XV.—The Distribution and Biology of Drosophilidæ (Diptera) in Scotland, including a New Species of *Drosophila*.

By **E. B. Basden,** Institute of Animal Genetics, West Mains Road, Edinburgh. *Communicated by* Professor C. H. Waddington, F.R.S. (With Two Plates and Nine Text-figures.)

(MS. received March 28, 1953. Revised MS. received December 4, 1953. Read January 11, 1954. Issued separately June 28, 1954.)

Synopsis

The paper presents the results of an investigation of the distribution and biology of flies of the family Drosophilidæ in Scotland. Methods of sampling the population are described and notes are given on the breeding of many species in the laboratory. All earlier records of Drosophilidæ in Scotland are brought together for the first time, and the new species, *Drosophila silvestris*, is described.

CONTENTS

I. Introduction

The published records of Drosophilidæ in Scotland are very scanty and usually give only the place and date of capture. Therefore, as a preliminary to further work with wild populations of these flies, an investigation was started in March 1950 to discover which species occurred in Scotland and to learn something of their biology. Their adaptability to laboratory culturing was also studied. The methods used for the elucidation of the first two points were to expose in various types of habitats bottle traps containing fermenting substances (baits) known to be attractive to *Drosophila* adults; to collect flies at such natural foods as fungi, sap exudations, over-ripe fruit and decaying vegetables, as well as from inside houses and other buildings;

and to try to rear specimens from the media in which the larvæ might feed. The substances and habitats investigated were thought likely to produce specimens of most if not all species of the genus *Drosophila* in Scotland, as well as some species of other genera, but by no means all sources of drosophilid material were investigated.

A distinction is drawn between the meanings of the terms bait and trap used in this paper. A *bait* is an attractive substance to lure flies but not to retain them artificially. Such a substance placed loose on the ground or inside a container not fitted with a fly-retaining device is referred to as a bait and not as a trap. On the other hand, a *trap* is any receptacle meant to retain flies once they have entered it. In our case all traps contained bait, but an empty jar fitted with a retaining device, such as a funnel-shaped opening, would also be a trap, though unlikely to catch many *Drosophila*. The bait used in a trap is the *trap-bait*.

The trapping was conducted in two degrees of intensity—an all-the-year survey of two private country estates near Edinburgh and of two fruit stores in Edinburgh, and a more general sampling of the *Drosophila* population of the rest of Scotland.

II. Baits and Traps

(a) *Baits.*—Seven food-stuffs have mainly been tried out as trap-baits. Fermenting middlings (fine wheat offal, wetted) collected too few specimens to be recommended for future use, although *D. funebris* and *D. busckii* found it attractive; it was not used after September 1950. Tomatoes were most disappointing, and these and middlings were objectionable to handle after a few days. Ordinary Drosophila culture medium (maize meal, molasses, yeast, agar and water) was much more attractive and it was used until September 1950, but it was poor compared with fermenting fruits (raspberries, apples, oranges, plums), which also remained sweet and attractive for much longer periods. For example, apple bait continued to attract *Drosophila* adults outdoors for quite four weeks after it had been prepared, and plum bait was still effective when it was thrown away after two weeks. In America bananas are claimed to be the most attractive bait (Spencer 1950, 538) but these were not used, as during most of the period they were in very short supply. Ultimately, from October 1950 apple bait was used almost exclusively, as this fruit attracted more species and specimens than did any of the other baits (Table I), and it was obtainable at all times of the year. It is probable that different varieties of apples vary in their attractiveness to *Drosophila* but this has not been investigated. The apples as purchased were usually a mixture of dessert varieties.

To prepare the fruit baits the entire fruit is cut into smallish pieces, a potato chipper being used for large quantities, and gently heated to 70° C. in a closed container, stirring occasionally, to kill any insects already present (*Drosophila funebris*, *D. melanogaster* and *D. subobscura* were reared from bruised apples as bought from a fruit shop). The fruit then becomes soft and ready to ferment. No sugar or yeast is added and the addition of a little water is usually unnecessary. The fruit is then kept in bulk in fly-proof jars at 25° C. for 3 to 6 days, when it is stirred once a day to facilitate fermentation and to prevent the growth of moulds. It is then ready to use. Agar at the rate of 10 c.c. of 3 per cent solution to each 100 gm. of fruit, or roughly 50 c.c. to 1 lb., can be heated in for setting, but this was used only very occasionally. With the more mushy baits, or when moisture condenses inside the traps, a piece of muslin cloth will provide a foothold for flies. The bait is placed to a depth of about 1½ inches inside the trap bottles. Three pounds of apples are sufficient for twelve half-pint size milk-bottle traps. The use of bottled apple juice instead of the whole fruit is being investigated.

The above *prepared baits* are distinguished from untreated, naturally occurring foods (*natural baits*, p. 613).

(b) *Traps.*—Half-pint glass milk bottles were used as standard containers for the bait (internal measurements 2″ diam. × 6″ deep, opening 1½″ diam., total capacity 286 c.c.) as these are readily obtainable, strong, and of convenient size for transporting. A fairly small quantity of bait was an advantage when the bait was kept for progeny of trapped flies to develop,

otherwise the task of sorting out too many emergents might have become overwhelming. The most efficient trap top proved to be a cork bored with 2 holes, each to take a two-inch length of card tubing (thermometer case) of $\frac{4}{10}$ inch (10 mm.) inside diameter and projecting about $1\frac{1}{2}$ inches inside the bottle (Pl. I, fig. *a*). These can be used repeatedly. To prevent rain, snow, fallen leaves, etc. from entering the traps or blocking the holes a shelter is placed over them (Pl. I, fig. *d*). A cardboard collar round the bottle to shade the trapped flies is sometimes advisable.

(c) *Trapping Stations.*—The two private estates that were intensively investigated for *Drosophila* were at Liberton and at Dalkeith. From these over 90 per cent of the total Drosophilidæ were captured.

The nearest boundary of the Liberton estate is about 1 mile from the southern built-up outskirts of Edinburgh, just over 1 mile from the Genetics Institute and just over 4 miles south-west of the Firth of Forth. The estate is approximately 450 acres in extent and lies between 400 ft. and 600 ft. above sea-level. It is well wooded, with the woodland mostly in the form of long narrow belts of mature beech trees, but there are also scattered plantations of pines and larches; and other trees (oak, sycamore, poplar, lime, horse-chestnut and yew) grow here and there in the woods or in the open. There are relics of timbered park-like areas though much land is now pasture or arable. Some pasture to the south-east of the mansion-house and garden is boggy, and a small stream runs along the southern part of the estate. The Braid Hills (698 ft.) and an open golf-course border the estate on the north-west. Tentacles of built-up areas skirt the estate on the east and west, but the land to the south is open arable. Trapping was carried out at 17 sites on the estate, including the kitchen and cellar of the mansion and part of a stable block being used to house poultry.

