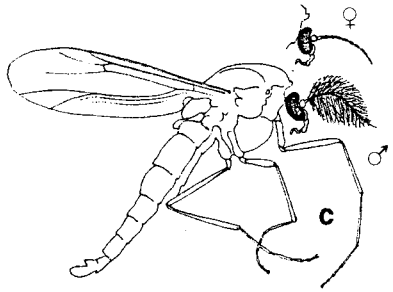


Fig.272.

The larvae of dung-frequenting chironomids are rather like *Culicoides* larvae mentioned above but have distinct prothoracic false legs and lobes on the anal segment in place of long hairs (Fig. 272a & b). The species concerned in this work have not been adequately studied in the larval stage for specific identification to be accomplished but only four species of Chironomidae have been positively recorded from cow-dung, based on reared adults. These can be distinguished by using the following key.

Key to dung-frequenting Chironomidae (adults)

1 Squamae (see the glossary - p.157) fringed with hairs (Fig. 273)
.....*Mesosmittia flexuella*

Fig.273.

- Squamae bare (Fig. 274)
.....2

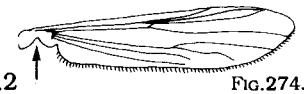


Fig.274.

2 Eyes entirely bare (Fig. 275)
.....*Camptocladius stercorarius*

Fig.275.

- Eyes clothed in very short pale hairs (Fig. 276)
.....*Smittia* species

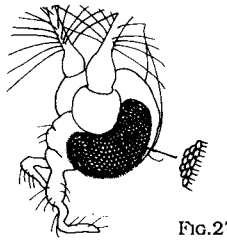


Fig.276.

All of the above species are extremely alike in general appearance and size (wing length 1.5-2.5 mm) and the males are best distinguished by the form of the claspers at the end of the abdomen, as shown in Fig. 277. Females of *Smittia* cannot be distinguished with certainty. For identification of British species see Pinder (1972).

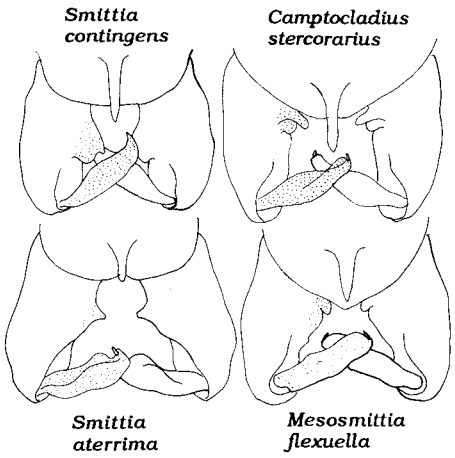


Fig.277.

Male claspers (dorsal view)

Family ANISOPODIDAE (window gnats)

Only one British species breeds in cow-dung but this is a very important member of the community, usually being one of the most abundant dipteran larvae present. The adults are seldom found in samples but often occur in large numbers at night. This fly, *Sylvicola punctata* is very distinctive, the wing having (approximately) three cloudy patches, as shown in Fig. 278a.

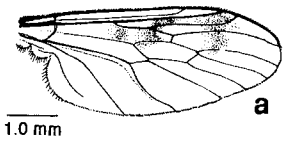


Fig.278.

The larva of *S. punctata* is also very easily recognised, being slender and wormlike with peculiar characteristic segmentation (Fig. 278b), unmistakable patterning of darker markings and 5 short rounded lobes around the anal spiracles (Fig. 278d). A larval head capsule is illustrated opposite (Fig. 278c). These larvae often occur in huge quantities in older cow-pats and are replaced subsequently by the distinctive pupae with their circlets of short spines around the abdominal segments (Fig. 278e).

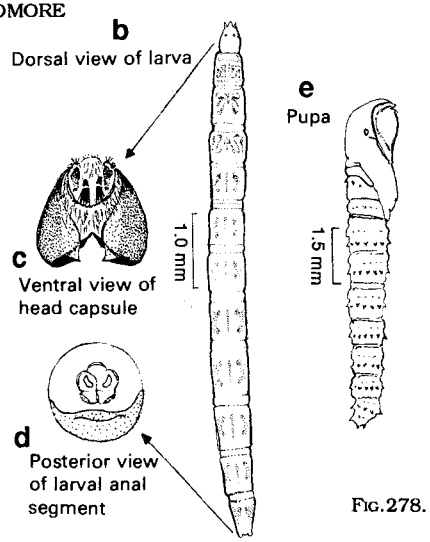


FIG.278.

Family BIBIONIDAE (fever flies, St Mark's flies)

Mainly black, heavy bodied flies which occur often in large swarms in grassy areas. In *Bibio* the front tibia has a sharp apical spur (Fig. 279b), whilst in *Dilophus* there is an apical circlet of spines instead (Fig. 279c). The adults probably never occur in cow-dung but the very distinctive larvae may sometimes invade from the surrounding soil. They are unmistakable amongst fly larvae in having round spiracles on the sides of all body segments (except the last where they are on the posterior face). The body is covered with short spines (Fig. 279d). They belong to the soil fauna. For identification of British species see Freeman and Lane (1985).

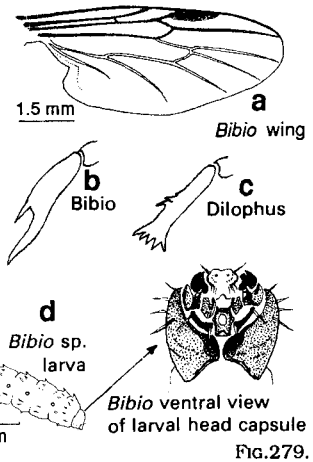


FIG.279.

Family SCIARIDAE (fungus midges)

Several species of these flies breed commonly in cow-dung but they have yet to be fully investigated; the total number of species and their true identity remain little understood.

Sciarid adults are quite distinctive being delicate, very active flies with scuttling gait, long antennae and legs, long spurs on the ends of the tibiae and very constant wing venation (Fig. 280a). In the male, the apical abdominal segment has strong paired claspers, replaced in females by a long pointed

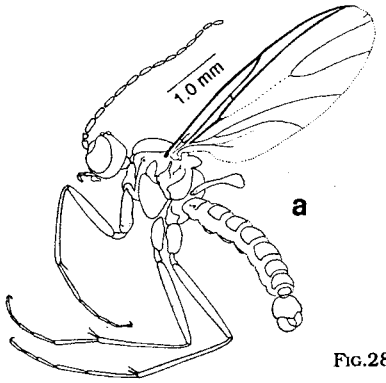


FIG.280.

ovipositor. *Pnyxeia scabiei* is remarkable in being wingless.

Sciarid larvae are very slow moving, rather featureless, whitish creatures which are, nevertheless, quite distinctive (Fig. 280b & c). In the pupae, there are pointed processes on the front of the head in front of the eyes (Fig. 280d).

As the name suggests these flies breed in fungi and very large numbers may be found on cow-dung, especially in old pats. It is not known, however, whether any species are exclusively associated with this medium. For identification of British species see Freeman (1987).

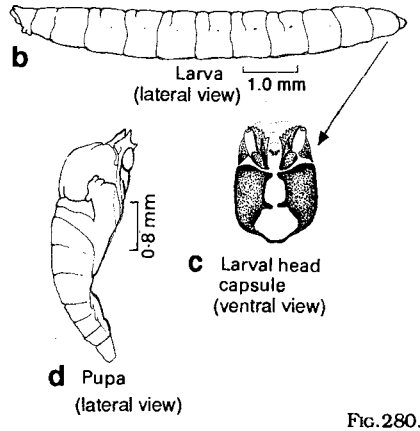


FIG.280.

Family SCATOPSIDAE

Very small, usually blackish, flies of very distinctive appearance, owing to the oblong body, short many-segmented antennae, short legs and usually whitish wings, on which only the veins near the front edge are pigmented (Fig. 281a). As in midges the wing needs to be viewed against a dark background with the light coming from above, in order to see the unpigmented veins. Alternatively, the translucent veins can be viewed with a strong light source directed from behind or underneath the wings. Five British species have been recorded from the dung of ungulates and the adults of these can be distinguished using the key below, but others probably occur also.

Scatopsid larvae are also easily recognised by their very lethargic movements and the body being extensively clothed in very short hairs (Fig. 281b, c & d). For identification of British species see Freeman and Lane (1985).

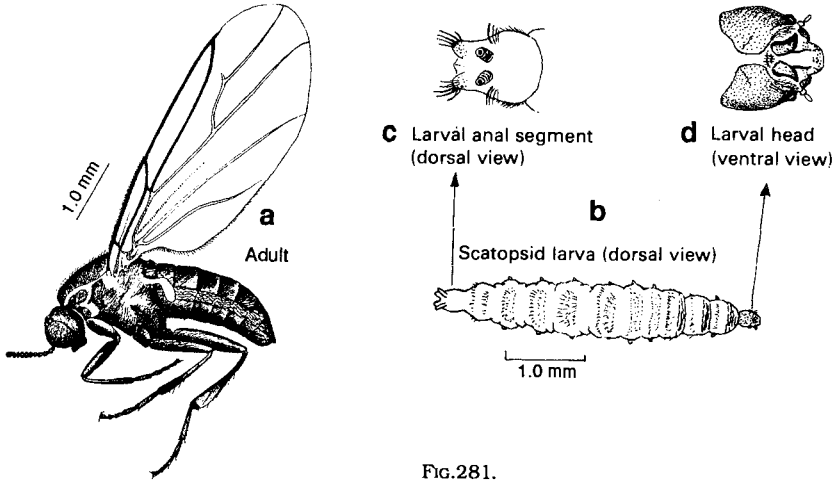


FIG.281.

Key to dung-frequenting Scatopsidae (adults)
(all illustrations' scales show 1mm)

1 Wings with distinct hairs on most long veins and on the membrane towards the posterior margin (Fig. 282). Body shining black with a yellowish base to the halteres
.....*Anapausis nigripes*

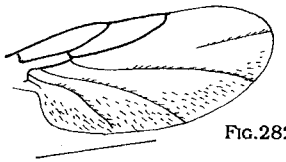


Fig.282.

- Wings without hairs on the membrane or on the long veins. Various colour combinations
..... 2

2 Complete cross-vein (cv) connecting the base of the median fork with the apex of the radial vein (Fig. 283). Black species with yellowish white tarsi
.....*Cookella albitarsis*

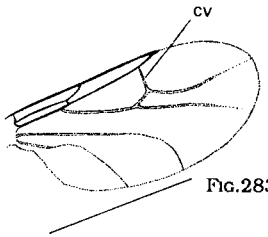


Fig.283.

- Cross-vein absent; at most a stub on the base of the median fork. Not black with white tarsi
.....3

3 Costal vein (c) hardly passing the middle of the front edge of the wing (Fig. 284). Entirely black including the halteres
.....*Coboldia fuscipes*

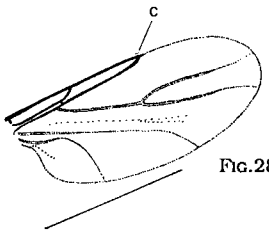


Fig.284.

- Costal vein clearly surpassing the middle of the front edge of the wing. Halteres, at least, are yellow
.....4

4 Upper branch of the median fork without a stump or an angle at the base (Fig. 285). Length 1.0-1.5 mm
.....*Reichertella pulicaria*

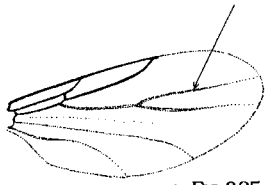


Fig.285.

- Upper branch of the median fork with a stump at the base (Fig. 286). Length 2.5-4.0 mm
.....*Scatopse notata*

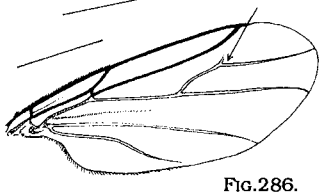


Fig.286.

Family STRATIOMYIDAE (soldier flies)

The soldier flies recorded from the dung of herbivores all belong to the subfamily Sarginae and are resplendent metallic flies with a characteristic wing venation. Three genera with eight species in total have been reared from cow-dung, and none could be mistaken for any other dung insects, either in adult or larval stages. The lethargic armoured larvae are very slow growing and are usually found in old dung. The adults are often seen visiting or ovipositing in fresh dung. For identification of British species see Oldroyd (1969).

Key to genera of dung-frequenting Stratiomyidae (Adults)

1 Eyes densely hairy. Length 7.5-9.0 mm
. Genus *Chloromyia* (p.104)

- Eyes without hairs. Length 3-12mm
.....2

2 Length 3.0-5.5 mm. Relatively broad flies (Fig. 287). Body entirely metallic green or abdomen shining black
.Genus *Microchrysa* (p.104)

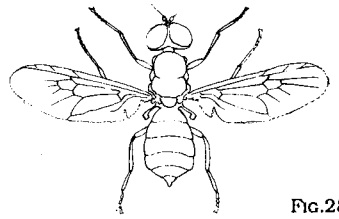


Fig.287.

- Length 6-12 mm. Relatively narrow flies (Fig. 288). Abdomen never shining black
.....Genus *Sargus* (p.105)

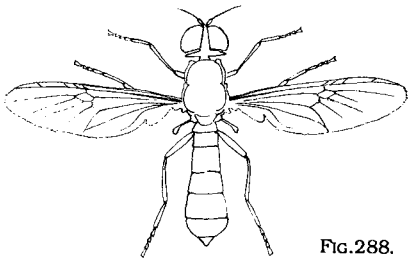


Fig.288.

Key to genera of dung-frequenting Stratiomyidae (Larvae)

1 Bristles on the abdominal segments short - barely half as long as the segment on which they are located (measured longitudinally); those on the last segment are much shorter than the length of the preceding segment (Fig. 289). Length up to 14 mm
.....Genus *Sargus* (p.105)


Fig.289.

- Abdominal bristles longer, most a little shorter than 'their' segment but those on the hindmost segment as long as (or even longer than) the length of the preceding segment. Length up to 12 mm
.....2

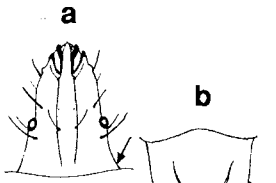


Fig.290.

2 Head widened behind the eyes (Fig. 290a) and the anal segment with apical bristles (ap) as long as subapicals (sap)(Fig. 290b). Length up to 12 mm
.....Genus *Chloromyia* (see below)

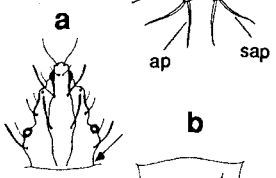


Fig.291.

- Head narrowed behind the eyes (Fig. 291a) and the anal segment with apicals (ap) minute; at most a third as long as the subapicals (sap)(Fig. 291b). Length up to 8 mm .
.....Genus *Microchrysa* (see below)

Genus *Chloromyia*
C. formosa , our only species, is a beautiful fly. The thorax is green; abdomen golden (♂) or dark blue (♀). The entire body, including the eyes, is clothed in light brown or dull orange fur, and the wings are slightly yellowish. The larva is pale brownish with about seven darker bands running the full length of the upper surface. Generally common in lowland areas.

Genus *Microchrysa*
The three British species are all fairly common generally and are familiar visitors to cow-dung. They are distinguished in adult and larval stages as follows.

Key to Larvae

1 Bristles on the body have dilated tips (Fig. 292)
.....*M. cyaneiventris*

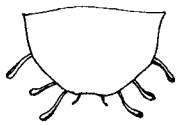


Fig.292.

- Bristles on the body without dilated tips
..... 2

2 Apical bristles (ap) of the anal segment about 1/5 length of the subapicals (sap) (Fig. 293). Length up to 8 mm
.....*M. polita*

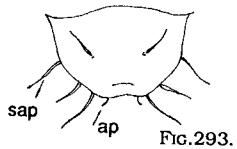


Fig.293.

- Apical bristles (ap) about 1/3 as long as the subapicals (sap) (Fig. 294). Length up to 6 mm
.....*M. flavicornis*

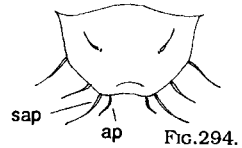


Fig.294.

Key to Adults

1 Abdomen shining black in contrast to metallic green thorax. Base of the antennae yellowish. Length 3.0-4.5 mm
.....*M. cyaneiventris*

- Abdomen **and** thorax metallic green. Length 3.5-5.5mm
.....2

2 Antennae entirely black. Length 4.5-5.5 mm
.....*M. polita*

- Antennae yellowish at base. Length 3.5-4.5 mm
.....*M. flavicornis*

Genus *Sargus*
Four British species of these superb flies have been recorded breeding in cow-dung, the adults often being seen visiting or ovipositing in fresh pats. As in many flies the males' eyes are holoptic (*ie.* joined along the top of the head) or very nearly so, but are clearly separated in the female. More unusually, the females are more colourful than the males. The larvae have shorter bristles than the previous two genera but often have similar longitudinal darker bands. At present it is not possible to separate adequately the four species mentioned below on larval characters. The adults of the species found on cow-dung are separated as follows.

Key to Adults

1 Legs orange, including all the femora
.....2

- Legs with at least the femora black
.....3

2 Length 10-15 mm. Thorax and abdomen unicolorous metallic green (♂); **or** thorax green, abdomen mostly clear orange towards the base and metallic blue with purple reflections in the apical half (♀). (A fairly common pasture species on the wing from July to early October)
.....*S. bipunctatus*

- Length 6.5-10.0 mm. Thorax metallic green. Abdomen is without orange at the base (front end); often entirely metallic blue or purple, frequently more bronze or coppery towards the apex (hind end) (Fairly common and highly eurytopic, also being found in woods and moorland areas)
.....*S. splendens* (♀)

3 Back of the head with very short irregular hairs behind the eyes, but longer ones in the midline (look from above). Entirely metallic green. Length 6.5-10.0 mm. Legs extensively orange
.....*S. splendens* (♂)

- Back of the head, behind the eyes, with a continuous fringe of uniformly long hairs. Length 6-12 mm. Legs usually darker
.....4

4 Wings with a dark cloud across the middle. (Distribution in Britain uncertain owing to confusion with the next species
.....*S. cuprarius*

- Wings without a dark cloud across the middle. (Generally common throughout Britain)
.....*S. iridatus*

Family RHAGIONIDAE (snipe flies)

The humicolous larvae may be found occasionally in old cow-dung (Fig. 295b & c). The adults of the 'downlooker' or 'snipe' fly (*Rhagio scolopacea*) are abundant in pastures in May and June (Fig. 295a). For identification of Rhagionidae see Oldroyd (1969).