The nearest boundaries of the Dalkeith estate are almost 4 miles south-east from Edinburgh suburbs and from the Genetics Institute, and 2 miles due south of the Firth of Forth. The main part of the estate of 1089 acres abuts on the northern edge of the township of Dalkeith (estimated population at June 1952, 8786), and it lies between 100 ft. and 200 ft. above sea-level. The several woodland areas total 401 acres and are carefully silvicultured. They range in age from mature mixed deciduous (mostly oak and sweet-chestnut), and partly mature beech, ash, elm, sycamore, larch and some poplar, to recently planted oak, sycamore, beech and various conifers. Scattered undercover patches of yew, holly, privet and box occur in the older woodlands. The most interesting area is the "Old Wood", of 88 acres, where numerous ancient (up to 300–400 year-old) oak trees grow fairly densely in a grassy park grazed by sheep and cattle (Pl. II, fig. *b*. See Fenton 1941). This is bounded either side by the rivers North Esk and South Esk, which meet at its northern point. There are also half a dozen large areas of pasture in the southern portion of the estate. The northern part is mainly arable and therefore more open. The pasture parks and agricultural lands total 636 acres. Water (stream, rivers, two ponds), buildings, etc. take up the remaining 52 acres. Trapping was carried out at 42 sites on the estate, all outdoors. The two estates at Liberton and Dalkeith are 3 miles apart at their nearest points.

Much incidental trapping and collecting was also done in a cottage and its small garden at Bonnyrigg (Midlothian), a small town (1951 pop. 4600) 3 direct miles south-east of the Liberton estate and $1\frac{3}{4}$ miles from Dalkeith.

The fruit stores that were examined regularly for Drosophilidæ were in the wholesale fruit and vegetable distribution area in the centre of Edinburgh. An unheated window-lighted miscellaneous fruit-vegetable store was investigated weekly from 24th September 1951 and a completely dark banana-ripening store (the rooms of which were periodically heated to about 72° F.) from October 1951. The banana store was approached by a 75-yard-long subterranean tunnel. The ripening rooms were sometimes empty for a week or more and were unheated during these periods, with the result that during the winter the *Drosophila* population was reduced to an occasional specimen of *D. funebris* only.

The general sampling of the drosophilid fauna of the rest of Scotland was carried out (1) by occasional trapping in a few other localities within a 12-mile radius of the centre of Edinburgh and south of the Firth of Forth (the *Edinburgh district*); (2) during two long collecting trips over the western and eastern parts of the mainland; and (3) through the kindness of many colleagues who put out traps when on holiday in different parts of Scotland.

During Collecting Trip I at the end of August and beginning of September 1950, traps were put out in the Liberton estate and then at every 10 miles of longitude south-west to the coast at Stranraer, then every 10 miles of latitude from Cairnryan (5 miles north of Stranraer) to Ullapool on the north-west coast. Two traps of Drosophila

medium, 1 of fermenting middlings and 1 of plum, were placed within an area of 3 to 4 sq. yds. at each of 28 stations, but no middlings at Station 29 just south of Ullapool. The traps were collected on the return journey, which meant that those put out last were exposed for the shortest time (2 days) and those out first were out the longest time (8 days), with others intermediately. Collections were also made at fungi and at a few houses during the trip.

During Trip II, in early September 1951, the eastern part of Scotland was sampled in a similar manner, all traps, except four, being exposed for about the same length of time, *i.e.* seven or eight days. The route followed was north from Edinburgh via Blairgowrie and Braemar to Inverness, Lairg and Tongue, then along the northern coast-line to Melvich, returning to Inverness via Helmsdale on the east coast. Thence east to Elgin, south-east to Aberdeen, and south along the lower east coast-line almost to Montrose, turning west inland through Brechin and Blairgowrie to complete the round trip in seven days. Traps were put out the first time round and recovered on the second journey seven or eight days later. The traps at four stations between Edinburgh and Blairgowrie were left until the last day and thus were out for 15 days. One trap of apple and one of plum at least were put at each of the 45 stations on the route, a total of 98 traps being exposed. A few buildings were examined for domestic species and many fungi were collected in the hope of rearing specimens. A summary of the captures in the traps on the two trips is given in Table I.

A few other Scottish areas that would have remained unsampled were trapped in by colleagues on holiday.

A total of 117 localities in Scotland has been tested during the present survey and Drosophilidæ were caught at 106 of them. A further 74 localities have yielded Drosophilidæ to other workers, making a total of 180 different Scottish localities from which flies of this family have been obtained, their location being shown in text-fig. 1 (p. 622). Most of the mainland of Scotland and a few islands have been covered, and most kinds of habitats have been explored. Further work needs to be done, however, around lochs, on high mountains and on the wetter boggy moorlands, in the areas of ancient pine forests and in the extensive young pine plantations, as well as in most of the Western Isles and in Orkney and Shetland. Coal-mines have not been investigated.

(d) *General Results of Trapping.*—Table I shows the relative attractiveness of some trap-baits exposed during Trips I and II.

TABLE I

The Attractiveness of Different Trap-baits

Species	Trip I									Trip II					
	Middlings (28 Traps)			Drosophila Medium (58 Traps)			Plum (29 Traps)			Plum (49 Traps)			Apple (49 Traps)		
	♂	♀	Total	♂	♀	Total	♂	♀	Total	♂	♀	Total	♂	♀	Total
D. subobscura	..	1	1	1	54	55	13	243	256	3	122	125	17	274	291
D. obscura	..	..	..	..	1	1	..	7	7	4	14	18	21	90	111
D. tristis	..	..	..	..	1	1	2	2	4	1	..	1	1	2	3
D. ambigua	..	..	..	..	..	..	..	1	1	..	1	1	1	..	1
D. silvestris	..	..	..	..	2	2	5	4	9	11	18	29	65	58	123
D. melanogaster	..	..	..	..	..	..	2	2	4	2	1	3	2	3	5
D. simulans	..	..	..	..	..	..	..	1	1	1	..	1	1	..	1
D. phalerata	..	..	..	2	1	3	2	3	5	..	..	..	4	4	8
D. transversa	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..
D. deflexa	..	..	..	..	..	..	4	19	23	..	..	..	2	1	3
D. funebris	..	..	..	..	1	1	1	5	6	..	..	..	6	3	9
D. buscki	..	..	..	..	..	..	..	..	..	..	..	..	2	..	2
Chymomyza costata	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..
Totals	1	1	1	3	61	64	29	287	316	22	157	179	122	435	557

It is obvious from Table I that the plum and apple attracted most specimens and species and that apple was better than plum. Apple has also been tested against orange and was more attractive in this case too. Raspberries, which are very attractive to *Drosophila*, are impracticable to obtain out of their short season and they are expensive to buy.