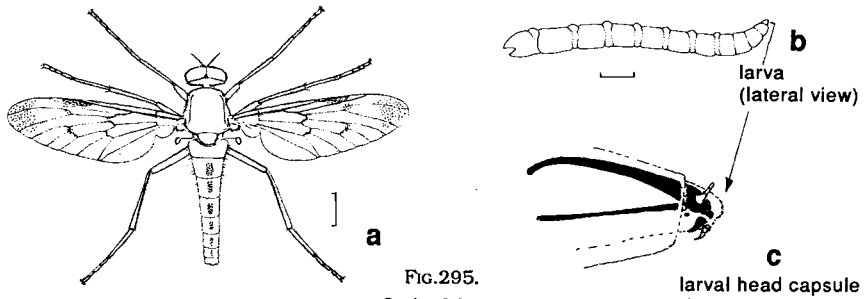


FIG.295.
Scales 2.0 mm

Family ASILIDAE (assassin flies)

One of the British species, *Asilus crabroniformis* (Fig. 296), one of our largest and most spectacular flies, measuring up to 25 mm in length and brown, black and bright yellow in colour, has often been recorded hunting around and perching upon old cow-dung. As the name implies, these flies are predaceous and among other insects noted as prey of this species are the rove-beetle *Philonthus splendens* , several dung beetles (*Aphodius* species), many of the larger dung-frequenting muscids (*eg. Mesembrina, Polietes* , etc.) and various sphecid and social wasps which themselves visit cow-dung in search of prey. Female *Asilus* are said to have been seen ovipositing in cow-dung and *Asilus* larvae have been recorded preying upon *Geotrupes* larvae. These observations have led to speculation that the species breeds in cow-dung, but this is mistaken. The larvae live in the soil, taking at least two years to develop and there is no conclusive proof that they are predaceous, although asilid larvae will certainly consume dead larvae of other insects. Formerly more widespread, this fly is now mainly found on the southern coastal counties from Kent to Cornwall. None of the other British asilids have been recorded visiting cow-dung. For identification of British species see Oldroyd (1969).

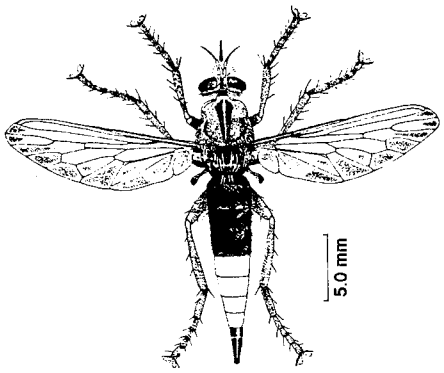


FIG.296.

SUPER-FAMILY EMPIDOIDEA

The three following families which constitute this superfamily are all large and diverse but the very few genera recorded from cow-dung are easily separated from each other on wing venational characters, etc., in the adult stage. Extremely little is known about the larval stages.

Family HYBOTIDAE (empid flies)

A large and extremely heterogeneous family many of which have humicolous larvae, and some may occur as casuals in cow-dung. As far as is known, however, only two genera include species which usually (? always) breed in cow-dung. The larvae are insufficiently known at present and the Figures here merely show a 'typical' empid larva (Fig. 297a) and pupa (Fig. 297b), not those of the relevant genera. In the adult state these genera are unmistakable and no key for their separation is needed. Collin (1961) gives keys to the British species.

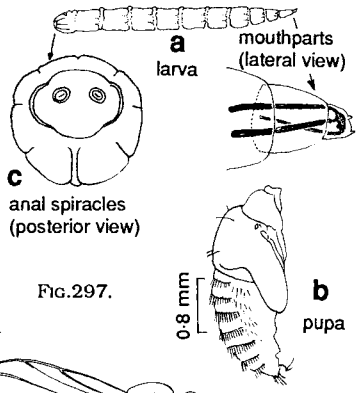


Fig.297.

Genus *Drapetis*
Tiny black rather hunchbacked, highly predaceous flies (Fig. 298), the specific identification of which is dependent on rather obscure characters. Length about 1 mm. Mainly found in more southerly parts of Britain.

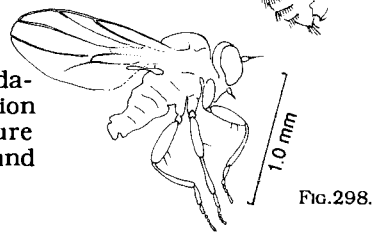


Fig.298.

Genus *Ocydromia*
O. glabricula is a small, very delicate fly in which the mainly blackish male has dark, very iridescent wings, whilst the mainly orange female has clearer wings (a wing is illustrated in Fig. 299). *O. glabricula* is very common species only known to breed in cow-dung.

Fig.299.

Family EMPIDIDAE (empid flies)

The only empid which has been recorded yet from cow-dung, where the humicolous larva no doubt occurred as a casual invader from the soil, is *Empis (Xanthempis) trigramma* (Fig. 300a). This is a yellowish fly with three dark dorsal thoracic lines. The wing-venation is typical of the family as is the very long downwardly-directed proboscis, adapted for a predatory mode of life (Fig. 300b). Collin (1961) provides a key to the British species.

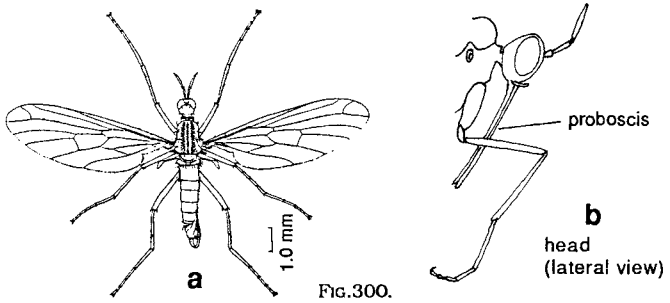


Fig.300.

Family DOLICHOPODIDAE (long-headed flies)

Many species of *Dolichopus* may visit fresh cow-dung in search of other small, delicate flies upon which they prey. They are of very distinctive appearance and predominantly metallic green in colour (Fig. 301). None, however, can be regarded as belonging to the cow-dung community. For identification of British species see Fonseca (1978).

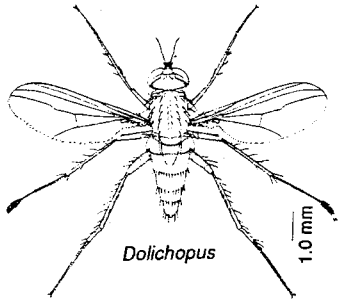


Fig.301.

Family SYRPHIDAE (hoverflies)

A large family of often spectacular flies whose characteristic wing venation renders them unmistakable (Fig. 302a). Only one species breeds in cow-dung, *Rhingia campestris*, a rather robust dark brownish grey fly with an orange abdomen and a long pointed snout; this is an adaptation to house the remarkably long proboscis which enables the fly to obtain nectar from long tubular flowers. The larva (Fig. 302b) is a soft-bodied, very dirty-looking maggot clothed with numerous tiny dark spines and longer star-like or branched processes of which the longest are on the last segment (Fig. 302c). The dorsal surface of the last segment also has a central prominence from which the anal spiracles arise. Length up to 12 mm. *Rhingia campestris* is a very common species throughout Britain. For identification of British hoverflies see Stubbs and Falk (1983).

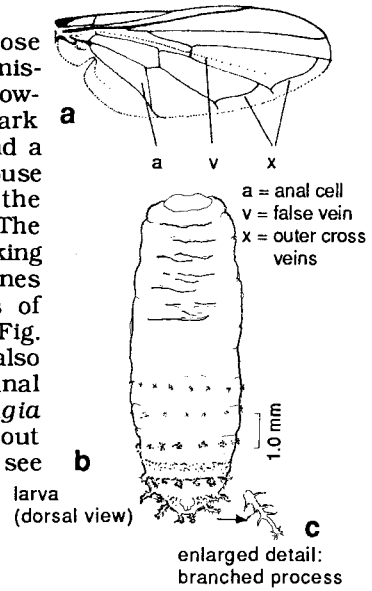


Fig.302.

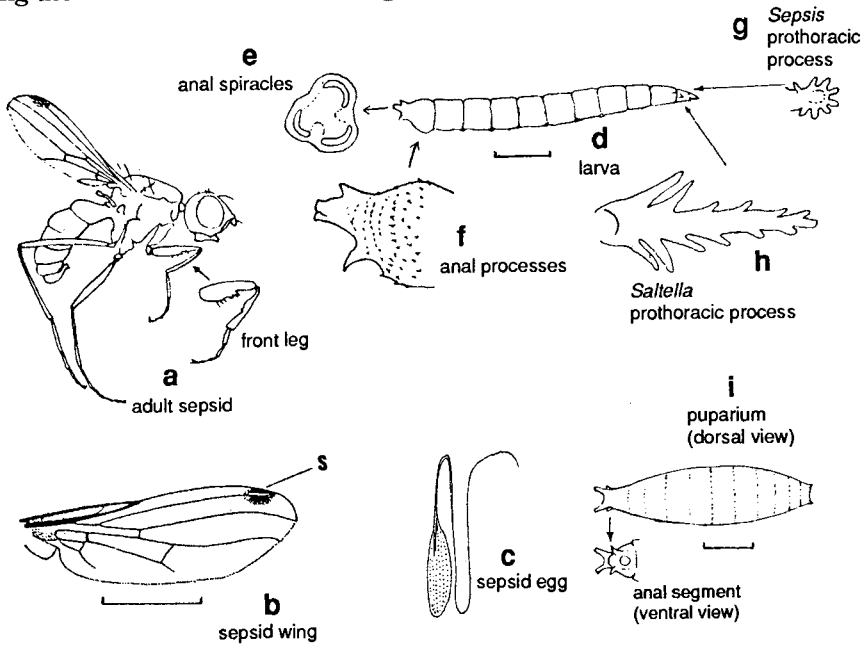
Family SEPSIDAE (sepsid flies)

A rather small family of distinctive flies of mainly dark-metallic colour with a distinct waist giving a somewhat ant-like appearance (Fig. 303a). In life, the wings, which in the main genus, *Sepsis* , have an apical dark spot (Fig. 303b), are held open and habitually waved in a semaphor-like motion. Identification of the adults is complicated by the strong sexual dimorphism, the males having ornamentations on the legs (Fig. 303a - inset). The key below merely separates the main genera; for specific identification of the adults, Pont (1979) should be used.

Sepsid eggs often have remarkably long thread-like respiratory horns which protrude from the surface of the dung when the egg is laid in the fresh cow-pat (Fig. 303c). These eggs cannot be mistaken for those of any other family of dung insects.

Sepsid larvae (Fig. 303d) are also rather distinctive as their anal spiracles (Fig. 303e) are borne on prominent processes which have supplementary horns at their bases (Fig. 303f). The length of the anal spiracular process is related to the larval habits; in *Saltella* and *Sepsis cynipsea* the processes are shorter and these live in the freshest dung, whilst in those inhabiting older dung (eg. *Sepsis flavimana, S. duplicata*, etc.) they are longer. The length of the prothoracic spiracular processes (on the sides of the second segment of the larva) also show a range in form; in *Saltella* they are very long and many-branched (Fig. 303h) but in other genera they are star-like (Fig. 303g). These larval features of course are still clearly distinct in the puparium. It is not yet possible to key out the larvae easily since little is known about some species. Sepsids are ubiquitous in cow-dung and are probably of great importance in the community. The adults often abound on flowers and may occur in huge swarms locally.

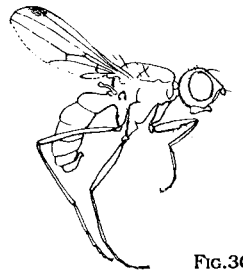
The puparium is also illustrated (dorsal view: Fig. 303i), with the inset showing the ventral view of the anal segment.



All scales 1.0mm

Fig.303.

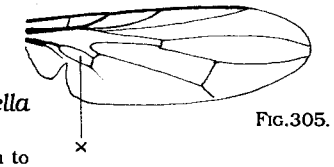
Key to genera of dung-frequenting Sepsidae (adults)



1 Wing with a dark preapical spot (Fig. 304). Ten British species, several of which are ubiquitous members of the cow-dung community, though none are restricted to this medium
.....Genus *Sepsis*

Fig.304.

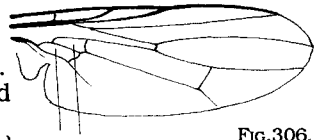
- Wings clear
.....2



2 Wing with only one basal cell (x) (Fig. 305)
.....Genus *Saltella*

Fig.305.

Note. The only British species, *S. sphondylii* is only known to breed in cow-dung and is fairly common from North Wales and northern England southwards.



- Wing with two basal cells as in *Sepsis* (Fig. 306). Only one of the ten British species is recorded from cow-dung. Entirely shining black flies
.....Genus *Themira (putris)*

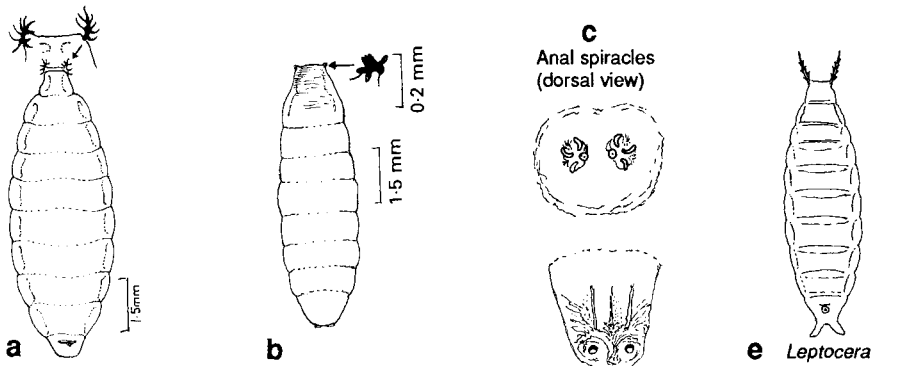
Fig.306.

Family SPHAEROCERIDAE (lesser dung flies)

A large family containing many species which breed mainly or exclusively in dung, and including some of the most abundant and ubiquitous members of the cow-dung community. Most species are black and of small to minute size, but they are readily recognised by the rapid scuttling habits in life and the very short basitarsus of the hind leg - see Fig.58, p.28. These flies often penetrate below the dung surface, using the tunnels made by larger insects and hence they are the flies most often found in samples of dung. The three British subfamilies are easily distinguished on their wing venation but identification to species is best achieved by reference to Pitkin (1988) in view of the large number of species and the probability that more of them will be found to occur in dung than have been recorded to date.

The immature stages of many species have been described but Pitkin considers that many of the earlier ecological records in the literature must be treated with caution. The main character for separating the three subfamilies is the shape of the prospiracular process but this is not applicable at generic level since the form thought to be characteristic for Sphaerocerinae

and Copromyzinae may also occur in Limosininae. In general it may be said that larvae (or, of course, puparia) with very long, only moderately branched processes belong to Limosininae (Fig. 307e), but strongly branched ones may also be Sphaerocerinae (Fig. 307a), whilst more star-like ones may be Copromyzinae (Fig. 307b). Until more species are known in the larval stage it will not be possible to identify sphaerocerids with any accuracy. In the case of puparia, Limosininae often have the anal spiracles on long processes similar to sepsids but lacking the basal horns. In Sphaerocerinae and Copromyzinae the anal spiracles lie in same plane as the posterior face of the segment.



a *Sphaerocera* puparium (ventral view) showing prospiracular processes enlarged

b *Copromyza* puparium (dorsal view) showing prospiracular process enlarged

e *Leptocera* puparium (ventral view)

Fig.307.

Key to the subfamilies of dung-frequenting Sphaeroceridae (adults)

1 Wing vein 5 practically reaches the wing margin or at least extends beyond the outer cross vein (x) (Fig. 308)
...Subfamily Sphaerocerinae (see opposite page)

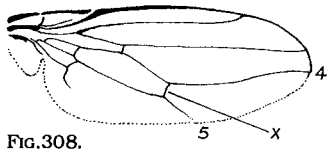


Fig.308.

- Wing vein 5 stops at the outer cross vein
.....2

2 Wing vein 4 reaches the wing margin (Fig. 309)
....Subfamily Copromyzinae (see opposite page)

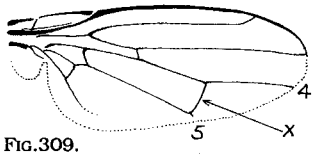


Fig.309.

- Vein 4 not reaching the wing margin (Fig.310)
.....Subfamily Limosininae (see opposite page)

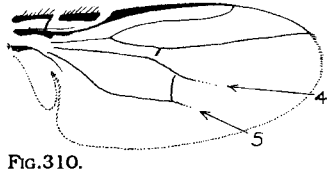
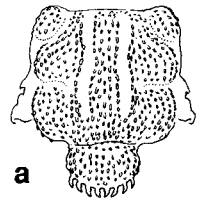


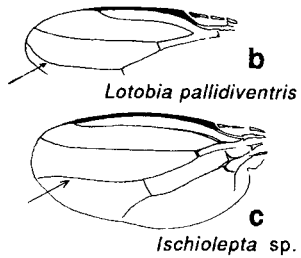
Fig.310.

Subfamily Sphaerocerinae



a

Included in this small subfamily are some of the more easily recognisable species. As in other groups, there may be considerable ecological differences between closely related species. For instance, whilst the largest British *Sphaerocera*, *S. curvipes*, is one of the commonest members of the horse-dung community, it has not been recorded breeding in cow-dung; indeed it is very seldom seen even visiting cow-dung. In contrast, *S. monilis*, is a cow-dung species which is unrecorded from horse-dung. The genera *Ischiolepta* and *Lotobia* have numerous tubercles on the upper surface of the thorax (Fig. 311a) whilst in the latter genus (including only one species, *L. pallidiventris*) vein 4 curves strongly forwards at the wing tip (Fig. 311b), unlike in *Ischiolepta* spp. (Fig. 311c).



b *Lotobia pallidiventris*

c *Ischiolepta* sp.

Fig.311.

Subfamily Copromyzinae

This subfamily includes the largest sphaerocerids, several species exceeding 4 mm in length. Many show interesting contrasts in dung preferences. Thus, whilst *Copromyza equina* and *C. similis* are ubiquitous in ungulate dung, *C. stercoraria* is only a rare stray from other biotopes.

Subfamily Limosininae

A very large subfamily of mostly minute flies the identification of which often relies on obscure characters requiring high magnification. As in other subfamilies, however, there are very considerable ecological differences between closely related species.

Family GASTEROPHILIDAE (horse bot flies)

Whilst these parasitic flies are only associated with horses the family is included in the event of this work being used in studies of the horse-dung community. *Gasterophilus* larvae feed in the alimentary canal of horses and when ready to pupate they release their hold on the wall of the gut and are passed out during defaecation. A larva is illustrated in Fig. 312. Very soon after deposition they pupariate and the very distinctive puparia are sometimes found in the dung. They are easily recognisable through their large size (c. 20 mm long) and the armature of very large spines encircling the intersegmental regions. The adult bot flies are very short-lived and do not feed. They resemble honey bees in size and colour.

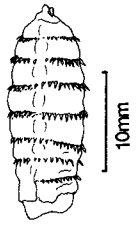


Fig.312.

Family OESTRIDAE (warble flies)

The species of *Hypoderma* are parasitic in the larval stage on cattle and deer, breeding in the skin of these animals. When fully grown, the larvae burrow out of the skin and drop to the ground where they pupariate, the flies hatching a week or so later, usually during June or July. Puparia may occasionally occur in cow-dung, presumably where much of the ground is covered in cow-pats (*eg.* watering places, gateways to pastures, etc.). The fully grown larvae (Fig. 313) and puparia closely resemble those of *Gasterophilus* (see above) in size and general shape but lack the strong spines around the segmental boundaries. Instead each segment has a number of large irregular swellings.

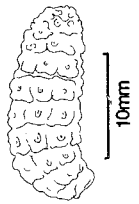


FIG.313.

Two species affect cattle (*H. bovis* and *H. lineatum*) and these occur throughout much of the country although they are not generally common since farmers are keen to eradicate them where they appear. They can cause a great amount of damage to the health of the cattle and to their hides. A third species, *H. diana* occurs in the Scottish Highlands where it affects deer in a similar way. As in *Gasterophilus* the bee-like adults are very short lived and do not feed.