Although the half-pint traps adequately sampled the *species* population of the genus *Drosophila*, which was the main purpose of the survey, they do have two main limitations, viz. the catch is frequently small, and other insects do invade them. These limitations doubtless apply to any trap, whatever its design. The number was doubtless influenced by the season of the year, by weather conditions, and by the fact that most bottles were exposed at ground-level instead of being a distance from the ground. Although several hundred and even over one thousand flies have been caught in a standard trap after a week's exposure, on other occasions only one or two flies, sometimes none, would be found, and in general a catch of 30 or more flies after a week was considered good. Thus it was necessary to expose the traps for a week, as a shorter period usually caught few flies. This precluded their use in any ground-level experiment where an average of at least 10 flies a trap after one or two days might be required. It was thought that at certain periods the two estates near Edinburgh, where most of the trapping was carried out, were not well populated with *Drosophila*, but when apple bait was put there loose on the ground it attracted plenty of flies, and many more than did apple inside traps. The following examples will show this.

When very few flies were being caught in traps, prepared apple bait of the same kind and quantity as that in the traps was tipped loose on to squares of brown cardboard on the ground. The cardboard facilitated the subsequent collection of flies. One loose bait and four traps were placed close together at each of five different sites on 12th June. Two days later the loose baits were examined at hourly intervals between 10 a.m. and 6 p.m., and during the last collecting round the trap bottles also were examined. The traps should have amassed a cumulative catch of flies during the two days, whereas the baits would have flies that had arrived only recently, and certainly within the preceding hour after the first examination. The flies at the open baits were caught by placing a net quickly over the bait and flat on the cardboard, with the net bag held up by finger and thumb. The flies readily flew into the net and could be seen through the transparent material (organdie). A quick twist of the wrist dislodged all to the bottom of the net and they were quietened in a jar of ether fumes. Those that feigned death at the bait were picked up by mouth-sucking tube. The whole process took 5 minutes at the most. The results of this experiment are given in the first two columns of Table II. The traps only were then left out for 4 more days, with the results in the last column of Table II.

TABLE II

The Numbers of Drosophila *Caught at 5 Sites*

Species	Open Baits (32 Collections during 8 Hours)		Traps (20 Traps exposed for 56 Hours)		Traps (the same 20 Traps exposed 4 more Days)	
	♂	♀	♂	♀	♂	♀
D. subobscura . . .	27	1	1	1	2	3
D. obscura	53	58	5	9	7	19
D. silvestris . . .	8	1	1	1	1	5
D. phalerata . . .	7	2	..	..	..	..
D. funebris . . .	1	..	..	..	..	1
D. tristis	1	..	..	2	2	..
Totals . .	97	62	7	13	12	28

Similar results were obtained on another occasion. Five standard traps were spaced out in each of two woods on the Dalkeith estate on 19th July and the flies were removed 5 days later. The apple bait in them was then immediately tipped on to cardboard at the same spot and examined 1 hour later and twice more at about 2½-hour intervals. Immediately after the third examination the bait was returned to the trap bottles, which were examined 3 days later, on 27th July. From the open baits out for 6 hours on 24th July, 148 ♂, 47 ♀ *Drosophila* were collected (*D. subobscura* 105 ♂, 18 ♀; *D. obscura* 40 ♂, 29 ♀; *D. silvestris* 1 ♂; *D. phalerata* 2 ♂), but in the traps out for 8 days there was a total of only 7 ♂, 20 ♀ *Drosophila* (*D. subobscura* 1 ♂, 13 ♀; *D. obscura* 2 ♂, 5 ♀; *D. silvestris* 2 ♂; *D. melanogaster* 1 ♂; *D. deflexa* 1 ♂, 2 ♀).

It is obvious from Table II and the experiment following that many more flies went to the loose baits than to the trap-baits, even though the former were exposed for a much shorter period. It is not thought that the smell of (wetted) cardboard influenced the results, as

earlier a bottle of apple accidentally smashed on bare ground also attracted much larger numbers of flies than did the unbroken traps out at the same time.

Another important point to note here is that open baits produced a preponderance of males, especially of *D. subobscura*, whereas the traps gave a majority of females. The latter is also obvious in Table I. At open baits males were resting on the outskirts of the baits, and many of them would be caught in the net even though not actually on the bait. Assuming that the sex ratio of *Drosophila* in nature is 1 : 1, then neither open baits nor traps would give a true sample of a population. A deficiency of males has already been remarked by Gordon (1942); and Table 16 in Burla (1951, 170) shows the same thing. On the other hand Spencer (1942, 55) records between three and four times as many males as females of *D. quinaria* Loew at yeasted banana bait in Ohio, but suggests this may be a sex dimorphism in food preferences, as collections from tomato and potato plants did not produce this disparity of the sexes. Similarly da Cunha *et al.* (1951, 99) found that the sex ratio of 3 American species of the *obscura* group at yeasted banana was approximately equal, whereas at yeasts alone males predominated.

One advantage of the open baits was that information could be obtained quickly as to whether *Drosophila* were present in a particular area, as the first flies were attracted to them six minutes after they were exposed, though in sparsely populated areas or during inclement weather this period might be longer.

It has been remarked (p. 607) that during 1950 and 1951 the numbers of flies in the traps were often disappointingly small, but during 1952 so far (to August), using apple and the same type of trap, the numbers have been very much higher, indicating that there are good and poor *Drosophila*-years.

The second limitation, of those traps placed outdoors, is that although for most of the year they attract mainly *Drosophila*, and often only *Drosophila*, other creatures do enter them, and may become a nuisance because of numbers, or by preying on the living and dead *Drosophila*, or by trampling themselves and the *Drosophila* to a mass of fragments, all of which make the examination of the material more arduous and the identification sometimes impossible. Nearly all of the 959 unidentifiable specimens encountered (Table III) were a result of these intruders. Spiders, various small beetles (mostly Staphylinidæ), wasps (*Vespula* spp.), *Scopeuma* (=*Scatophaga*) flies, and earwigs are the most unwelcome visitors. Traps out during May, June or first half of July attract numerous small beetles, 856 having been found in one trap after seven days. Wasps become a nuisance from the end of July until the end of October, the record being 180 wasps present in one trap after seven days, though they are usually dead or tipsy by then. Various Diptera (*Anisopus*, *Calliphora*, Anthomyidæ, Helomyzidæ, Sciomyzidæ, etc.) are also attracted to the traps, especially in autumn and winter, 226 specimens of the various species or 600 of *Anisopus* having been caught in one trap after one week. A distinct musky odour in the traps is associated with the presence of the larger Diptera, and this odour might conceivably affect the catch of *Drosophila*. A few predaceous *Scopeuma* in a bottle from April onwards can kill many *Drosophila* adults. Slugs are occasional visitors, but the cork tops of the standard traps are proof against mice and voles, which ate Drosophila-food baits when no tops or only cardboard ones were being used. Fortunately all of these pests except the small beetles can be excluded by fixing a hood of 10- or 7-mesh gauze (10 or 7 meshes to one linear inch) over the top of the trap bottle (Pl. I, fig. *a*), while still allowing *Drosophila* to enter.