Family SCATHOPHAGIDAE (yellow dung flies)

The only members of this family which develop in dung are the species of *Scathophaga*, loosely termed the yellow dung flies although the name is usually applied to *S. stercoraria*, the commonest species and the one which most people will have seen. The densely furry golden males often abound in pastures, especially in the springtime, or they congregate on cow-pats along with the duller greenish females. These flies are highly predaceous and will often attack much larger insects - even craneflies are not safe from them. When in peak numbers these flies must consume vast numbers of other insects, including pest species, and they are probably of considerable economic importance. *S. stercoraria* differs from its close relatives in having black antennae (Fig. 314a). In upland areas it may be replaced by the more orange brown and generally smaller *S. furcata* which has orange antennae, dark stripes on the front femora and the two cross veins on each wing strongly clouded. Being mainly an upland species in Britain, *S. furcata* partly replaces *S. stercoraria* in the sheep dung community. Putnam (1978) discusses the mating strategy of *S. stercoraria* in detail. Collin (1958) provides a key to the British species.

Scathophaga eggs are very distinctive, having two rounded lobes protruding at the front end, from which the pleats run back to meet at about the middle of the egg. In the somewhat similar eggs of the mydaeine muscids (see page 118), the lobes are pointed and often serrated. *Scathophaga* larvae are filthy-looking maggots clothed in dense black spines. There are strong papillae (wart-like protuberances) around the anal spiracles (Fig. 314c) and there are 15 to 20 lobes on the prospiracular processes (Fig. 314d). These details are all clearly seen in the puparia, so these should also be recognised easily.

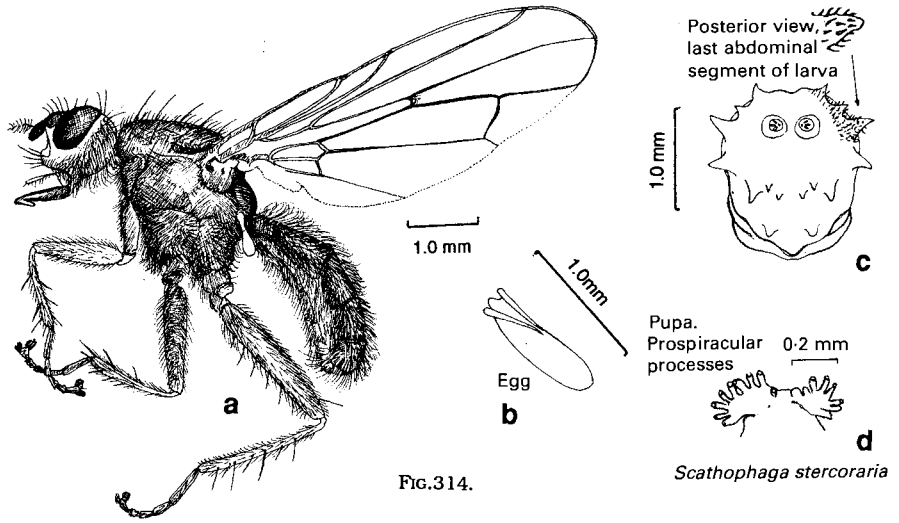


FIG.314. *Scathophaga stercoraria*

Family ANTHOMYIIDAE

Most members of this large family of flies breed in living plants (in leaf mines, roots or fruits, stems, etc.). Quite a number live in fungi. A very few genera include species which commonly breed in dung, the commonest affecting cow-dung being *Hylemya* and *Paregle* .

Anthomyiid eggs mostly resemble the phaoniine muscid type (see page 117), but, as in the Muscidae, some species are "ovoviviparous" (*ie.* the eggs are retained in the female until they hatch, so that young larvae are laid instead of eggs).

Anthomyiid larvae resemble *Scathophaga* in having distinct lobes or papillae around the anal spiracles, but unlike *Scathophaga* they are never clothed in black spines throughout. When such spines are present, they are restricted to the segmental margins. However, the body may be covered in an extremely fine pale pile of hairs which are much shorter than the spines found in *Scathophaga* and often may be clearly visible only on the last segment. Species of *Delia* and *Emmesomyia* have been recorded from cow-dung but probably only as casual visitors.

Key to genera of dung-frequenting Anthomyiidae (larvae)

1 Length up to 10 mm. With the prospiracular process obviously bipartite (Fig. 315a) and the mouth hook without a strong process behind (Fig. 315b)
.....Genus *Hylemya* (p.116)

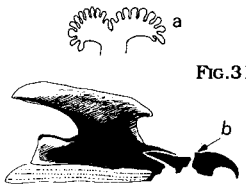


FIG.315.

- Up to 8 mm. With prospiracular process not bipartite (Fig. 316a). Mouth hooks with a very strong process behind (Fig. 316b)
  Genus *Paregle* and *Nupedia* (see below)

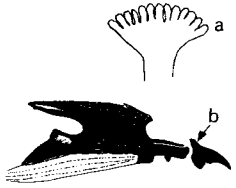


Fig.316.

Genus *Hylemya*
Two of the four British species (*H. nigrimana* and *H. vagans*) are well known cow-dung species, the latter being very common everywhere although the larvae are seldom found in any numbers in any individual cow-pat. This is presumably because the females are "ovoviviparous", depositing a single larva at a time. *H. nigrimana* and *H. vagans* are very similar in all respects, although the former is much more local in distribution.

Genera *Paregle* and *Nupedia*
In larval morphology and habits *P. cinerella*, *P. radicum* and *N. aestiva* are all very similar, and it is not yet possible to separate the species readily on larval characters. Unlike *Hylemya*, the females of these species lay eggs in the normal way and sometimes the larvae may be found in numbers in individual cow-pats (Fig. 317).

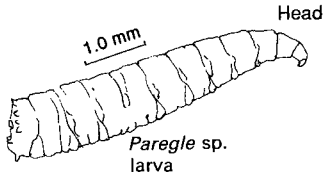


Fig.317.

Family FANNIIDAE

Larvae of this family occasionally occur in the old dung of ungulates, the most frequent perhaps being those of the lesser housefly *Fannia canicularis* in horse-dung. *Fannia* larvae are recognised very easily by their strongly reticulated cuticle and the spiny processes on all body segments. These are

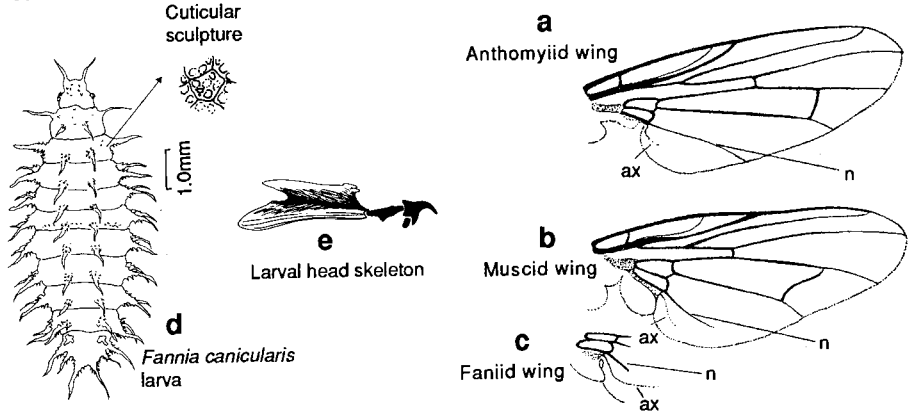


Fig.318.

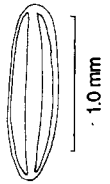
very well developed in *F. canicularis* (Fig. 318d) but much less so in some other species. The larvae show a very superficial similarity to those of the family Stratiomyiidae but in the fanniids the anal spiracles are clearly visible on the upper surface of the last segment and the mouthparts (Fig. 318e) much more closely resemble those of their relatives, the anthomyiids and muscids. Adult fanniids are much more difficult to distinguish from adults of these two families, the main difference being in the alignment and length of the anal and axillary veins (n and ax in the Figure opposite). In the fanniids an imaginary extension of the axillary vein would cross an extension of the anal vein before the wing margin (Fig. 318c), whilst in the muscids (Fig. 318b) and anthomyiids (Fig. 318a) these veins are parallel or divergent. The lesser housefly is the most ubiquitous domestic fly and it has been recorded breeding in more habitat types than any other insect apart from the housefly, *Musca domestica*. In general, however, fanniids are associated with decaying plant matter and many breed only in fungi. It is possible that when these larvae occur in old dung they are feeding on fungal hyphae and spores. For identification of the British species see Fonseca (1968).

Family MUSCIDAE (houseflies, etc.)

A large family of flies with many dung-frequenting species whose larvae perform a leading role in the cow-dung community. The adults never descend below the surface but will usually be well represented in sweep samples over cow-pats. Whilst most of the adults are of rather sombre coloration, patterned in greys and browns, the family includes some of the largest and most spectacular flies belonging to the dung community. Most conspicuous of all is the magnificent black noon fly (*Mesembrina meridiana*), a large bluebottle-sized black fly with orange wing bases and orange patches on the face. The habits of its equally large relative *Polietes lardaria*, a black and grey species, is also likely to attract attention. Large congregations gather on fresh cow-dung and rise with a great buzzing when disturbed. Some muscids (*ie. Neomyia* and *Eudasyphora*) are a beautiful metallic green or blue. Quite a number cause some annoyance by their bloodsucking habits (*ie. Haematobia* and *Haematobosca*) or their fondness for mammalian perspiration (the 'sweatflies' - *ie. Morellia*, *Drymeia vicana*, and *Musca autumnalis*). Several of the latter (especially *M. autumnalis*) transmit diseases amongst cattle (*eg.* Summer Mastitis). See Fonseca (1968) for comprehensive identification of the adults and Skidmore (1985) for details of the biology of the Muscidae worldwide.

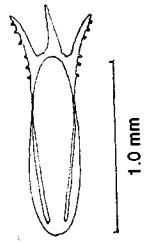
The eggs of muscids are of three main types:-

(a) **Phaoniine** type with broad flanges (the *hatching pleats*: lines of weakness from which the larvae emerges) running the full length of the dorsal surface but not projecting from either end (Fig. 319). Similar eggs are found in many other families of flies and this is assumed to be the primitive type in the Muscidae. In the genera listed on p.150 this type is found in *Muscina*, *Alloeostylus* and *Helina*.



Dorsal view
Fig.319.

(b) **Mydaeine** type with broad hatching pleats which project from the front end to form two or three horns of varying length (Fig. 320). The eggs are laid so that these horns project above the dung surface and act as respiratory horns. A similar type is found in *Scathophaga* (see above; p.114), but in the mydaeine type these horns are pointed and often have serrated edges. This type is found in *Hebecnema*, *Mydaea*, *Myospila*, and to a lesser degree, in *Brontaea*.



Dorsal view
FIG.320.

(c) **Muscine** type with hatching pleats taking the form of very narrow ribs which terminate just before the apices (Fig. 321a). An unusual variant is seen in *Musca autumnalis* where the front end of the egg is produced into a single respiratory horn (Fig. 321). As in the mydaeine type, this egg is laid so that the horn sticks above the dung in which it is laid. In *Mesembrina*, the egg, which is of the muscine type, is huge (about 4.5 mm long) and it hatches very soon after deposition (sometimes even whilst still in the parental oviduct). *Morellia*, *Neomyia* and *Eudasyphora* eggs are laid in batches of 50 or more in chambers excavated by the fly just below the surface of very fresh dung.

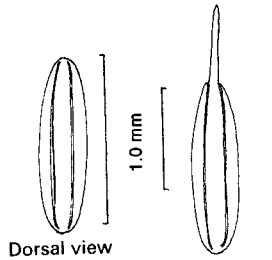


FIG.321.

In this book the muscids of the cow-dung community are divided into three main groups on larval morphology so that their role in the community may be easily appreciated (their morphology can be related to their position in the food web - see Fig.381 and the species list on pp.147-151). The recognition of these three main groups relies heavily on details of the larval mouthparts but these should be seen easily under modest magnification (up to x50 for smaller larvae). The larvae are killed by immersion in hot water; then a small cut or hole is made towards the front end of the body; the head end is then gently pressed under a glass coverslip so that the dark internal mouthparts can be seen easily through the skin (Fig. 322a). It will be seen that the armature (*ie.* the darkened mouthparts) consists of three parts as shown in Fig. 322b. At the anterior end are the paired *mouth hooks* (m), next the *hypopharyngeal sclerite* (h) and finally, the largest part, the *pharyngeal sclerite* (p) with its two backwardly directed processes or *cornua*. Having recognised these three main parts (which shouldn't be too difficult despite any confusion caused by the terminology!), it is necessary to look again at the mouth hooks. In some species an extra rod is seen below the hook and running parallel to it. This is the oral bar (o) and it usually reaches the apex of the hook. Having established whether, or not, the oral bar is present, examine the lower edge of the large pharyngeal sclerite. Is there a clearer part along the lower edge, sometimes showing very faint longitudinal parallel lines, or is the pharyngeal sclerite uniformly dark throughout? The clear pharyngeal floor with longitudinal lines indicates a *pharyngeal sieve* (s), whilst the uniformly dark pharyngeal sclerite indicates its absence. Now examine the rear end of the maggot, looking mainly at the paired anal spiracles (Fig. 322c). On each

spiracle are three respiratory slits (breathing apertures). Do these take the form of 'S'-shapes (or snake-like lines) (Fig. 322d) or are they straight or nearly so? Finally note the colour of the gut of the maggot; is it dung coloured or yellowish?

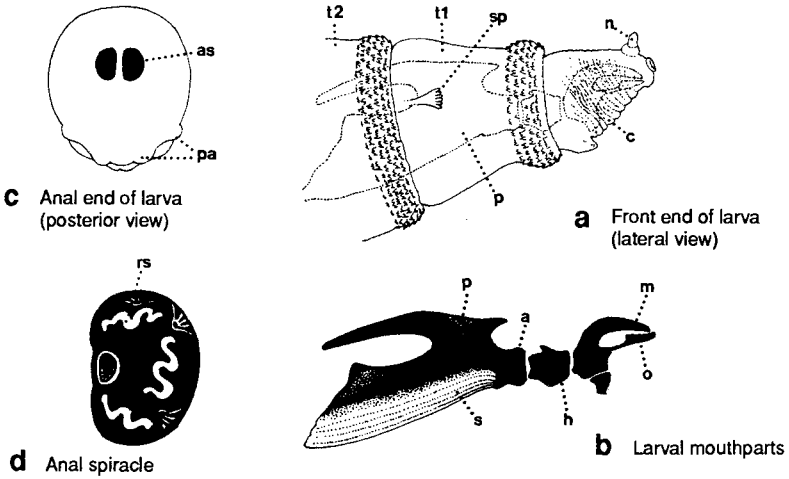


FIG.322.

The tabular key given in Table 4 (p.120) will identify the trophic group to which the specimen belongs.

A larva belonging to Trophic group **D** is purely coprophagous. One belonging to **E** is a facultative carnivore which can reach maturity on dung alone but will resort to carnivory if the chance arises. A category **F** species is purely carnivorous and will not survive if no prey is available although some at least appear capable of surviving without feeding for months. Some of the most rapacious carnivores amongst muscid larvae are, curiously enough, members of the facultative carnivore type.

Puparia of Muscidae are determined primarily on larval characters as described above except of course that gut colour is not applicable. There are, however, additional features which render the identification of some puparia easier than that of their respective larvae. In some *Hydrotaea* and *Brontaea* for instance the pupal horns are remarkably long (see p.127), whilst in many species the last segment has a strongly raised rim around the spiracular area. *Myospila* is unusual in that the puparium is usually enclosed in a cocoon. Perhaps most remarkable of all are the whitish puparia of *Musca autumnalis* with their huge anal plate (see p.125) (all other fly puparia found in cow-dung range from pale yellow to almost black; none has the chalky appearance of *M. autumnalis*, but an anal plate approaching the same size is found in *Neomyia*). *Morellia* puparia also are quite unmistakable owing to their reticulated cuticle and the diagonally flattened last segment. Fig. 323 overleaf shows the larva; in the puparium the shape is virtually identical but the flattened last segment is more accentuated.

TABLE 4
Tabular key to trophic groups of muscid larvae

TROPHIC GROUP	ANAL SPIRACULAR SLITS	ANAL SPIRACLES & ANAL PAPILLAE	PHARYNGEAL SIEVE	GUT	ORAL BAR
D	S-shaped to snake-like	Spiracles large; papillae distinct	Always present	Dung-coloured	Absent or rudimentary
E	Snake-like or straight	Spiracles large; papillae usually distinct	Always present	Dung-coloured or yellow	Complete
F	Always straight	Spiracles small; papillae usually absent	Always absent	Yellow	Complete

Key to genera of dung-frequenting larvae

(a) Trophic group **D** (coprophagous species)

1 Last segment of the body flattened, truncate (Fig. 323); skin leathery and strongly reticulate .....Genus *Morellia* (p.124)

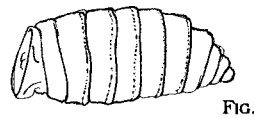


FIG.323.

- Last segment rounded (Fig. 324) and the skin not reticulate 2

FIG.324.

2 Minute oral bar present (Fig. 325) .....Genera *Neomyia* and *Eudasyphora* (p.124)

FIG.325.

- Oral bar absent 3

3 Pharyngeal sclerite with a strong dorsal tooth (t) (*ie.* located on the posteroventral cornua) (Fig. 326) .....Genus *Musca* (p.125)

FIG.326.

- Pharyngeal sclerite without this tooth (Fig. 327) 4

FIG.327.

4 Anal spiracles very large (separated by much less than the width of one of the spiracles) .....Genus *Haematobia* (p.125)

- Anal spiracles small (separated by about the width of one of the spiracles) .Genus *Haematobosca* (p.126)

Note . The latter two genera have a largely complementary distribution, *Haematobia* being highly thermophilous (preferring warmer sites), whilst *Haematobosca* is more eurythermic (tolerates a wider range of temperatures). Hence in colder areas only the latter occurs. Very exceptionally in Britain it is possible that *Stomoxys calcitrans* could breed in cow-dung in pastures as it does in hotter climates. The larvae would run out in this key to *Haematobosca* but the anal spiracles are still smaller and more triangular in shape. It is a very common species in manure heaps.

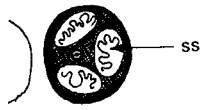
(b) Trophic group **E** (facultative carnivores)

1 Anal spiracular slits S-shaped to tortuous. The pharyngeal sclerite with an obvious atrial angle (Fig. 328: at)
.....2

Fig.328.

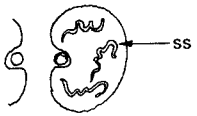
- Anal spiracular slits straight or nearly so. The atrial angle sometimes absent but not always
..... 3

2 Anal spiracular slits tortuous (Fig. 329: ss). Very large deep yellow maggot, usually with a dung-coloured gut. Length up to 20 mm
.....Genus *Mesembrina* (p.126)



Anal spiracle
Fig.329.

- Anal spiracular slits (ss) slightly tortuous, or S-shaped (Fig. 330). Length up to 17.5 mm
.....Genus *Polietes* (p.127)



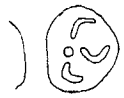
Anal spiracle
Fig.330.

3 Pharyngeal sclerite with a conspicuous atrial angle (Fig. 331: x). Length up to 8 mm
.....Genus *Azelia* (p.127)

Fig.331.

- Pharyngeal sclerite without, or with a very weak, atrial angle. Length up to about 10 mm
.....Genus *Hydrotaea* (part) (p.127)

Note. *Muscina* species have been recorded from cow-dung but probably only when this has been distributed from manure heaps where the room fly, *M. stabulans*, breeds commonly. The larva would run out to couplet 3 here but is very easily recognised by the larger size and the strongly curved anal spiracular slits - see Fig. 332(a). Another possible 'contaminant' from manure heaps which would also run out to this part of the key is *Hydrotaea dentipes*. The anal spiracular slits again reveal its identity for here they are straight, parallel, and sloping strongly inwards (see Fig. 332: b).


a Anal spiracle of *Muscina* larva


b Anal spiracle of *Hydrotaea dentipes* larva
Fig.332.

(c) Trophic group **F** (obligative carnivores)

1 Pharyngeal sclerite with a very distinct atrial angle (x), and a very long cornua (c) (Fig. 333)
.....Genus *Drymeia* (p.128)

Fig.333.

- Pharyngeal sclerite without a distinct atrial angle, and the cornua relatively shorter
.....2

2 Hypopharyngeal sclerite with an acute forwardly pointing dorsal tooth (t) and the pharyngeal sclerite (p) extremely slender (Fig. 334)
.....Genus *Helina* (p.128)

Fig.334.

- Hypopharyngeal sclerite without such a tooth and the pharyngeal sclerite not particularly elongate
.....3

3 Pharyngeal sclerite slender, usually with the dorsal (upper) cornua longer than the ventral (Fig. 335)
.....Genus *Hydrotaea* (part) (p.127)


Fig.335.

- Pharyngeal sclerite robust, with the cornua of equal length or the dorsal slightly shorter than the ventral
..... 4

4 Pharyngeal sclerite distinctly parallel-sided with a window (w) in the pharyngeal constriction (pc), which is longer than the cornua (c) (Fig. 336)
.....Genus *Hebecnema* (p.128)

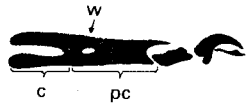


Fig.336.

- Pharyngeal sclerite widened behind, without such a window and with the cornua at least as long as the pharyngeal constriction
.....5

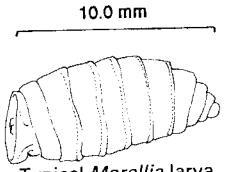
5 Mouthparts lacking a dorsal angle of the ventral cornua (Fig. 337)
.....Genus *Myospila* (p.128)

FIG.337.

- Mouthparts with a dorsal angle on the ventral cornua (Fig. 338)
.....Genus *Mydaea* (p.129)

FIG.338.

Genus *Morellia*
M. simplex and *M. hortorum* breed mainly in cow-dung and the adults are ubiquitous and troublesome sweatflies which may be found to be partially responsible for spreading the bovine diseases attributed to *Musca autumnalis* below (*ie.* Summer Mastitis, etc). They share with *Neomyia* and *Eudasyphora* the habit of laying their eggs in bubble-like chambers in very fresh cow-dung. The third British species is not known to be a sweatfly and it breeds in horse dung. This species (*M. aenescens*) is also smaller and more local in its distribution. *Morellia* larvae are unmistakable in shape and appearance (Fig. 339).

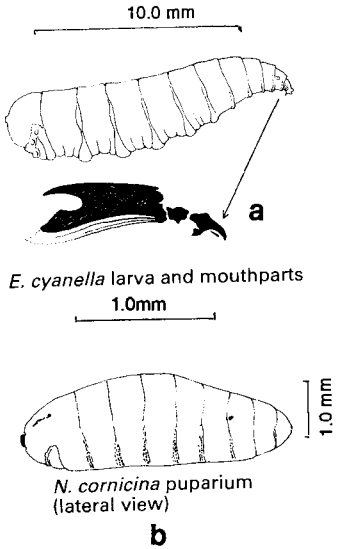


Typical *Morellia* larva

FIG.339.

Genera *Neomyia* and *Eudasyphora*
From a biological viewpoint, and in their larval form and oviposition habits, the four British species (two in each genus) are extremely similar except that adult *E. cyanicolor*, which are a most beautiful deep metallic blue, have only been recorded from sheep dung. It is far more cold resistant than the others and generally occurs in more upland areas. It probably does not share the same ovipositing habits of forming a chamber for the eggs since this would seem impossible in sheep dung. In contrast to *E. cyanicolor*, *N. viridescens* is essentially a southern species in Britain being scarce north of the Midlands. All of these flies hibernate in the adult state, unlike the vast majority of muscids which spend the winter as larvae.

A larva of *E. cyanella* and a puparium of *N. cornicina* are illustrated in Figs. 340a & b respectively.



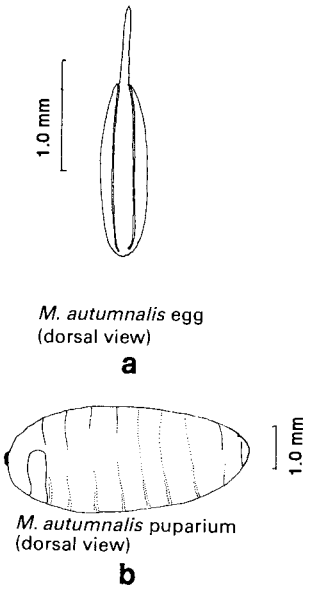
E. cyanella larva and mouthparts

N. cornicina puparium (lateral view)

b

FIG.340.

Genus *Musca*
Of the four British species, two of which are extremely rare, the one which concerns us in this book is the face fly *Musca autumnalis*. In most respects this is very different from the better known housefly, *M. domestica*. The adults of *M. autumnalis* show extreme sexual dimorphism, the male being black and orange, the female black and grey. Both sexes are sweatflies and they will feed on blood weeping from wounds. The species is now recognised as an important vector (carrier) of various diseases in cattle, notably Summer Mastitis. In all developmental stages it differs markedly from the housefly. It is the only muscid found in Britain with a single-horned egg (Fig. 341a). The larva, whilst having mouthparts very like *M. domestica*, differs in the enormous anal plate which is larger than in any known British muscid. The puparium (Fig. 341b) differs from all other known British muscids in being chalky whitish in colour. The species breeds primarily in cow-dung and sometimes larvae are found in very large numbers. Adults hibernate like *M. domestica* and the two previous genera. Contrary to the inference in Fonseca (1968), that this fly is very common and generally distributed, its occurrence in northern England is patchy whilst in Scotland it is known from very few areas. In more southerly parts of Britain it is a very familiar pasture fly. *M. domestica* does not belong to the cow-dung community, being a thermophilous eusynanthrope (warm-loving, living close to human habitation) it can only survive in our climate in artificial conditions. It often breeds in huge numbers in manure heaps, rubbish dumps, and, when these were widespread, in cess pits. *M. osiris* is only recorded from the dung of cows, donkeys and pigs, but is extremely rare in Britain.



M. autumnalis egg (dorsal view)

a

M. autumnalis puparium (dorsal view)

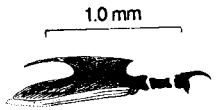
b

FIG.341.

Genus *Haematobia*
The single British species, the horn fly, *H. irritans*, is remarkable in many respects. A highly thermophilous species, it is found commonly only in the southern half of England and in Wales. The adults, whilst being fully winged, spend most of their life on the host animals (cattle) whose blood they suck through their needle-sharp probosces. As the cattle are moved from cowshed to pasture the horn flies accompany them and when a cow defaecates the female fly immediately darts down to oviposit and as quickly returns. It is said that the egg must be laid in dung at blood heat and that oviposition may occur before the dung has landed. The larvae quickly hatch and may occur in large numbers in a cow-pat. A week later they pupariate, usually in the pat.

Genus *Haematobosca*

In stark contrast to the horn fly, *H. stimulans* is more common in upland or northern areas, where the flies often abound on walls, etc. They too suck mammalian blood but are less specific in their choice of victim and spend most of their adult life away from the animals. Larval mouthparts of *H. stimulans* are illustrated in Fig. 342.

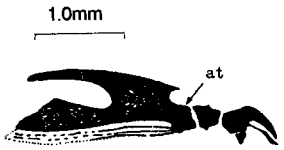


H. stimulans
larval mouth parts

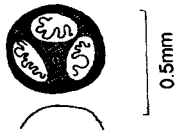
FIG.342.

Genus *Mesembrina*

The black noon fly, *M. meridiana*, is a spectacular insect in all respects, and, unlike some of the preceding, is in no way harmful from a human standpoint. An individual female lays up to five eggs during life (in contrast to say *Musca domestica* which may lay hundreds), and these are laid singly, at intervals of about two days. Therefore, she will only lay one egg per cow-pat because by the time the next egg is ready, the pat in which she laid the previous one will be too old. Consequently, each egg or larva found in a cow-pat must have been deposited by a different female. The egg hatches up to an hour after being laid but if oviposition is retarded, perhaps because a suitable cow-pat cannot be found, the egg may hatch in the parental oviduct, so that the fly deposits a first instar larva. If, however, she is even less successful this larva may undergo its first moult whilst still inside the parent, and a second instar larva is dropped. The third instar larva, like all facultative carnivores, becomes predatory if the opportunity arises. There are records of a single *M. meridiana* larva devouring large numbers of *Musca autumnalis* maggots, but they are not always highly carnivorous, despite their large size and formidable oral bars (Fig. 343a). The fully grown *M. meridiana* larva is the largest fly maggot to be found in cow-dung in Britain and appears to be popular with anglers and rooks alike. The deep yellow colour and lethargic habits together with the massive anal spiracles (Fig. 343b) and powerful mouthparts (Fig. 343a) make it easily recognisable. Pupariation occurs in the pat or on the soil just below and the puparium also is unmistakable, having a strong raised rim around the anal spiracles. Apart from the puparia of *Hypoderma* (and *Gasterophilus* in horse dung) it is the largest puparium found in herbivore dung in Britain. This fine fly occurs commonly throughout Britain.



a *M. meridiana*
larval mouth parts

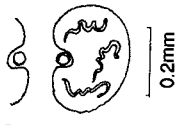


b *M. meridiana*
anal spiracle
of larva

FIG.343.

Genus *Polietes*

The four British species are very different in many ways although all the larvae are facultative carnivores, at least structurally. *P. lardaria* is the most abundant and the largest but carnivory has yet to be observed in the larvae, which may occur in huge numbers in fresh cow-dung. Both this species and *P. hirticrura*, which is a little smaller, are only known to breed in cow-dung, but the latter is extremely carnivorous and will eagerly consume the much larger maggots of *Mesembrina*. One might assume, therefore, that *P. hirticrura* should be a more successful species; this, however, is not the case for whilst it occurs commonly in northern and western Britain, it only otherwise occurs in Eurasia in eastern Siberia. *M. meridiana* on the other hand occurs throughout Eurasia. Curiously, however, P. *hirticrura* occurs widely in North America. The other two British *Polietes* breed in horse-dung, though *P. steini* is an extreme rarity. The very common *P. domitor*, though a facultative carnivore, is the most carnivorous of known muscid larvae when opportunity arises and it is clear that wherever it occurs very few other muscid larvae can survive (apart from the armoured larvae of *Morellia aenescens*). The larvae of the two cow-dung species are very easily distinguished. In *P. lardaria* the gut is usually dung-coloured and the anal spiracles are shallowly tortuous (Fig. 344a), whilst *P. hirticrura* is a much cleaner-looking entirely creamy-yellow maggot with S-shaped slits (Fig. 344b).



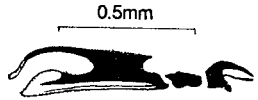
a *P. lardaria*

b *P. hirticrura*

FIG.344.

Genus *Azelia*

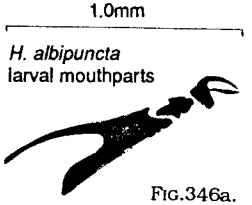
These are small muscids whose larvae may be found quite commonly in cow-dung. They much resemble small species of *Hydrotaea* but the anal spiracles are relatively larger and the last abdominal segment, at least in some species, is slightly pointed behind. The puparia are also similar to *Hydrotaea* but have much finer, straighter pupal horns. Also the cuticle is less rugose (coarsely sculptured) and thinner so the puparia appear yellowish rather than reddish. Larval mouthparts are illustrated in Fig. 345.



Azelia sp.
larval mouthparts FIG.345.

Genus *Hydrotaea*

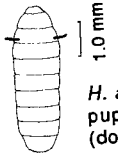
This is a diverse genus; some species have larvae which are facultative carnivores whilst others are obligative carnivores. An example of the former is *H. tuberculata*, and among the latter are *H. albipuncta* and *H. militaris*. It will be appreciated (from the comments on page 120) that in *H. tuberculata*, but not in the others just mentioned, there is a pharyngeal sieving mechanism. Generally, the most abundant *Hydrotaea* larva in cow-dung is *H. albipuncta* and in the adult stage, this species, like most *Hydrotaea* species, is a sweatfly. However, *H. albipuncta* mainly visits cattle. By far the most troublesome of these



H. albipuncta
larval mouthparts

FIG.346a.

sweatflies is the sheep head fly, *H. irritans*, which breeds in humus soil and may occasionally be found in the larval stage in old cow-dung. The adult swarms around most mammals, including humans, and is responsible for the transmission of several diseases of cattle. The larvae are generally easily recognised by the distinctive shape of the pharyngeal sclerite and the puparia by the long, thick, curved pupal horns. Larval mouthparts and puparia of *H. albipunctata* are illustrated in Figs. 346a & b respectively.

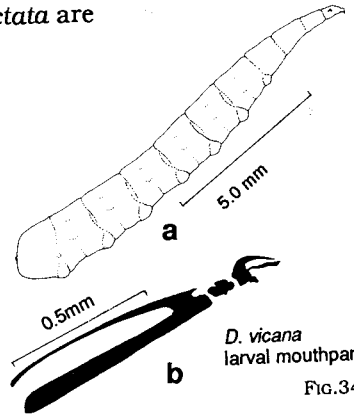


H. albipuncta puparium (dorsal view)

Fig.346b.

Genus *Drymeia*

D. vicana larvae are often numerous in old cow-dung and are very easily recognised by their extremely distinctive pharyngeal sclerite (Fig. 347b). They are very sleek, smooth-looking maggots (Fig. 347a) without the lobes which are so conspicuous around the anal plate in many of the muscid larvae mentioned above. The female flies are sweatflies and may occur in moderate numbers though these seldom reach the plague populations which typify *H. irritans* or, to a lesser extent, *Morellia*. Males are rarely seen.

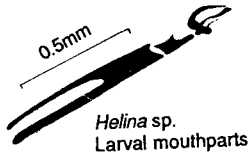


D. vicana larval mouthparts

Fig.347.

Genus *Helina*

Helina larvae mostly breed in humus soil from where they occasionally stray into cow-dung. In external appearance they are very like *Drymeia* but the pharyngeal sclerite lacks an atrial angle (Fig.348). The adults are mostly pollinators; none is a sweatfly.

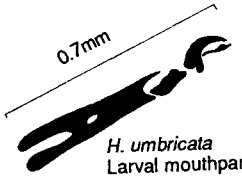


Helina sp. Larval mouthparts

Fig.348.

Genus *Hebecnema*

Hebecnema larvae are often numerous in cow-dung and have a distinctive pharyngeal sclerite (Fig.349). They are small maggots (length up to 8 mm). The puparia somewhat resemble *Hydrotaea* in having thick pupal horns though these are not usually as long. Adults have been recorded as sweatflies around cattle but this remains unconfirmed.



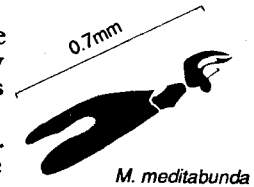
H. umbricata Larval mouthparts

Fig.349.

Genus *Myospila*

M. meditabunda is peculiar in that the eggs, which are of the typical mydaeine type (Fig. 320, p.118), have the horns and front half of the egg of a striking blackish colour. The larvae are highly predatory and this species has long been known as a major enemy of the housefly (*Musca domestica*) and the biting housefly (*Stomoxys calcitrans*) when it breeds in situations inhabited by the larvae of these flies. Since *M. meditabunda* is in no way harmful to man (unlike

some of the other major muscid predators on these same two flies) it must be regarded as being wholly beneficial. Another peculiarity of *M. meditabunda* is the cocooning habit of the larvae prior to pupation. This phenomenon occurs in very few muscids. *M. meditabunda* is one of the abundant, and therefore important, members of the cow-dung community. Larval mouthparts of *M. meditabunda* are illustrated in Fig. 350.

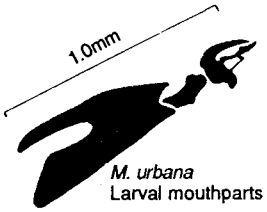


M. meditabunda Larval mouthparts

Fig.350.

Genus *Mydaea*

The biology of the *Mydaea* species occurring in cow-dung is very similar to that of *Myospila*, and eggs, larvae and puparia are also morphologically very similar. However, the eggs of *Mydaea* lack the blackish colouration of the horns, and the puparia are not enclosed in cocoons. The larvae similarly are voracious carnivores (mouthparts are illustrated in Fig. 351) and the adults are wholly inoffensive to man and his animals.

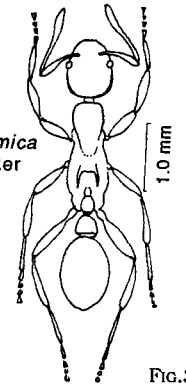


M. urbana Larval mouthparts

Fig.351.

ORDER HYMENOPTERA

Family FORMICIDAE (ants)



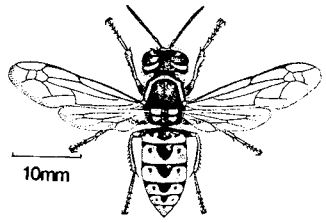
Myrmica worker

Fig.352.

Ants are frequently found under old cow-dung, especially in late summer when young queens are starting to establish new colonies. By far the commonest generally in such situations are red ants of the genus *Myrmica* (Fig. 352). For identification of British ants see Bolton & Collingwood (1975), and Willmer (1985).

Family VESPIDAE (social wasps, potter wasps, mason wasps)

These insects include the 'common' waps which are familiar to us all. The workers are sometimes seen on cow-dung, either sipping the moisture from the surface or foraging for prey. These wasps are distinguished from digger wasps (see below), which they superficially resemble in the striking black and yellow coloration, by the extremely narrow waist and abruptly widened abdomen, and by their wing venation (Fig. 353). Also, at rest, their front wings are longitudinally folded. For identification of British species see Willmer (1985) and Chinery (1986) .



German wasp *Paravespula germanica* (queen)

Fig.353.

Family SPHECIDAE (digger wasps)

The casual observer may mistake these for social wasps but they resemble these only in the black and yellow coloration. Amongst the very many differences are their habits, for, whilst these wasps may nest in colonies in a sense that numerous digger wasps burrows may occur in close proximity, there is no caste system and each female cares for its own progeny (young). Different species specialise on particular prey species to feed their larvae, and several use flies for this purpose. One of the commonest digger wasps in sandy areas is *Mellinus arvensis* (Fig. 354a) whose preferred prey include several of the muscids belonging to the cow-dung community (especially *Neomyia* and *Musca autumnalis*). Consequently, this wasp is often seen in late summer on fresh cow-dung, lying in wait for, or pouncing upon, the adults of these flies. Another common fly-hunter is the larger *Crabro cribarius* (Fig. 354b), the male of which has the front legs specially adapted for digging. For identification of British species see Richards (1980), Yeo and Corbet (1983), and Willmer (1985).