In spite of the previously described limitations it was considered more practicable and convenient to continue the use of the standard trap bottles, and these produced almost all the 43,629 specimens listed in Table III.

Although 2000 trap-baits have been exposed throughout Britain and Eire, each usually for about a week, the number of species caught in any one trap, even if several hundred specimens were present, was generally no more than 4 to 6. On two occasions only have as many as 8 species been obtained in one trap, and only on eleven occasions have 7 species been trapped together. All these were from woods in Scotland. Therefore, of the 16 or so species that one has at least a faint chance of trapping at fermenting baits, not more than one-third to one-half are actually ever caught in any one trap.

The results of continuous trapping in a small area and of placing traps at different heights in trees will be published separately.

Other workers have described the results of their various methods of catching Drosophilidæ (Burla 1951, 28; Dobzhansky and Epling 1944, 18; Hadorn *et al.* 1952, 135; Patterson 1943, 10; Spencer 1950, 535; Williams 1953; Williams and Miller 1952, 2). It is obvious from these and from my own experience that to obtain a truly representative sample of a population of the genus *Drosophila* of an area, not to mention a representative sample of the whole family, it would be necessary to use a combination of different baits and traps in different habitats and at different heights (in wooded habitats), as well as to employ other methods of collecting.

One type of trap that can be usefully employed is the Johnson suction trap (Johnson 1950; improved by Taylor 1951), which segregates the catch into hourly lots. Dr J. A. Campbell of the Ectoparasite Unit, George Square, Edinburgh, has used two of these in the open on the Bush Estate, Milton Bridge, Midlothian, in a study of biting midges (Ceratopogonidæ). Mr E. C. Pelham-Clinton of that Unit has kindly allowed me access to what Drosophilidæ have been preserved from one trap placed 6 feet above the ground. Other specimens had been discarded. It is a pleasure to thank both these gentlemen for the opportunity of making known the following few but interesting results. The flies were captured within the hour previous to the times given, which are Greenwich Mean Time. It is interesting that as many specimens of *Chymomyza costata* were captured in the trap during $3\frac{1}{2}$ weeks as has previously been found in the whole of Scotland, including the 3 specimens of this survey. It is obvious that useful information on the hour-by-hour activities of drosophilid adults would be obtained from more extensive collections, and that more specimens of those species not normally attracted to fermenting baits would also be obtained. The specimens, which are not included in Table III, were:

Drosophila obscura	1 ♂	11th August 1951	0400 hours
	1 ♀	18th August 1951	2000 ,,
D. funebris	1 ♂	23rd August 1951	2100 ,,
Scaptomyza graminum	1 ♀	12th September 1951	0400 ,,
	1 ♀	12th September 1951	0500 ,,
Parascaptomyza disticha	1 ♂	3rd August 1951	2000 ,,
	1 ♂	9th August 1951	2100 ,,
	1 ♀	9th August 1951	1700 ,,
	1 ♂	10th August 1951	1900 ,,
	1 ♂	15th August 1951	1000 ,,
Chymomyza costata	1 ♀	3rd August 1951	1800 ,,
	1 ♂	11th August 1951	1100 ,,
	1 ♀	14th August 1951	1500 ,,
	1 ♀	16th August 1951	0500 ,,
	1 ♀	18th August 1951	1600 ,,
	1 ♂	23rd August 1951	1200 ,,
	1 ♂	23rd August 1951	1400 ,,
	1 ♂	26th August 1951	1900 ,,

III. Habitats and Natural Foods

(a) *Habitats.*—Species found at baits are not necessarily dwellers in the habitat in which the baits are exposed. Carson (1952, 245) has found that *D. robusta* Sturt. in America will travel 1850 ft. to banana bait. However, useful indications of the predilection of a species for a habitat can be obtained by trapping, especially if the trap-bait is small in quantity as used in this survey, but it is obvious that a truer picture would result from the collecting of free-living specimens. This latter, however, is often impracticable, as many species, especially of the *obscura* group, are very rarely or never ordinarily seen unless baits are put out. This has also been mentioned by Dobzhansky and Epling (1944, 18).

The various habitats are grouped here into Wooded Areas, Open Areas, and Built-up Areas, with the two extraneous groups of Transport Vehicles and Waste Dumps. In general only the results obtained from the survey are discussed, as the majority of earlier records or the data with museum specimens do not state the precise nature of the country in which the flies were collected.

The term *indoors* means inside all buildings (houses, stores, glasshouses, animal sheds, etc.) and motor vehicles, and in their windows. *Outdoors* is outside buildings and motor vehicles. An *indoor species* is usually found in buildings and often breeds therein, whereas an *outdoor species* breeds, as far as is known, exclusively outdoors, though the adults may sometimes occur indoors.

Most trapping and collecting has been done in the various types of wooded areas, where 20 species of Drosophilidæ have been found in Scotland. Deciduous woodland appears to be the most frequented habitat, with the 18 species listed below. The 2 species that have not been found in deciduous woods but have been trapped in other types of wooded habitats are *D. forcipata*, once in a timbered park, and *D. simulans*, once in a small patch of scrub in arable country. Coniferous woods and plantations, with 9 species, have been investigated much less, so the drosophilid fauna of these two types of woodland cannot yet be satisfactorily compared.

The denser, shadier and more mature deciduous woods are usually more productive of specimens and species than the more open or younger ones. There appeared to be a definite correlation between the type of ground cover and the abundance of *Drosophila*, especially of the *obscura* group. Where there was little or no undergrowth but plenty of leaf-mould, more *Drosophila* were trapped; but when the ground was covered with grass, and leaf-mould had not accumulated, there were fewer. This correlation between type of ground cover and the abundance of *Drosophila* was thought to be mainly due to the presence or absence of leaf-mould, in which the larvæ probably fed (woodland toadstools are also breeding sites of a few species of *Drosophila*). It is now considered more likely that the denser woodlands, which would have a barer ground cover and more leaf-mould as a matter of course, are more attractive to *Drosophila* for other reasons, such as pockets of sap exudation for feeding or breeding (Carson 1951; Carson and Stalker 1951), or even for the shade or the shelter. However, experiments continuing in the old oak park at Dalkeith indicate that some trees in open, grassy situations yield many *Drosophila* provided that the traps are high up in them and not on the ground, although the partial decay of the more ancient of these trees, or even perhaps the copious honey-dew from aphids, might here be significant attractants. The deciduous woods trapped in were of no great extent, being not more than 300 yards at the widest and two-thirds of a mile at the longest, but most were much smaller. The following species have been caught in deciduous woodlands in Scotland: *D. subobscura, D. obscura, D. silvestris, D. tristis, D. ambigua, D. deflexa, D. funebris, D. cameraria, D. phalerata, D. transversa, D. busckii, D. melanogaster, D. hydei, Chymomyza costata, Amiota alboguttata, Scaptomyza graminum* and *Parascaptomyza disticha.*

D. littoralis should also be included here, though it was found only in the larval stage in stumps of trees in a recently clear-felled woodland.

The first 9 species of the preceding list have also been trapped in coniferous woods and plantations.

The next most productive habitat of wooded areas consists of patches of scrub or bushes in more or less open country. Ten species have been trapped in these, viz. the first 7 species in the preceding list as well as *D. phalerata, D. melanogaster* and *D. simulans.* The last species has not yet been found in deciduous woodlands but it is rare outdoors anyway, although it has been trapped in a wooded garden, which latter type of habitat has also produced *D. subobscura, D. obscura, D. silvestris, D. tristis, D. deflexa, D. funebris, D. phalerata* and *D. transversa.*

Timbered grass parkland * is less productive of species than is deciduous woodland, the following 12 species having as yet been found there: *D. subobscura, D. obscura, D. silvestris, D. tristis, D. deflexa, D. funebris, D. forcipata, D. melanogaster, D. transversa, D. phalerata, D. cameraria* and *Amiota alboguttata.*

It would be interesting to compare orchards that have grass undercover with timbered parkland, but too few orchards have been explored. If the records from three English orchards are included, the species list for orchards is *D. subobscura, D. obscura, D. deflexa, D. phalerata, D. hydei, P. melanogaster, D. simulans, D. funebris* and *D. busckii.*

Small copses, of a few trees with shrubs, in arable or pasture fields are not very productive, as only *D. subobscura, D. obscura, D. silvestris, D. ambigua, D. phalerata* and *D. melanogaster* have been found in them.

Three woodland species (*D. silvestris, D. cameraria* and *Amiota alboguttata*) have not been trapped where trees or bushes do not grow, and these three and *D. tristis, D. deflexa, D. littoralis* and *D. transversa* are the only species that have not been found by me inside any type of building in Scotland.

The species associated with woodland fungi and tree saps are discussed on pp. 613–614.

Habitats in open country (*i.e.* relatively treeless) areas were found to be less productive of species than those in wooded or built-up areas. Only 10 species have been obtained, all of which are to be found also in wooded areas in Scotland, viz. *D. subobscura, D. obscura, D. tristis, D. silvestris, D. deflexa, D. funebris, D. phalerata, D. melanogaster, D. transversa* and *Scap. graminum. Scap. apicalis* and *Par. disticha* should be included here, as they have been obtained in open habitats by other collectors. It is probable that to obtain the maximum number of species in the open, trapping should be augmented more than in woodland areas by other methods of collecting, such as sweeping with a net or the employment of a suction trap (pp. 609, 615).

In open arable-pasture country only *D. subobscura, D. obscura, D. tristis* and *D. silvestris* have been obtained, mainly in the hedgerows between fields, but in this type of habitat in southern England *D. melanogaster* and 1 ♀ of *D. immigrans* have also been trapped.

Pastures near woods might appear to be promising trapping grounds, but only *D. subobscura, D. obscura, D. phalerata* and *D. melanogaster* have been caught, although *D. silvestris* occurred on the edge of a wood next to pasture.

The two most open and exposed types of habitat in Scotland are moorlands and coast dunes. So far only *D. subobscura* has been obtained on the coast, probably because too

* *Park* or *parkland* is used here only for pasture areas containing timber trees (oak, sycamore, etc.) and in which cattle, sheep, deer, etc. might feed; and not for the pleasure, flower-bed type of park in towns, which can be differentiated by being called *garden-parks.*

little collecting has been done there, and Lever and Sobels (1951, 86) mention *D. subobscura* * from open dunes in Holland. In 41 traps in fifteen areas of desolate moorland in various parts of Scotland only *D. subobscura* regularly occurred, but 1 ♀ *D. transversa* was trapped on wild moorland just north of Tyndrum, Perthshire, and 1 ♀ *D. melanogaster* near the roadside on the remote and desolate Black Mount, Rannoch Moor, Argyllshire.

Mountains have not been purposely investigated for Drosophilidæ. Traps have been exposed in only one place over 2000 ft., near the Devil's Elbow in the Grampians (2400 ft.), where 1 ♀ *D. subobscura* was obtained. R. L. Coe has collected *D. fenestrarum* and *Par. disticha* by Loch Etchachan (3200 ft.), and the latter species also on the summit of Ben Macdhui (4296 ft.) in the Cairngorms.

Another type of open habitat of interest is the treeless islets and islands, mainly off the west coast. My small-scale trapping on these has produced only *D. subobscura, D. obscura, D. tristis, D. deflexa, D. funebris, D. transversa* and *Scap. graminum*; but *D. fenestrarum* (*sens. lat.*), *D. phalerata, Par. disticha* and *Scap. apicalis* are recorded in the literature from various of them.

The drosophilid fauna in gardens and buildings of built-up areas (towns and villages) in Scotland is fairly rich, with 18 species, but neither habitat has yet produced as many species as deciduous woodlands. Three of the species (*D. immigrans, D. ananassæ* and *Scap. apicalis*) have not yet been found in any type of wooded habitat in Scotland. Gardens in built-up areas are the link between built-up areas and open and wooded areas. The 9 species found in rural wooded gardens have been given on p. 611. The cottage type of vegetable-flower garden in built-up areas, with perhaps a tree or a bush or two, have yielded 12 species, viz. *D. subobscura, D. obscura, D. silvestris, D. tristis, D. ambigua, D. funebris, D. busckii, D. melanogaster, D. phalerata, Par. disticha, Scap. graminum* and *S. apicalis*.

Some, but not all, of the species trapped or collected in gardens have also been found in glasshouses and conservatories. They are *D. subobscura, D. busckii, D. funebris, Par. disticha, Scap. graminum*, and *S. apicalis*. These 6 species have also been found on the inside of house windows in Scotland, as have also *D. melanogaster, D. hydei, D. forcipata* and *D. obscura*, the first of these four quite commonly, the rest uncommonly.