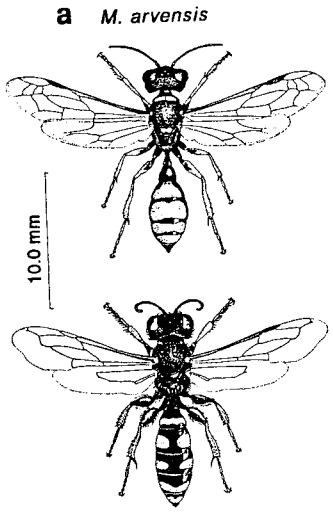


Fig.354.

Family ICHNEUMONIDAE (ichneumons)

A huge family of parasitic wasps whose range of hosts include most other groups of insects. A few ichneumons, all of small or very small size, parasitise fly larvae which belong to the cow-dung community. The main genus of ichneumons concerned in this activity is *Atractodes* (Fig. 353b), females of which may be found on fresh cow-dung searching for suitable hosts. Specific identification is best left to a specialist.

'Typical' wing venation - with two discoidal cross-veins (a,b) - is illustrated in Fig. 355a.

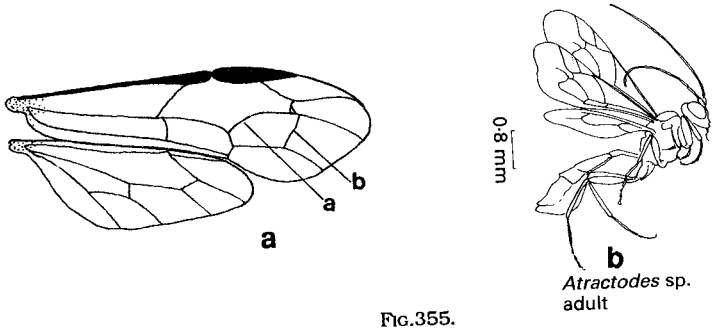


Fig.355.

Family BRACONIDAE

In most respects, members of this very large family very closely resemble ichneumons (Fig. 356a) but they possess only one discoidal cross vein instead of two - compare Fig. 356c (a braconid) with Fig. 355a (an ichneumon). In the cow-dung community this family is much more important than the previous one because several braconid genera are parasitic on fly larvae. The braconids concerned all belong to one very distinctive subfamily, the members of which should not be mistaken for any other parasitic Hymenoptera because of their aberrant mandibles. In other insects the main function of the mandibles is the fragmentation (chewing) of food and therefore their apices meet during feeding. However, in the alysiine braconids, which include the cow-dung species, the mandibles do not meet when closed (Fig. 356b) and often have large teeth on their outer surface, suggesting that their primary function is connected with opening rather than closing them. A number of possible explanations have been proposed. One is that they assist in rowing the insect through fluid substrates in search for prey, a not impossible explanation for those which breed in such situations, but in fact the majority of alysiines do not develop in such places. Another explanation is that they are used to break out of the puparia of their hosts - all of which are Diptera whose pupae are housed in puparia. A shortcoming of this hypothesis is that of all of the many groups of parasitic insects which develop in fly puparia only the alysiines have these peculiar mandibles: the normal biting type appear to be perfectly adequate for the purpose? Certainly the ancestors of the alysiines had normal mandibles, for their type is known in no other Hymenoptera.

The cow-dung alysiines are all very small, slender insects which may often be seen in large numbers crawling over fresh cow-dung. Generically, they are easily distinguishable from each other but specific separation is very difficult in many cases. The largest and most distinct species belong to the genus *Phaenocarpa*.

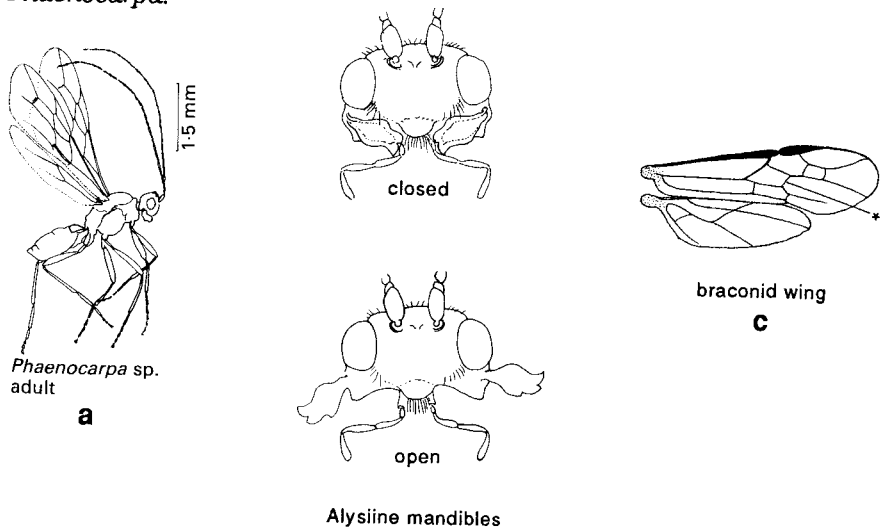


Fig.356.

Key to Genera of Braconidae recorded from dung of ungulates

Note. Fig. 357 illustrates the cell notation used in the following key.

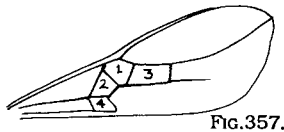


FIG.357.

1 Cells 1 and 2 of the forewing joined (Fig. 358) .....Genus *Aphaereta*

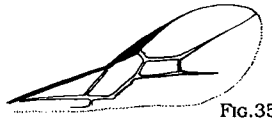


FIG.358.

- Cells 1 and 2 separated by a cross vein 2

2 Antennal joint 4 shorter than antennal joint 3 (Fig. 359) 3

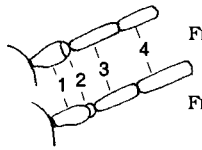


FIG.359.
FIG.360.

- Antennal joint 4 at least as long as antennal joint 3 (Fig. 360) 4

3 Cell 4 of the forewing absent (Fig. 361) .....Genus *Asobara*

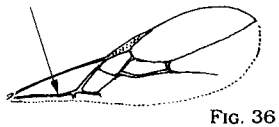


FIG. 361.

- Cell 4 present, though open towards the base of the wing (Fig. 362) ..... Genus *Phaenocarpa*


FIG.362.

4 Cells 1 and 3 of the forewing joined (Fig. 363) .....Genus *Synaldis*

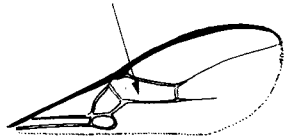


FIG.363.

- Cells 1 and 3 separated by a colourless cross vein (Fig. 364) .....Genus *Aspilota*

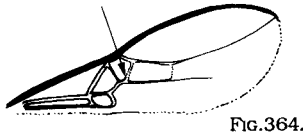


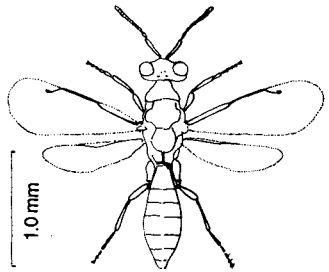
FIG.364.

As mentioned above, the braconids are frequently seen crawling over fresh cow-dung in search of their hosts which appear to consist mainly of muscid larvae. *Aphaereta* species have been mainly recorded from *Neomyia*, *Musca autumnalis* and *Haematobia irritans*, but there is some evidence that *Neomyia* may be favoured. *Phaenocarpa picinervis*, a common species with the outer discoidal cross vein clouded (as illustrated in the previous key), has been reared from puparia of *Hebecnema umbratica* and *Fannia canicularis*, suggesting that it is a general parasitoid of wide tastes. *Synaldis concolor* has been reared from *Hebecnema umbratica* and the related, though in Britain non-coprophilous, muscid genus *Lispa*. It may, therefore, be a specialist parasitoid on members of that muscid subfamily. Since *Aspilota* parasitizes muscids and fanniids which breed in manure heaps, this too may be a non-host-specific genus. *Asobara* has been reared from samples of fresh cow-dung and presumably attacks one or other of the earliest dipteran colonisers.

Family PTEROMALIDAE

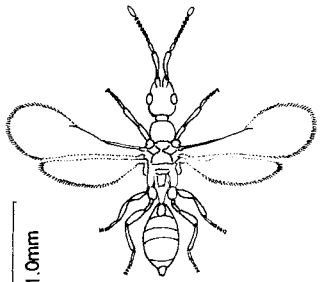
Another very large family of parasitic wasps, mostly of a very beautiful appearance when viewed under the microscope. The predominating colours are metallic greens and blues, often with yellow- or orange-marked legs and antennae and usually glassy-clear wings against which the very few wing veins stand out boldly in black. Their wing venation is characteristic of the group. A few genera only have been noted from cow-dung, the most remarkable being adult members of the genus *Spalangia*. These are unusual pteromalids, being predominantly black, rather flattened insects with a very characteristically shaped head (Fig. 365b). The adults of this and other genera which parasitise fly puparia may be found searching fresh cow-dung along with other parasitic Hymenoptera, or they may be seen awaiting emergence through the translucent walls of the puparia of their hosts.

Stenomalina species (Fig.365a) may occur commonly as casuals on cow-dung, straying from adjacent grasses where they parasitize chloropid larvae. *Nasonia vitripennis* and *Muscidifurax raptor* on the other hand mainly attack muscid and calliphorid puparia. *Spalangia* also chiefly attack these families and Anthomyiidae, but *S. subpunctata*, which has been noted in quantities on fresh cow- and sheep-dung, has been reared from the puparia of a syrphid (hoverfly) and *Chrysomyza demandata*. For the identification of the British Pteromalidae see Graham (1969).



Stenomalina sp.
adult (typical pteromalid)

a



Spalangia sp.
adult

b

FIG.365.

Family EUCOILIDAE

A very interesting and highly distinctive family of small (length 1.5-5.0mm) mainly blackish parasitic wasps, of which several of the 52 British species have been recorded from cow-dung where they parasitise fly larvae. Like members of the preceding three families the adults emerge from the puparia of their hosts. These small wasps cannot be mistaken for any other Hymenoptera owing to the distinctive cup-like structure on the scutellum (Fig. 366: s) (*ie.* the hindmost parts of the upper surface of the thorax). The wings also have a radial cell (Fig. 366: r). Four British genera have so far been recorded from cow-dung and these can easily be distinguished with the following key. However, since other genera will quite probably also prove to parasitise members of the cow-dung community, reference to the key by Quinlan (1978) is recommended for accuracy.

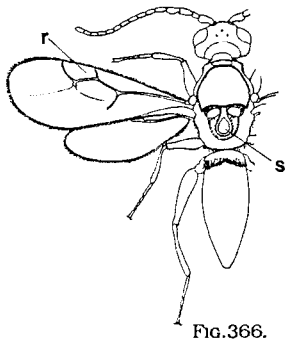


FIG.366.

Key to the Genera of dung-frequenting Eucoilidae

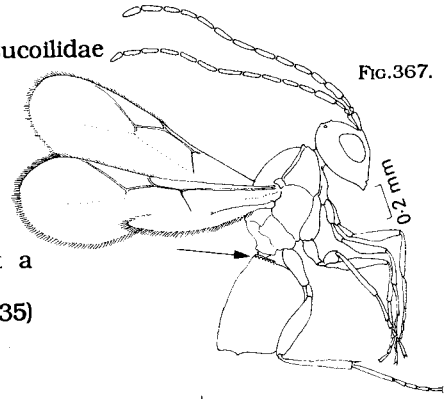


FIG.367.

1 Basal abdominal segment without a furry collar (Fig. 367)
...Genus *Cothonaspis* (p.135)

- Basal abdominal segment with a dense furry collar (Fig. 368)
.....2

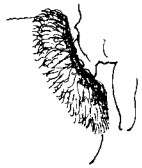


FIG.368.

2 Collar complete, without a dorsal break (Fig. 369)
.....Genus *Trybliographa* (p.135)


FIG.369.

- Collar with a dorsal break (Fig. 370)
.....3


FIG.370.

3 Forewing evenly rounded at the tip (Fig. 371)
.....Genus *Eutrias* (see below)

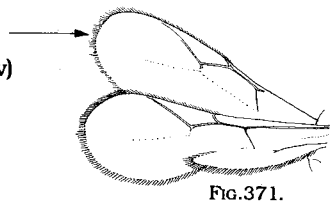


FIG.371.

- Forewing not evenly rounded at the tip, but at least slightly excised (*ie.* wavy) (Fig. 372)
.....Genus *Kleidotoma* (see below)


FIG.372.

Genus *Cothonaspis*
C. gracilis (Fig. 367) has been recorded as a parasite of *Sepsis cynipsea* but it is not known whether these eucoilids specialise on sepsid larvae.

Genus *Trybliographa*
Members of this genus are only known to parasitise larvae of anthomyiid flies. *Trybliographa* may occur on fresh cow-dung in some numbers and it is possible that their hosts here may be larvae of *Hylemya* and *Paregle*.

Genus *Eutrias*
According to Quinlan (1978) the single British species, *E. tritoma*, has been recorded 'ex Diptera on day-old cow-dung'.

Genus *Kleidotoma*
The notched wing tip in members of this genus is very characteristic. The only positively recorded hosts have been larvae of sphaerocerid flies and it may be that *Kleidotoma* species specialise on that family.

Family FIGITIDAE

The wing venation and general appearance of these wasps is very similar to that of the eucoilids, but the figitids lack the scutellar cup (Fig. 373a) (enlarged thorax; Fig. 373b); instead the top of the scutellum (Fig. 373a: s) is very coarsely sculptured. *Figites*, the only genus of this family positively recorded from cow-dung, parasitises larvae of Anthomyiidae and Muscidae (Diptera). Adult *Figites* are frequently seen on fresh cow-dung.

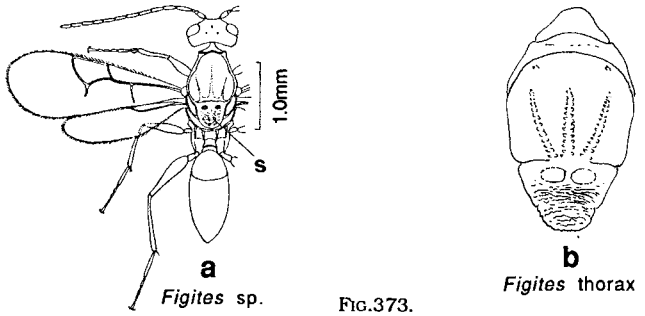
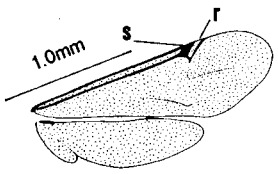


FIG.373.

Family PROCTOTRUPIDAE

Adult proctotrupids are regularly found in numbers about fresh droppings. They are mainly blackish wasps of usually small size and slender build but their peculiar wing venation makes them unmistakable - the triangular black stigma followed by a very narrow radial cell (see Fig. 374: s,r) is absolutely diagnostic. These wasps are parasitic, mainly on beetle larvae although *Phaenoserphus calcar*, one of our commonest species, has also been recorded from the centipede *Lithobius forficatus*. Most proctotrupid wasps are in the size-range 2-5 mm (including the long, curved female ovipositor), but our largest species *Proctotrupes brachypterus*, which has been taken on fresh cow-dung, may reach 10 mm in length. This species is parasitic on various carabid larvae as are *Codrus* and *Phaenoserphus* species. *P. calcar* and *Exallonyx trifoveatus* appear to specialise mainly on *Philonthus* and other staphylinid larvae. Nixon (1980) gives a key and ecological data, and the taxonomy was revised by Townes & Townes (1981).

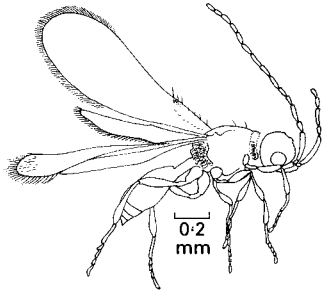


Proctotrupid wings

Fig. 374.

Family DIAPRIIDAE

A rather varied family of small to very small wasps about which little is known regarding their biology. Two genera have been recorded positively from cow-dung, but others doubtless occur. The two genera concerned, *Phaenopria* and *Trichopria*, have been reared from puparia of muscids and sphaerocerids. In these genera the wing venation is virtually absent (a shortened costal vein only in the basal third of the front margin of the forewing - Fig. 375). For identification see Nixon (1980).



Phaenopria miron

Fig. 375.

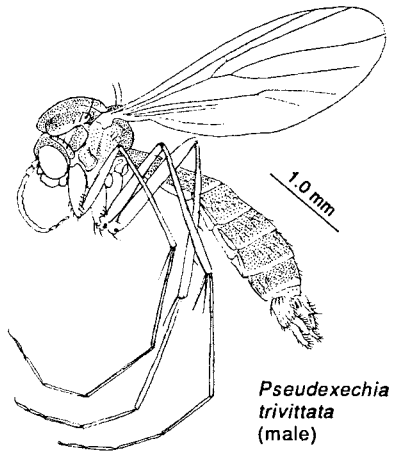
PART THREE

DIPTERAN FAMILIES OCCURRING AS CASUALS IN COW-DUNG

Note. This section is only intended to highlight those families of diptera which are the most likely to be encountered as 'casuals' on cow-dung. Identification should be confirmed using a comprehensive text such as Colyer and Hammond (1968) and Unwin (1983).

Family MYCETOPHILIDAE

One species only of this very large family of flies, namely *Pseudexechia trivittata* (Fig. 376), has been recorded from unspecified dung (possibly from manure). All members of this family breed in fungi, hence the popular name of fungus gnats, and it appears remarkable that none has been positively associated with any of the fungi which commonly occur in cow-dung (see p.12). Their place there appears to be taken by the Sciaridae (p.100).

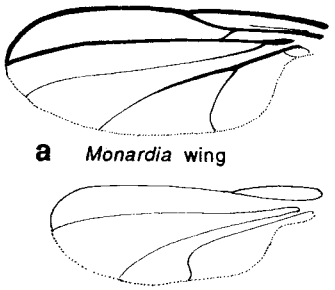


Pseudexechia trivittata (male)

Fig.376.

Family CECIDOMYIIDAE

The larvae of most members of this vast family of flies live in plant tissues where they provoke gall-formation, hence the popular name of gall midges. Many of these abound in grassland and consequently occur sometimes in cow-dung as pure casuals. Some cecidomyiids, however, are free-living, leading either a predatory mode of life or feeding on fungal mycelia in decaying plant material. Species of *Mycophila* (wing illustrated in Fig. 377b) for instance breed in manure and an unspecified species of the very similar genus *Monardia* (wing illustrated in Fig. 377a) has been recorded from cow-dung. The only work dealing with these genera in English is by Edwards (1938).



a *Monardia* wing

b *Mycophila* wing

Fig.377.

Family OPOMYZIDAE

A small family of flies whose larvae develop in the stems of grasses, and which often occur in vast abundance in grasslands. The adults are easily recognised by virtue of their often heavily marked wings. *Opomyza germinationis* is probably one of the commonest flies of open grassland whilst *O. florum* is equally abundant in more sylvan (wooded) areas. For the identification of the British species see Collin (1945).

Family LONCHAEIDAE

A rather small family of shiny blue-black flies with very clear wings which develop mainly in decaying vegetable matter. Most breed in rotten wood but some breed in damaged parts of herbaceous plants. None has been recorded breeding in ungulate dung and any occurrences therein are of a casual nature. The family was dealt with by Collin (1945).

Family AGROMYZIDAE

A very large family of very small flies whose larvae are leaf and stem miners. Many species occur in great abundance in grassland and individuals consequently turn up frequently in cow-dung. For identification of the British species see Spencer (1972).

Family LAUXANIIDAE

Several of the British species abound in open grassland where they could occur casually on cow-dung, but the only known breeding situations are in decaying vegetation and humus soil. For the identification of the British species see Collin (1948).

Family EPHYDRIDAE

A large and remarkably diverse family of flies, including species which breed in a range of materials (with the possible exception of ungulate dung!). Many species abound in grassland where some breed in muddy soil, others in rotting vegetation and others, notably the members of the genus *Hydrellia* (which may be amongst the most abundant of insects in grasslands), in stems of grasses, including cereals. Being amongst the most abundant of grassland flies, *Hydrellia* adults commonly occur on cow-dung. For a list of relevant references see Colyer and Hammond (1968).

Family CHLOROPIDAE

A very large family of flies of which the vast majority breed in the stems of grasses. Consequently, many species abound in grassland where individuals inevitably land on cow-dung. For the identification of the subfamily Oscinellinae see Collin (1946), which is out-of-date but remains useful.

Family ANTHOMYZIDAE

A small family of flies which mostly breed in stems of grasses. One or two species may occur commonly in grassland and could be found casually on cow-dung. Collin (1944) provides a useful background to the family but the group is currently under taxonomic revision.

Family OTITIDAE

One species only, *Chrysomyza demandata* has been recorded from horse-dung in France. In Britain this very distinctive, partly bright metallic green fly is not generally common. It is mainly associated with manure heaps and it is possible that the French record may relate to horse manure. Illustrated in Colyer and Hammond (1968).

Family DRYOMYZIDAE

Dryomyza flaveola and *D. anilis* are yellow to deep orange red fies which vary in size, sometimes attaining a length of 10 mm. They occur in shaded places in woods and develop in rotting plant and animal matter. Neither has been recorded breeding in ungulate dung, but they may visit cow-dung lying under trees. See Colyer and Hammond (1968).

Family TRIXOSCELIDAE

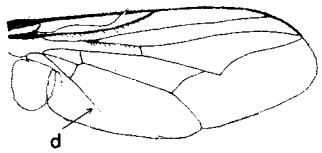
The single genus *Trixoscelis* has been recorded in the literature from dung, presumably arising from a record of one of the species having been reared from an old bird's nest and assuming that it had bred in the guano (birds' droppings). *Trixoscelis* species are not generally common and the likelihood of their being found in ungulate dung even as casuals, seems very remote. For the identification of the British species see Collin (1943).

Family DROSOPHILIDAE

A large family of small, mostly yellowish or grey to brown flies characterised *inter alia* by their highly characteristic antennal arista. They breed mostly in decaying plant or animal matter in which fermentation is taking place. Several species abound in grassland, the commonest being *Scaptomyza graminum*, the larva of which is unusual in being a leaf-miner of a wide range of plants, and *S. pallida* which breeds in rotting vegetation. None of the species has been recorded breeding in the dung of ungulates, any occurrences therein being of a purely casual nature. For the identification of the British species see Shorrocks (1972).

Family SARCOPHAGIDAE (flesh-flies)

One of two calypterate (see p.29) families which may occur as 'casuals'. The members of this family are mostly black and grey flies in which the abdomen has a chequered pattern, the light and dark areas of which vary with the angle of view. The wing venation is rather characteristic in that the discal vein (d) usually ends well before the wing tip (Fig. 378). None of the British species breeds in the dung of ungulates but in many other parts of the world there are sarcophagid flies which commonly do so. The normal breeding situations are in decaying animal matter but some are parasitic on other invertebrates in the larval state. Length up to about 15 mm. For identification of British species see van Emden (1954).

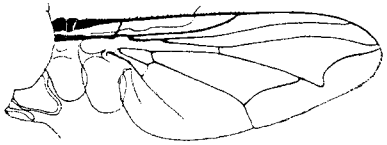


Sarcophagid wing

FIG.378.

Family CALLIPHORIDAE (blowflies etc)

The second of the two calypterate families which may occur as casuals in dung (see also the Sarcophagidae above). Most of the calliphorids are at least partly metallic blue or green and include some of the most familiar house-frequenting insects - the bluebottles or blowflies. The biology is in general similar to the flesh-flies (see above), these also breeding mainly in decaying animal matter whilst parasitism of other invertebrates and of mammals, birds and even amphibians is known to occur. None, however, is known to breed in the dung of ungulates, but adult bluebottles (*Calliphora* species; wing illustrated in Fig. 379), greenbottles (*Lucilia* species) and the dead dog fly (*Cynomya mortuorum*) are often seen visiting fresh cow-dung. The dead dog fly, our largest calliphorid, reaches a length of about 15 mm. For identification of the British species see van Emden (1954).



Calliphora sp. wing

FIG.379.

PART FOUR

THE COW-DUNG COMMUNITY AND ITS ROLE IN THE NUTRIENT CYCLE IN PASTURES

Many agents are involved in the breakdown of the metabolic waste products in the gut of the consumer, but the activity of most end when they are evacuated with the faeces during defaecation. Adapted to the stable microclimate of the gut, they rapidly succumb to the lethal conditions which confront them in the outside world. However, some animals may survive this transition. Parasitic organisms, on completion of one stage in their life cycle and in preparation for the next, are also passed out with the faeces. These will now be entering a quiescent resting stage, as eggs, cysts, etc. In horses, for instance, the fully grown larvae of horse bot flies (*Gasterophilus intestinalis*) are thus evacuated to pupariate in the dung. Surprisingly, even though puparia of the warble flies (*Hypoderma* spp.) may occasionally be found in cow-dung, the larvae live in the skin of cattle rather than in the gut. It must be assumed that it is purely by chance that they may drop into fresh cow-dung in the places where the animals congregate.

The view of Putman (1983) that earthworms are the primary invertebrate agents of cow-dung decomposition may be an over-simplified view but the purpose of this book is to survey the relevant insect communities. Statistical estimates of relative importance are outside the brief of this publication.

Changes in the dung community occur almost without delay following defaecation. Members of the newly forming community start to arrive immediately, with the horn fly (*Haematobia irritans*), where it occurs, prominent in the first offensive. It is thought that this highly thermopilous fly needs to oviposit in dung at body heat; in any case it has been recorded laying on the dung before it hits the ground! Many other species arrive during the first few minutes and the major period of colonisation lasts until a distinct crust has formed, following which many groups are physically incapable of entering the pat. Most flies have soft pliable ovipositors incapable of penetrating a hard crust. The flies have a wide variety of ovipositing strategies; some lay their eggs on the surface or just push them through the surface film. Often the eggs have long respiratory horns (*eg.* Sepsidae) which project above the dung. Others, like *Neomyia*, excavate bubble-like cavities in the upper layers of the dung and arrange the eggs around the inner walls; several females may share a single cavity. Clearly the egg stage is vulnerable to attack and some flies have dispensed with it by laying young larvae instead (*eg. Hylemya*).

By the end of the second day most fly eggs will have hatched and the young larvae will have congregated just below the surface where the oxygen supply is greatest. Usually, as the first waves of dipterous colonisers arrive, they are joined by numerous beetles. Some of the latter, like *Sphaeridium*, dive into the fluid fresh dung and swim or tunnel throughout it, scattering the carefully arranged egg-bubbles of *Neomyia* etc, in the process. It may be due to the aerating effects of these activities that such eggs hatch nevertheless. Certainly, the extensive oxygenation of the pat by insect activity as the dung ages and crust formation progresses, assists its total utilisation by fly and

beetle larvae. Within a day or two a thriving metropolis of insect activity may be found beneath the now firm crust. In the first day or two, extreme competition may occur between the eager colonists. In general, a balance is struck between participants but sometimes one or other may take over to the exclusion of the rest. Thus, in September, vast swarms of the dung beetle *Aphodius contaminatus* may descend on a cow-pat and elbow everything else aside; sometimes there may be more beetles than dung and the effects of such visits are to scatter the dung over a wide area and to render it useless for other community members.

The interspecific relationships between the community and its environment are complex and as yet little understood, but it is clear that the overall effect of the cow-dung community is to accelerate the humification of the dung. Whilst degradation of cow-dung by fungal and bacterial activity alone may be possible, it is always very slow and can take several years. Indeed the frequent occurrence in certain sedimentary rocks of coprolites (fossil dung pellets) suggests that natural degradation may not occur at all in the absence of insect decomposers. Pasture land covered by undegraded cow-dung is effectively non-productive and it has been shown that the undegraded dung from five cattle can remove from grazing one acre of land annually. Fig. 380 shows the nutrient cycle in pastures in which the cow-dung community plays so important a role. For the reasons stated above the fungal conversion pathway is shown as a weaker link running in parallel with the role of the

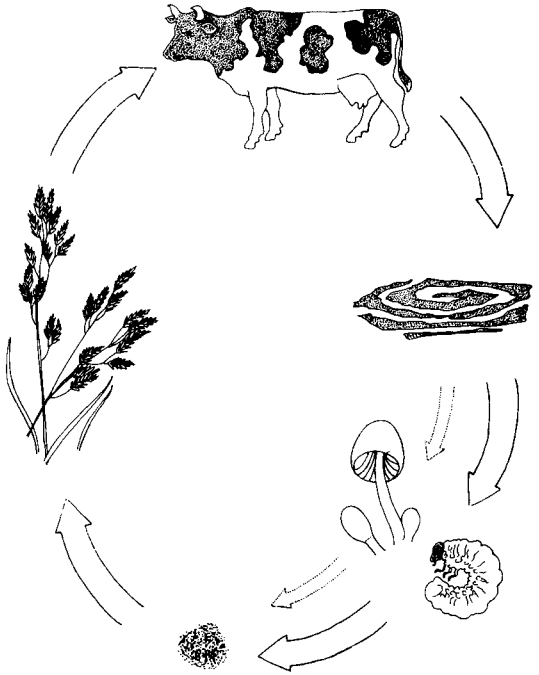


FIG.380.

The nutrient cycle in pastures

The cow-dung community of insects is represented by the dung beetle larva which helps in the cycle by accelerating conversion of dung into humus. The much slower conversion, resulting from fungal activity, is represented by the Basidiomycete fungus.

cow-dung community. It should, however, be recognised that these agents perform biochemical processes of which animals are incapable and that the weakness really only relates to the comparative slowness of this pathway. Indeed, even with an extremely efficient insect community, the fungal decomposers are essential for certain processes required by the humifiers - the final link in the return of vital nutrients to the soil.

A simplified food web representing the cow-dung community is shown in Fig. 381 and the trophic groups are coded to allow correlation with the species lists on pages 147-151. This will enable the student to allocate any insect on that list to its correct trophic group within the community. It remains to explain briefly the roles of the various trophic groups which are referred to in Figs. 381 and 382.

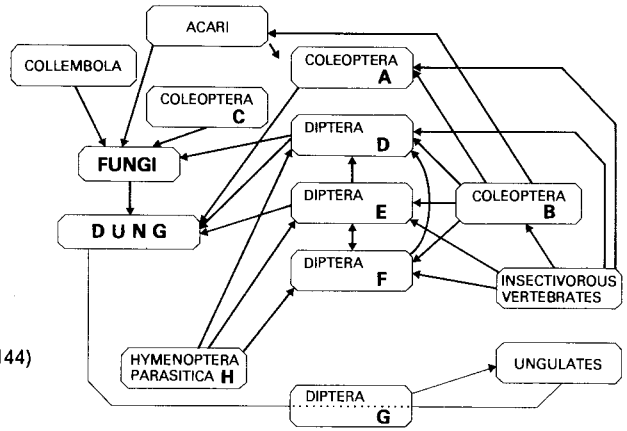


FIG.381.

Simplified food web of the cow-dung community

(for explanation see pp 143 & 144)

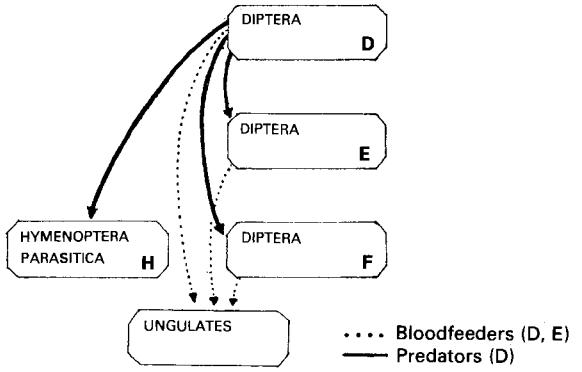


FIG.382.

The role of adults of trophic groups D, E, F & H

(for explanation see pp 143 & 144)

The Trophic Groups of the Cow-dung Community (see Figs. 381 & 382)

Whilst a broad categorisation of different habits amongst a community is of course fraught with problems due to the exceptions to any given set of parameters, a tentative system of trophic groups is proposed below and in Fig. 381. The codes given to each group are used in the species list (pp.148-151) to enable the student to understand, in general terms, the type of activity in which any listed species is involved within the community. The trophic groups are as follows:-

Coleoptera A. This group includes all beetles and their larvae which feed entirely or mainly on the dung itself. It should be stressed at the outset that although most non-carnivorous animals living in dung are assumed to be feeding on the dung, this is probably not correct. They are probably grazing on the bacteria and microfungi. However, in the interests of tradition and in the absence of hard evidence to the contrary, these are termed dung feeders or 'coprophages'. Group A then are the coleopterous coprophages, and foremost amongst these in importance are the dung beetles (Geotrupidae and Scarabaeidae) and the Hydrophilidae. It may be added that species of at least one genus of the latter family (*ie. Sphaeridium*) are thought to be facultative carnivores - carnivorous if the opportunity arises, and it is possible that this applies to the other hydrophilids included here. The oxyteline rove-beetles may also be at most facultative carnivores and, hence, are included in this trophic group.

Coleoptera B. Included here are the predatory beetles and their larvae, and by far the most important are members of the Staphylinidae - the rove-beetles. As far as is known most are obligative carnivores - species adapted exclusively for carnivory. A remarkable group are the coleopteran parasitoids belonging to the genus *Aleochara* which affect dipteran puparia.

Coleoptera C. These are the fungus-feeding species which graze on fungal mycelia and spores. A clear distinction between these and members of group A is not possible without full knowledge of the diets of these animals. Members of group C are those which occur only when fungal colonisation is advanced. The rove-beetle genus *Micropeplus* belongs to this group.

Diptera D. Included here are those Diptera whose larvae are non-carnivorous and generally regarded as being coprophagous or saprophagous. (For a discussion of the habits of adults in members of groups D-F see Fig. 382 and the comments below.) They are best regarded as comprising all species whose larvae feed only on the bacteria and/or fungi. Most dipteran families belong in this group.

Diptera E. Included here are the Muscidae in which the larvae become facultative carnivores in the final instar. Whilst including very few species, this group may exert a major influence since some of the species are ubiquitous and abundant. In the horse-dung community a species which would belong in this category is thought to be one of the most efficient dipterous controllers of fly populations known (*Polietes domitor*). Related species with very similar habits develop in cow-dung. Clearly facultative carnivory is an extremely efficient strategy since in the absence of live food a diet of more accessible food is adequate. It has been shown in these flies that the life cycle is merely hastened by turning to carnivory in the larval stage. In these larvae, the mouthparts in the final instar are adapted to a predatory mode of life as in the next group.

Diptera F. This group includes all of the Muscidae in which the larva is an obligative carnivore. In abundant food supply these predators are extremely efficient, but in the absence of live food their growth may be very slow, taking perhaps several months to mature as acceptable food may become available. If no prey is forthcoming death occurs. The mouthparts of these maggots are quite incredibly elegant with the mouth hooks cutting in a vertical plane and the blades of the oral bars slicing outwards. On contacting a victim these mouthparts rapidly penetrate the skin of the prey and, with astonishing rapidity, scour out the contents of the body, leaving merely an empty husk. Such 'drained' victims are a frequent sight in cow-pats.

Diptera G. This category includes those flies whose larvae are internal parasites of the animals which produce the dung. Their role in the breakdown of the dung is insignificant. In horses, the horse bot fly (*Gasterophilus intestinalis*) belongs here; the larvae breed in the gut of the host and are passed out with the faeces where the puparia may be found. As stated earlier puparia of warble flies (*Hypoderma* spp.) which breed in the skin of cattle occasionally occur in cow-dung. It is not known whether these insects derive any benefit from their puparia occurring in the dung.

Hymenoptera (Parasitica) H. Included here are the many small Hymenoptera whose larvae are parasitic in the larvae or pupae of other insects; the main hosts belong to the Diptera.

Collembola. These animals, popularly called springtails, feed on decaying plant matter and fungi and they are often numerous in older dung. They mostly belong to the soil fauna.

Acari. The mites are numerous in species and are very varied in habits (see p.16). Apart from coprophagous and saprophagous species they also include others which are at least partly predaceous or parasitic on insect larvae and eggs and have a phoretic (see the glossary, p.157) association with adults (*ie.* species of *Parasitus* and *Macrocheles*). They are mostly brought to the fresh dung by insect colonisers.

Insectivorous Vertebrates. This group includes birds such as crows, starlings, wagtails etc, and mammals like shrews and moles. In warmer climates, reptiles would probably be included.

Ungulates. This category will include the animal producing the dung.

As stated above, the food web in Fig. 381 presents only a partial picture in that categories D-H refer only to larvae. The interrelationships between the adults are very different (see Fig. 382). Thus, one of the most important of dipterous predators in pastures is the yellow dung fly (*Scathophaga stercoraria*), whose larva belongs to trophic group D since it is purely coprophagous. Less numerous but similar in habits are the empid flies.

These flies, especially *Scathophaga*, undoubtedly exert a very significant influence on insect populations in pastures. Another very important group of species belonging to group D are those muscids whose adults are bloodfeeders on mammals, notably the cattle themselves in pasture areas, but often including man also. Some of these species are known to be responsible for transmission of certain debilitating diseases in cattle. The horn fly, *Haemotobia irritans*, in some regions of the world is a very serious nuisance to the cattle which the adults seldom leave for more than a few seconds and upon whose blood they feed. A few adult members of groups E and F are attracted to mammalian perspiration, as are more of the group D species, and some of these will certainly feed on blood if the opportunity arises. Curiously, however, no members of group E or F are predatory in the adult state. Thus, whilst the group D larvae are subject to decimation by groups E and F larvae, in the adult state the tables are turned! Also, the parasitic Hymenoptera in group H are also attacked in the adult state by adults of group D flies like *Scathophaga stercoraria*.

The food web is also incomplete in that it does not include the casual invaders from adjacent habitats, most of which visit the dung in search of prey. Most of the beetles could probably be regarded as belonging to group B. Another important group of visitors are the digger wasps (Hymenoptera: Sphecidae); one of these, *Mellinus arvensis*, relies heavily on flies which breed in dung for the food supply for its progeny.