The investigation of fruit stores in Edinburgh is not yet completed, but 11 species have been collected or trapped on or near the fruit and 5 other species have occurred only in the windows. The former are *D. subobscura, D. obscura, D. funebris, D. busckii, D. melanogaster, D. simulans, D. immigrans, D. phalerata, D. ambigua, D. ananassæ* and *D. hydei*. The first seven of these have been frequently found also in the windows. The 5 species found only in the windows are *Par. disticha, Scap. graminum, S. apicalis, Chymomyza costata* and *Drosophila forcipata*.

Two types of habitat that do not fit into any of the above three groups are transport vehicles and waste dumps. Of the former only a few motor-cars and public buses have been examined. The species in them were *Scap. apicalis, Par. disticha, D. forcipata* and *D. subobscura*. Although these might have been drawn accidentally, it is interesting that they all are species found also in glasshouses or in windows of buildings. An examination of aircraft (for example Whitfield 1939, 412) and of trains and more motor vehicles would no doubt add greatly to the list. Waste dumps include the domestic refuse bin (dust bin) and rubbish dumps in gardens, and the large tips of town refuse controlled by a local authority. This special type of habitat needs further investigating, but the following 9 species have been taken on or close to dumps, viz. *D. subobscura, D. obscura, D. silvestris, D. funebris, D. busckii, D. phalerata, D. melanogaster, D. simulans* and *Par. disticha*.

* Lever and Sobels (p. 84) incorrectly give *subobscura* Coll. as a synonym of *obscura* Fln., but *obscuroides* Pom., which they list as a good species, is the synonym of *obscura* (see Cain, Collin and Demerec 1952).

(b) *Natural Foods.*—The substances in nature likely to attract *Drosophila* adults and the naturally occurring foods in which the larvæ might develop can be considered together. These *natural baits* are distinguished from prepared baits (p. 604).

The larger umbrella-like toadstools on the ground and the bracket-like toadstools on trees, both comprising the so-called fleshy fungi, have been carefully observed. A total of 6 species of *Drosophila* has been caught on and reared from them, viz. *D. phalerata, D. transversa, D. cameraria, D. funebris* and, rarely, *D. busckii* and *D. subobscura.* Also 1 ♀ *Scap. graminum* was caught on fungus on oak stump, 25.v.53. Toadstools from open, non-wooded areas have not been examined, and no attempt has been made to discover the preference of *Drosophila* for any particular fungus species or group. The main toadstool season in Scotland extends from June into October. Further general notes on these toadstool species of *Drosophila* are given under each species in Section IV (*c*).

Fifteen sap exudations of standing beech, elm and sycamore trees were kept under observation from early March until the end of October 1950, but the only species caught was *D. obscura,* at elm and beech, and no *Drosophila* were reared from the frequent samples taken. The stumps of some, but not all, species of trees felled in early spring bleed to a lesser or greater degree, and these were much more productive. The following records are from the Edinburgh district. Adults of *D. subobscura, D. obscura* and *D. phalerata* were collected by me on those of sycamore (*Acer pseudo-platanus* L.), and Dr H. Graber reared *D. subobscura, D. obscura* and *D. littoralis* from the exudates. One adult of *D. subobscura* was found on a bleeding stump of birch. At a small stump of *Salix* sp. from which sap was flowing, adults of *D. subobscura, D. obscura* and *D. tristis* were collected, and the first two species were reared by me from some of the exudate. One female *D. transversa* was caught on a bleeding elm stump (E. B. Basden), and one female *D. subobscura* was reared from exudate from another elm stump nearby (H. Graber).

Fewer failures to rear *Drosophila* from sap exudates might have resulted if the exudates, when brought to the laboratory, had been augmented with the normal Drosophila rearing medium. Only those from the sycamore and *Salix* stumps were so augmented. The development of wild larvæ into adults from such augmented saps is not, however, proof that they would have developed or could develop satisfactorily on sap alone.

The figures given below of flies caught at the one *Salix* stump and at some of the sycamore stumps show how the relative abundance of *D. subobscura* and *D. obscura* at a bait may change over a short period.

Date	*Subobscura*	*Obscura*	*Tristis*
(i) *Salix* sp. (Dalkeith estate)			
27th March 1952	17 ♂ 3 ♀	nil	nil
11th April 1952	8 ♂ 1 ♀	13 ♂	,,
25th April 1952	1 ♂	43 ♂ 6 ♀	4 ♂
9th May 1952	nil	2 ♂	nil
30th May 1952	,,	nil	,,
	(Sap now almost dried up)		
(ii) *Sycamore* (Liberton estate)			
28th March 1952	1 ♀ (dead in the sap)	nil	nil
10th April 1952	27 ♂ 15 ♀	16 ♂ 2 ♀	,,
19th April 1952	1 ♂ 4 ♀	27 ♂ 8 ♀	,,

27th March was a warm sunny day but with keen wind, and there was a 3-inch fall of snow in the evening. 28th March was also sunny but much colder, the temperature at the time of collecting being 37° F. This accounts for the absence of *Drosophila* on the latter date.

The only known Scottish specimens of *Chymomyza distincta*, a pair in cop, were taken at birch sap, at Port Appin (Argyllshire) on 30.ix.51 (E. C. Pelham-Clinton).

Gordon (1942) records adults of *D. subobscura*, *D. obscura* and *D. funebris* as feeding on yeasty sap exudates of standing elm trees near Aberdeen, and *D. obscura* was breeding there.

Some hitherto unpublished English records of specimens taken at sap and examined by me from Dr O. W. Richards's collection are included here. At oak sap, 22.v.32, Windsor Forest (Berks), *D. obscura* (2 ♂), *D. rufifrons* Lw. (1 specimen—the latter is additional to the record in Collin (1952, 197), which was of four specimens identified by me. *D. rufifrons* has not yet been found in Scotland.) At oak sap, 16.viii.35, Goudhurst (Kent), *D. subobscura* (1 ♂). At fermenting birch sap, 6.v.37, Burnham Beeches (Bucks), *D. subobscura* (1 ♂). At bleeding birch stump, 29.iii.42, Burnham Beeches (Bucks), *D. subobscura* (1 ♀).

Related to sap exudates are oak galls. As long ago as 1853, Walker (Vol. **2**, 236–237) mentioned that "*D. cellaris* L.", which he gave as a Scottish species, fed on oak-apples in the larval stage. A more recent gall record is given in Basden (1952, 200). An additional English one from O. W. Richard's collection is 1 ♀ *D. subobscura* emerged 12.vii.42 from galls of *Biorrhiza pallida* collected 20.vi. 42, Black Park (South Bucks).

From decaying vegetables, *D. funebris* was reared from potatoes in the cellar of the mansion-house, Liberton estate; and a heap of decaying onions in a farmyard at Halewood (Lancashire, England), November 1951, abounded with adults of *D. melanogaster*, *D. simulans*, *D. busckii*, *D. funebris*, *D. immigrans* and *D. hydei*, and the last three species were reared.

A probable natural food is wild and cultivated fruits. There are 84 species and subspecies of wild trees, shrubs and herbs with succulent or semi-succulent fruits recorded from the Edinburgh district alone, including 17 *Rubus* spp. and 17 *Rosa* spp. (Martin 1934), besides the very many ornamental and other cultivated species and forms in gardens and orchards. Some at least of these fruits would appear to be suitable as food for the larvæ. The only wild fruit examined has been blackberries (*Rubus*) near Edinburgh in October, but no *Drosophila* was seen on them or reared from them. The fruit in Scottish orchards has not yet received the attention it deserves, but fallen apples in Buckinghamshire (England) in December attracted many adults of *D. subobscura* and *D. obscura*.

Although over-ripe, damaged or fallen fruits are believed to be natural breeding media of many species of *Drosophila* (*e.g.* Buzzati-Traverso 1948), it is probable that sound fruit is rarely or never attacked in Britain. Austen (1905) records *D. melanogaster* from hothouse grapes ("Lady Downe's Seedlings") at Thongsbridge, near Huddersfield (England), but it is not stated whether the grapes were originally healthy or not. During a survey of insects associated with cultivated forms of *Rubus* in England, Dicker (1939, 133) reported, from Friend (1927), larvæ of *Scaptomyza graminis* Fln. (*sic*) in basal drupelets of raspberry fruits, which had probably been damaged by the raspberry beetle (*Byturus tomentosus* F.). (From the unsatisfactory drawings in Friend's paper and the fact that F. W. Edwards, who determined Friend's specimens, was then giving the name *S. graminum* to *Parascaptomyza disticha*, the insect in question must have been *P. disticha*. This tends to be confirmed by the specimens from watercress referred to by Friend as closely related to his "*graminis*", being definitely *P. disticha* (*teste* R. L. Coe, 17.x.53)). However Hill (1952), reporting on a large-scale investigation of insect pests of cultivated raspberries in the east of Scotland, does not record any Drosophilidæ.

Leaf-mould from woods was thought to be a possible breeding-site for some *Drosophila*, especially of the *obscura* group (p. 610), but no specimens were obtained from large quantities of beech leaf-mould collected. Dobzhansky and Epling (1944, 21) appear to have had the same result. Adults of the leaf-mining and other supposedly plant-tunnelling forms (*Scaptomyza*, *Chymomyza*) were occasionally encountered but no special search was made for

them. A few adults of *S. apicalis* were reared from larvæ in leaves of kales, broccoli and turnips (p. 646), and of *S. graminum* in leaves of *Stellaria media* Vill. (p. 648). The adults are not attracted to the usual fermenting baits, and the sweeping of herbage would collect more of these and of other species. Sturtevant (1921, 16, and 1942, 20), and Patterson and Stone (1952, 92–94) give short summaries of natural foods of *Drosophila* larvæ.

Note added September 1953. The value of sweeping is abundantly proved by the results of a total of an hour with a net over a stream of watercress (*Nasturtium microphyllum* Boen. ex Rchb.—det. A. G. Lyon) on the Liberton estate, 24.viii.53 and 15.ix.53. The following species were obtained, the numbers being additional to those in Table III. Except as noted all were present on both occasions.

	♂	♀	
D. transversa . . .	1		On 15.ix only.
D. forcipata . . .	39	36	Only 7 specimens previously obtained by me.
D. fenestrarum . . .	6	13	Not previously found by me.
Scap. apicalis . . .	4	7	Only 14 specimens previously.
S. graminum . . .	3		On 24.viii only.
S.? montana . . .	17	6	Not previously found by me.
Parascap. disticha . .	39	54	Only 24 specimens previously.

IV. The Species of Drosophilidæ in Scotland

(a) *General Notes.*—A total of 28 species of Drosophilidæ has so far been found in Scotland, the total recorded for all Britain being 42. Twelve species had been recorded, under seventeen different names, previous to this survey. These actually comprised 14 species, as *Parascaptomyza disticha* and *Drosophila forcipata* were not distinguished from *Scaptomyza graminum* and *Drosophila fenestrarum* respectively. Twenty-five species have been found during the survey since March 1950, and these include all 14 species previously collected or recorded. The total is made up to 28 by *Scaptomyza trochanterata* and *S. griseola*, which have only recently been reported by Collin (1953), and by *Chymomyza distincta*, caught by E. C. Pelham-Clinton in 1951. These 3 species were not found during the survey.

It is very difficult, often impossible, to identify the species from old records where no specimens are available, as the synonymy is much confused. Some records, however, were checked against specimens in the Royal Scottish Museum, Edinburgh, and in the British Museum (Natural History), South Kensington, London. Further Scottish specimens doubtless exist in other collections, but except in one instance these have not been investigated.

The species from Scotland known to me when the survey began are listed below. The original references are given later in the notes on the individual species.

1. *Drosophila subobscura* Collin. 2. *D. obscura* Fln. 3. *D. silvestris* Basden (recorded as *D.* sp. nr. *obscura*). 4. *D. funebris* (Fabr.) (including records of *D. cellaris* L. and *D. confusa* Staeg, which probably, though not certainly, were this species). 5. *D. phalerata* Mg. 6. *D. transversa* Fln. 7. *D. cameraria* Hal. 8 and 9. *D. fenestrarum* Fln., some of which were *D. forcipata* Coll. 10 and 11. *Scaptomyza graminum* (Fln.) (also recorded as *S. incana* Mg. and *S. tetrasticha* Beck), and which included *Parascaptomyza disticha* (Duda). 12. *S. apicalis* Hardy (also recorded as *S. flaveola* Mg.). 13. *Chymomyza costata* (Ztt.). 14. *Amiota alboguttata* (Wahl.) (recorded as *Phortica alboguttata*). In addition, four specimens from Kirkwall (Orkney), Fair Isle, Hirta (St Kilda), and Raasay were separately recorded as *Drosophila* sp. (Grimshaw 1905*a*, 1906, 1907; Evans and Grimshaw 1916 respectively). The one from Hirta was later identified as *D. fenestrarum* but the three others remain anonymous.

From the beginning of the survey up to 31st August 1952 a total of 43,629 drosophilids had been trapped and collected in Scotland, and an additional 12,507 specimens had been reared from various baits (Table III). Only a small number of the baits exposed was kept for the emergence of adults, the very great majority of baits being discarded as soon as the trapped flies had been removed.