Whilst the food web discussed above has been based primarily on the insects belonging to the cow-dung community, strong similarities exist in the communities associated with other ungulate dung types. In many instances the same insect families are involved, often the same genera. It is usually at species level that major differences occur. The following list includes records from other dung types. Very useful comparative studies of the communities in different dung types could be conducted. However, it is necessary to ensure that the only variable is the dung type since, for instance, the insect fauna of cow-dung deposited at night differs from that dropped during the day. Also, great differences may be noted in the cow-dung community in shaded sites compared with open ones, or wet marshy areas as against dry ones. Altitude of the site is also important. Thus, in warmer southern areas the horn fly *Haematobia irritans* may be one of the most abundant inhabitants of cow-dung, whilst in cold upland areas it will be absent, its place taken by a related bloodsucking muscid, *Haematobosca stimulans*.

A final note of caution to students of cow-dung ecology. Be sure that the dung which you are sampling has been deposited by a cow! Dung strewn about fields by the farmer may consist largely of manure from his manure heap. The fauna of manure is very different from cow-dung, even when the manure consists mainly of cow-dung. An accumulating manure heap is able to maintain high temperatures. In these artificial conditions many species are able to breed which could never survive otherwise in the British climate. Typical manure heap insects include the lesser earwig (*Labia minor*), the biting housefly (*Stomoxys calcitrans*) and the common housefly (*Musca domestica*). Discovery of any of these in samples thought to be pasture-produced cow-dung should raise suspicions!

LIST OF INSECTS ASSOCIATED WITH THE DUNG OF UNGULATES

The list on the following pages includes all of the species of British insects which are known to the author to have been recorded from the dung of cattle, sheep, deer and horses. Those recorded from manure, whatever its origin, are not included. The list will inevitably be found to be incomplete even for true members of the relevant communities, but it would be quite impractical to include all casuals also. Such a list would need to include the entire soil fauna and species from other biotopes. Since literature records often do not stipulate the dung type a final category for 'unspecified dung types' is included. The list is arranged as follows:

Species column Sometimes only a higher classificatory division is given. This is done where no more detailed information is available to the author. Classification and nomenclature are in accordance with the most recent literature - generally from relevant publications produced by the Royal Entomological Society of London, 41 Queen's Gate, South Kensington, London SW7.

Column 1 Trophic group. The letters are those used in the above discussion and in Figs. 381 and 382.

Column 2 Stages of life cycle in which species is known to occur.
O - breeding species
I - adult only recorded
? - uncertain whether species breeds in biotope indicated

Column 3 Cow-dung; see note below

Column 4 Sheep-dung; see note below

Column 5 Deer dung (species unspecified); see note below

Column 6 Horse-dung; see note below

Column 7 Unspecified dung type but assumed to be one of types 3-6; see note below

NOTE. In columns 3-7 three different symbols are used as follows:
x - recorded frequently
r - very scarce, or unconfirmed records.

Taxon (order/family/species)	1	2	3	4	5	6	7
Order COLLEMBOLA		I	x			x	x
Order DERMAPTERA							
Forficula auricularia L.		0	x			x	
Order HEMIPTERA							
Family LYGAEIDAE		I	r				
Family SALDIDAE		I	r				
Order COLEOPTERA							
Family CARABIDAE			x				x
Family HYDROPHILIDAE							
Sphaeridium bipustulatum F.		A	O	x			x	x
lunatum F.		A	O	x			x	x
scarabaeoides (L.)		A	O	x			x	x
Cercyon analis (Pk.)		A	O				x	x
atomarius (F.)		A	O	x	x		x	x
atricapillus (Marsh.)		A	O					x
haemorrhoidalis (F.)		A	O	x	x	x	x	x
lateralis (Marsh.)		A	O				x	x
lugubris (Ol.)		A	O	x		x	x	x
melanocephalus (L.)		A	O	x	x	x	x	x
pygmaeus (Ill.)		A	O	x	x	x	x	x
quisquilius (L.)		A	O	x		x	x	x
terminatus (Marsh.)		A	O	x	x		x	x
unipunctatus (L.)		A	O				x	x
Megasternum obscurum (Marsh.)		A	O		x		x	x
Cryptopleurum crenatum (Kug.)		A	O					x
minutum (F.)		A	O			x	x	x
subtile Sharp		A	?				r	r
Family HISTERIDAE								
Onthophilus striatus (Forst.)		B	O	x			x	x	x
Hister bissexstriatus F.		B	?	x				r
quadrimaculatus L.		B	?	x				x
unicolor L.		B	O	x			x	x
Paralister carbonarius (Hoffm.)		B	O	x		x	x	x
Atholus duodecimstriatus (Schr.)		B	?	x				x
Peranus bimaculatus (L.)		B	?	r				r
Family PTILIIDAE								
Ptenidium nitidum (Heer)		C	O	x	x	x	x	x
pusillum (Gyll.)		C	O	x			x	x
Ptiliolum fuscum (Er.)		C	O	x	x	x	x	x
Ptiliola kunzei (Heer)		C	O	x	x		x	x
Nephanes titan (Newm.)		C	O				x	x
Baeocrara variolosa Muls. & Rey		C	O	x	x	x	x	x
Acrotrichis cognata (Matth.)		C	O	x		x	x	x
dispar (Matth.)		C	O	x			x	x
fascicularis (Hbst.)		C	O	x	x	x	x	x
grandicollis (Mann.)		C	O	x	x	x	x	x
rugulosa Rossk.		C	O	x	x	x	x	x
sericeus (Heer)		C	O	x			x	x
silvatica Rossk.		C	I	x			x	x
thoracica (Waltl)		C	O	x	x		x	x
Family STAPHYLINIDAE								
Micropeplus porcatus (Pk.)		C	I					x
Megarthrus denticollis (Beck)		B	I		x			r
depressus (Pk.)		B	O	x	x	x	x	x
Deliphrum tectum (Pk.)		B	O	x		x	x	x
Acrolocha sulcula (Steph.)		B	O	x			x	x
Aploderus caelatus (Grav.)		A	O		x			r
Platystethus arenarius (Fourc.)		A	O	x	x	x	x	x
Anotylus complanatus (Er.)		A	I	x				r
fairmairei (Pand.)		A	O					x

Taxon (Order/Family/Species)	1	2	3	4	5	6	7
hamatus (Fairm. & Lab.)		A	O					x
sculpturatus Grav.		A	O	x	x	x	x	x
tetracarinatus (Block)		A	O	x	x	x	x	x
Oxytelus laqueatus (Marsh.)		A	O	x	x	x	x	x
piceus (L.)		A	O	x	x	x	x	x
Gyrohypnus angustatus Steph.		B	I			x	x	r
fracticornis (Ml.)		B	I				x	r
punctulatus (Pk.)		B	I					x
Xantholinus glabratus (Grav.)		B	I	x			x	r
Philonthus addendus Sharp		B	I				x	r
albipes (Grav.)		B	I					x
alpinus Eppels.		B	I					x
cephalotes (Grav.)		B	I				x	r
cruentatus (Gmelin)		B	O	x			x	x
debilis (Grav.)		B	I	x				r
fimetarius (Grav.)		B	O	x	x	x	x	x
fuscipennis Mann.		B	I	x				r
intermedius Boisd. & Lac.		B	O	x			x	x
jurgans Tott.		B	I					x
laminatus (Creutz.)		B	I	r			r	r
longicornis Steph.		B	I					x
marginatus (Stroem)		B	O	x		x	x	x
nigriventris Thoms.		B	I				x	x
parcus Sharp		B	I					x
politus (L.)		B	I					r
puella Nordm.		B	O	x	x	x	x	x
rectangulus Sharp		B	O	x	x		x	x
sanguinolentus (Grav.)		B	O	x	x		x	x
sordidus (Grav.)		B	I					x
splendens (F.)		B	O	x		x	x	x
succicola Thoms.		B	I					x
tenuicornis Muls. & Rey		B	I	x			x	r
varians (Pk.)		B	O	x			x	x
Gabrius piliger Muls. & Rey		B	O	x			x	x
Leptacinus batychrus Lec.		B	I	x				x
Ontholestes murinus (L.)		B	O	x			x	x
tessellatus (Fourc.)		B	I		x			r
Emus hirtus (L.)		B	I	x			x	r
Platydracus pubescens (Deg.)		B	I	x			x	r
stercorarius (Ol.)		B	I	x				r
Tachinus humeralis Grav.		B	I		x		x	r
laticollis Grav.		B	O	x	x		x	x
marginellus (F.)		B	O	x	x		x	x
pallipes (Grav.)		B	I					x
proximus Kraatz		B	I					x
signatus Grav.		B	I	x				r
Autalia puncticollis Sharp		B	O	x		x	x	x
rivularis (Grav.)		B	O	x	x	x	x	x
Atheta (*Microdota*) *atricolor* (Sharp)		B	O	x		x	x	x
excelsa Bernh.		B	I				x	r
inquinata (Grav.)		B	I				x	r
glabricula (Thoms.)		B	I				x	r
subtilis (Scriba)		B	I				x	r
(*Coprothassa*) *melanaria* (Mann.)		B	I				x	r
(*Acrotona*) *aterrima* (Grav.)		B	O	x	x		x	x
benicki Allen		B	I				x	r
sordida (Marsh.)		B	I				x	r
(*Dimetrota*) *cinnamoptera* (Thoms.)		B	O		x		x	x
atramentaria (Gyll.)		B	O	x	x	x	x	x
cauta (Er.)		B	I				x	r
ischnocera (Thoms.)		B	O	x		x	x	x
laevana Muls. & Rey		B	O		x	x	x	x
macrocera (Thoms.)		B	O	x	x		x	x
marcida (Er.)		B	I	x	x	x	x	r
nigripes (Thoms.)		B	I	x		x	x	x

Taxon (Order/Family/Species)	1	2	3	4	5	6	7
picipennis (Mann.)		B	I		x		r
puncticollis Benick		B	I		x	x	x	x
setigera (Sharp)		B	O	x	x	x	x	x
(*Pachyatheta*) *cribrata* (Kraatz)		B	I			x	r
(*Datomicra*) *sordidula* (Er.)		B	O	x		x	x	x
(*Chaetida*) *longicornis* (Grav.)		B	O	x	x	x	x	x
Oxypoda nigricornis Motsch.		B	O	x	x		x	x
opaca (Grav.)		B	I	x	x			x
sericea Heer		B	I		x	x		x
Tinotus morion (Grav.)		B	O	x			x	x
Aleochara bilineata Gyll.		B	O	x				x
bipustulata (L.)		B	O	x	x		x	x
discipennis Muls. & Rey		B	I	x			x	r
intricata Mann.		B	O	x	x		x	x
lanuginosa Grav.		B	O	x	x	x	x	x
moesta Grav.		B	I					x
tristis Grav.		B	I			x	r
Family PSELAPHIDAE								
Euplectus sanguineus Denny		C	I				x	x
Family GEOTRUPIDAE								
Typhaeus typhoeus (L.)		A	O	x	x	x	x	x
Geotrupes mutator (Marsh.)		A	O	x			x	x
pyrenaeus Charp.		A	O	x		x		x
spiniger (Marsh.)		A	O	x	x		x	x
stercorarius (L.)		A	O	x	x	x	x	x
stercorosus (Scriba)		A	O		x	x	x	x
vernalis (L.)		A	O		x	x		x
Family SCARABAEIDAE								
Aphodius ater (Deg.)		A	O	x	x	x	x	x
borealis Gyll.		A	O	x	x	x	x	x
brevis Er.		A	O	x			x	x
coenosus (Pz.)		A	O	x	x		x	x
conspurcatus (L.)		A	O	x	x		x	x
consputus Creutz		A	O	x	x			x
constans Duft.		A	O	x	x	x	x	x
contaminatus (Hbst.)		A	O	x	x	x	x	x
depressus (Kug.)		A	O	x	x	x	x	x
distinctus (Ml.)		A	O	x			x	x
equestris (Pz.)		A	O	x	x	x	x	x
erraticus (L.)		A	O	x	x		x	x
fasciatus (Ol.)		A	O		x	x		x
fimetarius (L.)		A	O	x	x	x	x	x
foetens (F.)		A	O	x	x	x	x	x
foetidus (Hbst.)		A	O	x			x	x
fossor (L.)		A	O	x		x	x	x
granarius (L.)		A	O	x	x	x	x	x
haemorrhoidalis (L.)		A	O	x	x		x	x
ictericus (Laich.)		A	O	x	x	x	x	x
lapponum Gyll.		A	O	x	x			x
lividus (Ol.)		A	I	x	x	x	x	x
luridus (F.)		A	O	x	x	x	x	x
merdarius (F.)		A	O	x	x	x	x	x
nemoralis Er.		A	O		x	x		
obliteratus Pz.		A	O	x	x	x	x	x
paykulli Bedel		A	O	x	x			x
porcus (F.)		A	O	x	x		x	x
prodromus (Brahm)		A	O	x	x	x	x	x
pusillus (Hbst.)		A	O	x	x	x	x	x
putridus Fourc.		A	O	x	x	x	x	x
quadrimaculatus (L.)		A	O	x	x	x		x
rufipes (L.)		A	O	x	x	x	x	x
rufus (Ml.)		A	O	x	x	x	x	x
scrofa (F.)		A	I	x	x		x	r
sordidus (F.)		A	O	x		x		x
sphacelatus (Pz.)		A	O	x	x	x	x	x
subterraneus (L.)		A	O	x			x	x
zenkeri Germ.		A	O	x	x	x	x	x

Taxon (Order/Family/Species)	1	2	3	4	5	6	7
Euheptaulacus sus (Hbst.)		A	I					r
villosus (Gyll.)		A	I					r
Heptaulacus testudinarius (F.)		A	I					r
Copris lunaris (L.)		A	O	x			x	x
Onthophagus coenobita(Hbst.)		A	O	x			x	x
joannae Goljan		A	O		x	x	x	x
nuchicornis (L.)		A	I					r
nutans (F.)		A	I					r
similis (Scriba)		A	O		x	x	x	x
taurus (Schreber)		A	O	x				r
vacca (L.)		A	O	x	x		x	x
Family ELATERIDAE		A						r
Family RHIZOPHAGIDAE								
Monotoma longicollis Gyll.		C	I				x	r
picipes Hbst.		C	I	x			x	r
Family CRYPTOPHAGIDAE								
Atomaria apicalis Er.		C	I	x	x		x	x
fuscipes (Gyll.)		C	I		x	x	x	x
hislopi Woll.		C	I			x	x	x
nitidula (Marsh.)		C	I	x	x	x	x	x
rubida Reitt.		C	I	x	x		x	x
ruficornis (Marsh.)		C	I	x			x	x
Ootypus globosus (Waltl)		C	I	x			x	x
Order DIPTERA								
Family TRICHOCERIDAE		D	O	x				x
Family TIPULIDAE		D	O	x				x
Family PSYCHODIDAE								
Pericoma trivialis Eaton		D	O					r
Psychoda albipennis Zett.		D	O	x			x	x
brevicornis Tonn.		D	O	x				x
cinerea Banks		D	O	x				r
grisescens Tonn.		D	O	x				x
minuta Banks		D	O	x				
parthenogenetica Tonn.		D	O	x			x	x
phalaenoides (L.)		D	O	x				
pusilla Tonn.		D	O	x				
setigera Tonn.		D	O	x				
surcoufi Tonn.		D	O	x				x
trinodulosa Tonn.		D	O	x				
Family CERATOPOGONIDAE								
Forcipomyia bipunctata (L.)		D	O	x				x
brevipennios (Macq.)		D	O	x			x	x
Culicoides chiopterus (Mg.)		D	O	x				x
dewulfi Goetgh.		D	O	x				x
Family CHIRONOMIDAE								
Camptocladius stercorarius (Deg.)		D	O	x				
Mesosmittia flexuella (Edw.)		D	O	x				
Smittia aterrima (Mg.)		D	O	x				
contingens (Walk.)		D	O	x				
Family ANISOPODIDAE								
Sylvicola punctata (F.)		D	O	x				
Family BIBIONIDAE								
Dilophus febrilis (L.)		D	O	x				r
Family MYCETOPHILIDAE								
Pseudexechia trivittata (Staeg.)		D	I					r
Family SCIARIDAE								
Trichosia pilosa (Stg.)		D	O	x				
Lycoriella leucotricha Tuom		D	O	x				
Pnyxeia scabiei (Hopk.)		D	O					r
Bradysia brunnipes (Mg.)		D	O					r
Scatopsciara vivida (Winn.)		D	O					r
Family SCATOPSIDAE								
Anapausis palustris (Edw.)		D	O	x				r
Coboldia fuscipes (Mg.)		D	O	x			r	x
Cookella albitarsis (Zett.)		D	O	x				r
Scatopse notata (L.)		D	O	x				x
Reichertella pulicaria (Lw.)		D	O					r

Taxon (Order/Family/Species)	1	2	3	4	5	6	7
Family CECIDOMYIIDAE							
Monardia sp.	D	O	r				
Mycophila sp.	D	O					x
Family STRATIOMYIDAE							
Chloromyia formosa (Scop.)	D	O	r				r
Microchrysa cyaneiventris (Zett.)	D	O	x				
flavicornis Mg.	D	O	x				
polita (L.)	D	O	x			x	x
Sargus bipunctatus (Scop.)	D	O	x				r
cuprarius (L.)	D	O	r			x	x
iridatus (Scop.)	D	O	r				x
splendens Mg.	D	O	x				x
Family RHAGIONIDAE	D	O					r
Family ASILIDAE							
Asilus crabroniformis L.	D	I	r				
Family HYBOTIDAE							
Drapetis humilis Frey	D	O	x			r	r
nigritella (Zett.)	D	O	x				x
Ocydromia glabricula (Fln.)	D	O	x				
Family EMPIDIDAE							
Empis trigramma Mg.	D	O	r				
Family DOLICHOPODIDAE	D	I	x				x
Family SYRPHIDAE							
Rhingia campestris Mg.	D	O	x				
Family SEPSIDAE							
Saltella sphondylii (Schr.)	D	O	x			x	x
Themira putris (L.)	D	I	r				r
Sepsis biflexuosa Strobl.	D	O	x			x	x
cynipsea (L.)	D	O	x				x
duplicata Hal.	D	O	x				x
flavimana Mg.	D	O	x				x
fulgens Mg.	D	O	x				x
neocynipsea Mel. & Spul.	D	O	x	r		x	x
nigripes Mg.	D	O	x				x
orthocnemis Frey	D	O	x				x
punctum (F.)	D	O	r				r
thoracica (R.-D.)	D	O	r				r
Nemopoda nitidula (Fln.)	D	I	r				r
Meroplius stercorarius (R.-D.)	D	I	r				r
Family SPHAEROCERIDAE							
Subf. Sphaerocerinae							
Sphaerocera curvipes Latr.	D	O		x		x	x
monilis (Hal.)	D	O	x				
Ischiolepta denticulata (Mg.)	D	O	x			x	x
pusilla (Fln.)	D	O				x	r
Lotobia pallidiventris (Mg.)	D	O	r			x	r
Subf. Copromyzinae							
Alloborborus pallifrons (Fln.)	D	I				x	r
Borborillus costalis (Zett.)	D	I	x			x	r
sordida (Zett.)	D	O	x			x	x
uncinata (Duda)	D	I				x	r
vitripennis (mg.)	D	O				x	x
Copromyza equina (Fln.)	D	O	x	x		x	x
similis (Collin)	D	O	x	x		x	x
stercoraria (Mg.)	D	I					x
Crumomyia fimetaria (Mg.)	D	O				x	
nigra (Mg.)	D	O	x			x	x
nitida (Mg.)	D	O	x			r	x
Lotophila atra (Mg.)	D	O	x	x		x	x
Subf. Limosininae							
Leptocera nigra (Ol.)	D	I					r
fontinalis (Fln.)	D	I	x			x	r
fuscipennis (Hal.)	D	I					r
Chaetopodella scutellaris (Hal.)	D	O	x	x	x	x	x
Coproica acutangula (Zett.)	D	O	x	x		x	x
ferruginata (Sten h.)	D	O		x		x	x
hirticula Collin	D	I	x				
lugubris (Hal.)	D	O	x	x		x	x
pusio (Zett.)	D	I				x	r
vagans (Hal.)	D	I	x			x	x
Elachisoma aterrima (Hal.)	D	I				x	
Gigalimosina flaviceps (Zett.)	D	I					r
Halidayina spinipennis (Hal.)	D	O	x			x	x
Kimosina longisetosa (Dahl.)	D	I				x	r
Limosina silvatica (Mg.)	D	O	x			x	x
Minilimosina alloneura (Rich.)	D	I	x				
fungicola (Hal.)	D	O				x	
Opalimosina collini (Rich.)	D	I	x				r
denticulata (Duda)	D	O	x		x	x	x
liliputana (Rond.)	D	I	x				
mirabilis (Collin)	D	I	x	x		x	x
simplex (Rich.)	D	I	x				
Philocoprella quadrispina Lawr.	D	O	x				r
Pullimosina heteroneura (Hal.)	D	O	x	x			x
Spelobia bifrons (Stenh.)	D	O				x	r
cambrica (Collin)	D	O			x		
clunipes (Mg.)	D	O	x	x		x	x
nana (Rond.)	D	O	x				
palmata (Rich.)	D	I	x	x			x
Telomerina pseudoleucoptera (Duda)	D	O	x			x	
Trachyopella lineafrons (Spuler)	D	I	x				
minuscula Collin	D	I	x				
Family DROSOPHILIDAE	D	I					r
Family EPHYDRIDAE	D	I					r
Family OESTRIDAE							
Hypoderma bovis (L.)	G	P	r				
diana Brauer	G	P			r		
lineatum (de Vill.)	G	P	r				
Family GASTEROPHILIDAE							
Gasterophilus intestinalis (Deg.)	G	P				r	
Family SARCOPHAGIDAE	D	I					r
Family CALLIPHORIDAE	D	I					r
Family SCATHOPHAGIDAE							
Scathophaga furcata (Say)	D	O	r	x			x
lutaria F.	D	I	r				
stercoraria (L.)	D	O	x	x			x
Family ANTHOMYIIDAE							
Delia platura (Mg.)	D	O	x	x			r
Hylemya nigrimana (Mg.)	D	O	x				
vagans (Pz.)	D	O	x			r	x
variata (Fln.)	D	O	x				r
Paregle cinerella (Fln.)	D	O	x	x		x	x
radicum (L.)	D	I	r			r	r
Nupedia aestiva (Mg.)	D	O	x				x
infirma (Mg.)	D	I					r
Emmesomyia socia (Fln.)	D	I					r
Family FANNIIDAE							
Fannia canicularis (L.)	D	O	r			x	r
sp. indet.	D	O	x	x			
Family MUSCIDAE							
Muscina levida (Harr.)	E	I	r			r	r
stabulans (Fln.)	E	I	r			r	r
Hydrotaea albipuncta (Zett.)	F	O	x				r
dentipes (F.)	E	I	r			r	r
floccosa (Macq.)	F	O	r			x	x
irritans (Fln.)	F	O	r				r
meridionalis Portch.	F	O	x				x
militaris (Mg.)	F	O	x				x
pellucens Portch.	F	O	x				x
tuberculata Rond.	E	O	x				x
velutina R.-D.	E	O	x				x
Azelia cilipes (Hal.)	E	O	x			x	x

Taxon (Order/Family/Species)	1	2	3	4	5	6	7
macquarti (Stg.)	E	O	x			x	x
triquetra (Wd.)	E	I				r	r
zetterstedti Rond	E	O	r				r
Thricops longipes (Zett.)	E	I	r			r	r
Alloeostylus diaphanus (Wd.)	F	I	r				r
Drymeia hamata (Fln.)	F	O	r				r
vicanus (Harr.)	F	O	x				x
Polietes domitor (Harr.)	E	O				x	
hirticrura Meade	E	O	x				x
lardaria (F.)	E	O	x		r	r	x
steinii Ringd.	E	O				x	r
Mesembrina meridiana (L.)	E	O	x			x	x
Eudasyphora cyanella (Mg.)	D	O	x			r	x
cyanicolor (Zett.)	D	O	r	x			x
Neomyia cornicina (F.)	D	O	x	r		r	x
viridescens R.-D.	D	O	x				x
Morellia aenescens R.-D.	D	O				x	
hortorum (Fln.)	D	O	x			r	x
simplex (Leow)	D	O	x				x
Musca autumnalis Deg.	D	O	x			r	x
domestica L.	D	I	r	r		r	r
osiris Wd.	D	O	x			x	x
Stomoxys calcitrans (L.)	D	O	r	r		r	r
Haematobia irritans (L.)	D	O	x				x
Haematobosca stimulans (Mg.)	D	O	x				x
Mydaea princeps (Harr.)	F	O	x				x
urbana (Mg.)	F	O	x			r	x
Myospila meditabunda (F.)	F	O	x	x		r	x
Hebecnema fumosa (Mg.)	F	O	x				x
nigricolor (Fln.)	F	O	r				r
umbratica (Mg.)	F	O	x			r	x
vespertina (Fln.)	F	O	r				r
Brontaea humilis (Zett.)	F	O				x	x
Helina celsa (Harr.)	F	O	r				r
depuncta (Fln.)	F	O	r				r
impuncta (Fln.)	F	O	r				r
obscurata (Mg.)	F	O	r				r
quadrum (F.)	F	O	r				r
reversio (Harr.)	F	O	r				r
Order HYMENOPTERA							
Family ICHNEUMONIDAE							
Phygadeuon sp.	H	O	x				x
Atractodes sp.	H	O	x			x	x
Family BRACONIDAE							
Aspilota sp.	H	O	x				x
Aphaereta minuta (Nees)	H	O	x				x
Synaldis concolor (Nees)	H	O	x				
Phaenocarpa picinervis (Hal.)	H	O	x			x	x
Asobara tabida (Nees)	H	O	x				
Family EUCOILIDAE							
Cothonaspis sp.	H	O	x				x
Kleidotoma sp.	H	O	x				x
Eutrias tritoma (Thoms.)	H	O	x				
Trybliographa sp.	H	O	x				x
Family FIGITIDAE							
Figites sp.	H	O	x				x
Family PTEROMALIDAE							
Spalangia sp.	H	O	x	x		x	x
Stenomalina sp.	H	O					r
Nasonia vitripennis (Walk.)	H	O					x
Muscidifurax raptor Gir. & Sand.	H	O					x
Family PROCTOTRUPIDAE							
Proctotrupes brachypterus Schr.	H	I	r				
Family DIAPRIIDAE							
Phaenopria miron Nixon	H	O	x				
Family FORMICIDAE	I	x				x	x
Family VESPIDAE	I	x				x	x
Family SPHECIDAE							
Crabro cribrarius (L.)	I	x					
Mellinus arvensis (L.)	I	x					

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GLOSSARY

ALULA The membranous lobe located at the base of the wing of some flies (Diptera). It is absent in many species (*eg.* Fig 57)
APEX Part which is furthermost from the base. In insects, and other arthropods, the apex is located away from the main body of the animal. Therefore, the abdominal base is towards the front, whereas the base of the pronotum is towards the rear
ANGULATE Having angled (or sharp) corners
BASE (see "Apex" above)
BUCOPROPHILOUS Associated with cow-dung
CAUDAL Located at the "tail"; refers to the tip (apex) of the abdomen in this key
CERCI Appendages originating from the tip of the abdomen
CONCAVE Hollow, curved inwards
CONVEX Curving outwards
COPROPHAGOUS Dung-eating
COXA Basal segment of the insect leg (*e.g.* Fig. 57)
DILATED Swollen, expanded outwards
DIMORPHIC Having two distinct forms
EDAPHIC Belonging to the physical environment (i.e. non-biotic factors)
ELYTRON (plural = ELYTRA) A hard or leathery front wing, usually forming a cover for the rear wings (in Coleoptera)
EURYTHERMOUS Able to withstand a wide range of temperatures
EURYTOPIC With a wide range of distribution
EUSYNANTHROPIC Living in close proximity to human habitation
FACULTATIVE Optional; can adopt a certain behaviour, or diet, if the opportunity presents itself
FLUTING A series of grooves, or channels
FRONS Upper part of the insect face, from between (and slightly below) the antennae
GRANULATE A "grainy" rough surface
HOLOPTIC With eyes which touch, or nearly touch, on top of the head
HUMICOLOUS Living in, and feeding on, the decaying organic matter in the soil
HUMIFICATION Process whereby organic matter is broken down in the soil
HYPHAE Tubular, thread-like processes which form the vegetative (i.e. non-fruiting) part of a fungus
LABIUM The lower part of an insect's mouthparts - forming a 'lower lip'
LABRUM The upper part of an insect's mouthparts - forming an 'upper lip'
MANDIBLES The jaws of an insect; can be adapted for biting or piercing, but are absent from many insects (including most Diptera)
MAXILLAE The second part of an insect's mouthparts, lying just behind the jaws.
MEDIAL Located along the mid-line
METAPLEURON One of a series of "plates" which make up the hindmost sides of the thorax
OBLIGATIVE Compelled, by physical constraints, etc., to adopt a fixed behaviour, or diet
OBTUSE Blunt; greater than a right angle (90^0), but less than 180^0
OCELLUS (plural = OCELLI) An insect simple eye (*i.e.* not a compound eye), usually located on top of the head
PABULUM Food; source of nourishment
PALP A segmented mouthpart, usually having a sensory rather than mechanical function (*e.g.* Fig. 57)
PAPILLA A wart-like protuberance

PARASITOID An animal adopting a semi-parasitic lifestyle, usually feeding off a living host before killing it (true parasites rarely kill their hosts - in the short-term at least)
PERISPIRACULAR The area immediately surrounding the spiracles (see below)
PHORESIS The use of one animal by another for transport
PREAPICAL Located next to, but falling just short of, the apex (see above)
PRONOTUM The foremost dorsal surface of the thorax
PROTISTAN A single-celled animal (formerly called protozoans)
PUPARIUM (plural PUPARIA) The hardened skin of the final instar larva (in higher diptera) which contains the true pupa.
RETICULATION A net-like pattern
RETRACTILE Capable of being withdrawn, or contracting into, another body segment
RUGOSE Wrinkled, corrugated
SAPROPHAGOUS Feeding on decaying organic matter
SCARABAEIFORM C-shaped active coleopteran larvae; with thick, fleshy bodies and well developed jointed thoracic legs but lacking "false" abdominal legs
SCLEROTISED Hardened (usually referring to the external body wall of arthropods)
SCUTELLUM The hindmost dorsal surface of the thorax
SHAGREENATION Micro-sculpture of body surface, forming a tiny network of wrinkles
SPIRACLES Breathing pores - external openings of the tracheal system
STERNITE The hardened plates (sclerite) covering the lower (ventral) surface of each of the abdominal segments. The 3 corresponding plates covering the ventral surface of the thorax are named individually - prosternum, mesosternum and metasternum
STRIAE Impressed longitudinal lines on the wing covers (elytra - see above) of many beetles.
SQUAMAE The three membranous flaps or lobes located at the base of the wings in Diptera (the alula - see above - is the outermost of these)
SUBAPICAL Located just below the apex - see preapical also
TARSUS The ultimate segment of the leg - the insect "foot" - which may itself be divided into several sub-segments (*e.g.* Fig. 57)
TEMPLE The side of the head, between the hind edges of the eyes and the "neck" (i.e. the junction of the head and thorax)
TERGITE One of a number of plates forming the dorsal surface of the abdomen
THERMOPHILOUS Warm-loving
TIBIA The leg segment located between the femur and tarsus (*e.g.* Fig. 57)
TROPHIC (level) One of a number of stages in energy transference in the food-chain of a natural community
UNGULATES Herbivorous hoofed mammals - horses, pigs, cattle, sheep, etc.
UNICOLOROUS Having one colour throughout
VERTEX The upper part of the head located between, and behind, the hind inner corners of eyes

INDEX Note: Synonyms are only indicated where the names used in this work differ from those used in the most recent RES Handbooks or Checklists. Scientific names (generic and specific) are italicised and when a species name following a generic name is bracketed this signifies that the genus contains only that species in Britain.

AIDGAP PUBLICATIONS

The following AIDGAP titles have been published by the Field Studies Council:

Insects of the British cow-dung community
P. Skidmore (1991) Occasional Publication 21

British Sawflies (Hymenoptera: Symphyta): a key to adults of the genera occurring in Britain
Adam Wright (1990) Offprint No. 203

Soil Types: a field identification guide
Stephen Trudgill (1989) Offprint No. 196

Keys to the families of British Spiders
L.M. Jones-Walters (1989) Offprint No. 197

A key to adults of British Water Beetles
L.E. Friday (1988) Offprint No. 188

A key to the major groups of British Terrestrial Invertebrates
S.M. Tilling (1987) Offprint No.187

A key to the major groups of British Freshwater Invertebrates
P.S. Croft (1986) Offprint No.181

Sea Spiders. A revised key to the adults of littoral Pycnogonida in the British Isles
P.J. King (1986) Offprint No.179

A field guide to the British Red Seaweeds (Rhodophyta)
Sue Hiscock(1986) Occasional Publication 13

British Grasses: a punched-card key to Grasses in the vegetative state
R.J. Pankhurst & J. Allinson (1985) Occasional Publication 10

Bees, Ants & Wasps - the British Aculeates
Pat Willmer (1985) Occasional Publication 7

A key to the families of British Coleoptera (beetles) and Strepsiptera
D.M. Unwin (1984: revised 1988) Offprint No.166

A field guide to the Slugs of the British Isles
R.A.D. Cameron, B. Eversham & N. Jackson (1983) Offprint No.156

A key to the Crabs and Crab-like Animals of British inshore waters
John & Marilyn Crothers (1983: revised 1988) Offprint No.155

A key to families of British Diptera
D.M. Unwin (1981) Offprint No.143

An illustrated guide to the Diatoms of British coastal plankton
J.B. Sykes (1981) Offprint No.140

A field key to the British Brown Seaweeds
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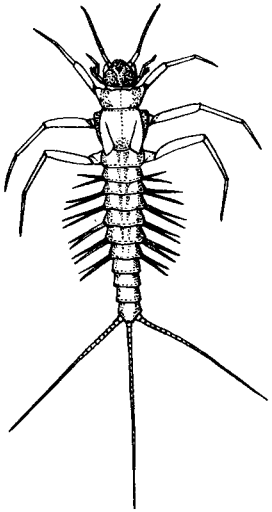
FIELD STUDIES COUNCIL AIDGAP PROJECT

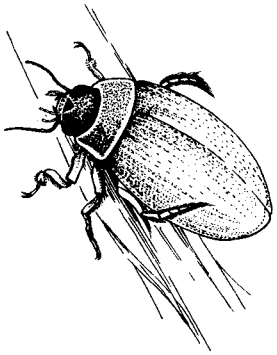
AIDGAP
AIDS TO IDENTIFICATION IN DIFFICULT GROUPS OF ANIMALS & PLANTS

Field Studies Council,
Central Services,
Preston Montford,
Montford Bridge,
Shrewsbury SY4 1HW
Telephone Shrewsbury (0743) 850674



Aims and objectives

The accurate identification of specimens is a fundamental part of most forms of biological fieldwork. Although the "popular" groups, such as butterflies, moths, birds and wild flowers, are well-served by numerous aids to identification, other groups are often neglected. The principal objectives of the AIDGAP project are to identify those groups for which the difficulty in identification is due to the absence of a simple and accurate key rather than being due to insuperable taxonomic problems and, subsequently, to produce simple, well-written aids to identification. These aids avoid obscure terminology, are clearly illustrated and need not be restricted to traditional methods of presentation. For example, the AIDGAP keys to *Salix* spp. and grasses have used multi-access tabular and punched-card formats.



Testing

A significant feature of all the keys is the extent to which they are "tested" before final publication. In addition to routine editing and refereeing by acknowledged experts, the keys are subjected to extensive field tests. Several hundred copies of a preliminary draft—the "test" version—are sent to potential users: school and university staff and students, amateur naturalists, research workers and others involved in surveys who need to identify organisms in groups outside their own sphere of interest. The authors are asked to amend the keys in the light of feedback from these "testers" before final publication.

Feedback

The success of any project such as this depends on feedback from the public. Most people who have experience of fieldwork are aware of "gaps" in the literature but unless these are communicated to the project co-ordinator, AIDGAP can do little to help alleviate the situation. Anyone wishing to contribute identification aids, or to suggest possible subjects for future projects, should contact the co-ordinator at the address above. Projects need not be confined to the biological field; AIDGAP would be equally interested in geological, palaeontological and geographical subjects.

The Field Studies Council

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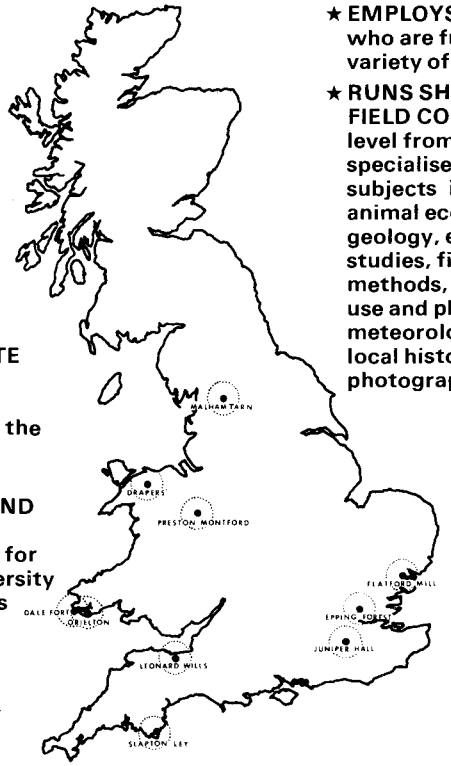

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THIS GUIDE

The cow-dung community plays a vital role in the nutrient cycles and productivity of pastures. Whilst many insects are essential for the rapid conversion of dung into humus, others, such as those which are vectors of cattle diseases, have a more negative role. This guide will be of use to specialists and beginners alike; for those who are involved in research into the ecology and management of pasture areas, or for those who wish to carry out a simple investigation into a convenient ecological unit – one in which ecological patterns and processes can be studied in a small area and over a very short time span. The first part of this book will enable beginners to identify the major groups of invertebrate animals associated with cow-dung (and some dung-frequenting plants as well); the next section covers identification in more detail and provides extensive notes about the habits and distributions of the cow-dung fauna. The guide also includes extensive background notes and reference sections covering detailed aspects of the ecology of the cow-dung community, but also allowing comparisons to be made with the dung fauna associated with other ungulate animals.

Like all other AIDGAP keys, earlier versions were tested extensively by beginners and specialists, and this, the first published version, has been revised in the light of their comments. Further details of the AIDGAP project are given inside.

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