TABLE III

The Numbers of Drosophilidæ Trapped, Collected and Reared from the whole of Scotland, March 1950 to 31st August 1952

Species	Collected at Baits or Trapped				Reared from all Baits.
	Males	Females	Not Sexed	Total	(Those *ex* natural baits are in brackets)
D. subobscura	4,465	8,747	2,976	16,188	6,642 (157)
D. obscura	6,527	8,776	12	15,315	1,860 (27)
D. tristis	360	569	1	930	159
D. ambigua	6	15	..	21	65
D. silvestris	2,276	2,588	..	4,864	520
D. deflexa	41	76	2	119	..
D. funebris	1,128	949	194	2,271	1,782 (10) ‡
D. busckii	37	39	..	76	14 (3)
D. melanogaster	316	517 *	531	1,364 *	206
D. simulans	166	152 *	..	318 *	34
D. ananassæ	5	2	..	7	..
D. phalerata	221	273	3	497	874 (869)
D. transversa	4	11	..	15	33 (14)
D. cameraria	9	25	..	34	308 (308)
D. littoralis †	..	..	..	..	4 (4)
D. immigrans	227	173	..	400	..
D. hydei	14	10	..	24	..
D. forcipata	2	5	..	7	..
Scap. apicalis	3	5	..	8	6 (6)
S. graminum	7	15	..	22	..
Para. disticha	9	8	7	24	..
Chym. costata	..	3	..	3	..
Am. alboguttata	78	83	2	163	..
Species indeterminable	..	..	959	959	..
Totals	15,901	23,041	4,687	43,629	12,507 (1398)

* Some female *simulans* were doubtless determined as *melanogaster* during the early stages of the investigation.

† Larvæ found August 1952, adults emerged September 1952.

‡ Plus a few from rotten potatoes.

Additional captures are given on pp. 609 and 615 and under *D. transversa*, and additional rearings under *Scap. apicalis* and *S. graminum*.

The figures in Table III indicate the relative abundance of the various species in Scotland as caught by the methods already described, and more particularly in the Edinburgh district, where 41,666 (95·5 per cent) of the total number for Scotland were trapped and collected.

(b) *Descriptive Key to Species.*—When many specimens are to be determined the comparison of only one morphological character obviously saves time. In female Drosophilidæ, the shape and bristling of the ovipositor guides (ovipositor plates) readily distinguish the species or determine the specimen to one of two. In the males, the bristle arrangement on the claspers and other genital details are usually adequate in fresh or spirit specimens, but are not always visible in dried material. In cases of doubt other characters have to be examined. The descriptions in the following key were drawn up from wild-caught flies and mainly from pinned and spirit specimens, though live specimens were sometimes used.

Spirit specimens (70 per cent alc. with 5 per cent glycerine) are especially useful for body-length measurements (all parts remaining flexible and retaining their original length) and for rapid examination of the genitalia, which are in their natural position and can be cleanly and crisply dissected out, and if necessary permanently mounted direct in liquide de Faure, or passed quickly through cellosolve (ethylene glycol mono-ethyl ether) into balsam on a slide or on a celluloid pin-mount. Body spots and stripes are often not easily seen on spirit specimens, however.

A species can be identified with fair certainty by using only the first characters given at each step of the key. The other characters within round brackets need be used only for the

final checking of an identification. Holotype, allotype, and some paratypes of the new species, *Drosophila silvestris*, will be deposited in the British Museum (Natural History), South Kensington, London (see p. 630). Live stocks of this species have been sent to the Istituto di Genetica, Pavia, Italy, and to the Genetics Foundation, University of Texas, U.S.A., as well as continuing to be maintained at the Institute of Animal Genetics, Edinburgh. It may be found that *D. silvestris* is close to *D. meigeni* Duda (Duda 1935, 74, 91), but the latter also sounds something like *D. ambigua* Pom.

Descriptive Key to the Scottish Species of Drosophilidæ

1. Eyes covered with dense short pile, though the edges may be bare. Post-vertical bristles well developed 2
   Eyes practically bare. Post-vertical bristles weak, not obvious or outstanding 24
2. 8 more or less well-defined rows of acrostichal hairs anterior to the large dorso-central bristles, *i.e.* 4 rows either side of middle line. Posterior cross-vein not shaded (except lightly in *D. immigrans* and fugitively in *D. tristis*) 3
   6 rows of anterior acrostichal hairs on dorsum 15
   4 rows of anterior acrostichal hairs on dorsum 18
   2 rows of anterior acrostichal hairs on dorsum. (Facial carina well developed and nose-like in profile. Only one long strong humeral bristle. Centre of dorsum with brown stripe) *Parascaptomyza disticha* (Duda) (p. 648)
3. A dorsal preapical tibial bristle on hind leg only. (Dorsum matt, yellow, with 3 brown longitudinal stripes, the middle one bifid posteriorly. Pleuræ with 2 or 3 brown stripes) . . *Drosophila busckii* Coq. (p. 635)
   A dorsal preapical bristle on all tibiæ 4
4. Mesonotum completely matt, grey, with brown spots or blotches, with almost every hair and bristle arising from a brown spot or a brown area. (Carina of face shallowly grooved along its whole length. Tarsal joints of first leg of male with long slightly curved hairs on inner surface, these hairs being as long as second tarsal joint) . . . . . *Drosophila hydei* Sturt. (p. 643)
   Mesonotum not spotted brown, though there may be brown stripes. (Carina smooth, not grooved. Males without the extra long hairs on fore tarsi) 5
5. Mesonotum greyish or blackish, though the pollinosity may be somewhat golden, and sometimes with brownish stripes 6
   Mesonotum unicolorous yellow or light brown (sometimes darkish brown in *D. funebris*). 11
6. Lateral scutellar bristles longer than apicals and reaching back to or very nearly to the ends of the apicals. (3 sternopleural bristles, the middle one the shortest and weakest but distinctly longer and stouter than the hairs below it. A pair of posterior prescutellar hairs distinctly longer than the other acrostichals. No sex combs on male tarsi. First femur somewhat swollen, especially in the male. Carina bulbous, almost spherical, at end) . . . . . *Drosophila deflexa* Duda (p. 632)
   Lateral and apical scutellars of equal length, so that the former do not nearly reach back to the ends of the apicals. (Only 2 sternopleural bristles, both long and strong. Exceptionally one of the uppermost sternopleural hairs is longer than the others and this might be mistaken for a third bristle. No distinctly enlarged prescutellar bristles. Sex combs present at distal end of first two tarsal joints of first leg of male. First femur of normal plumpness. Carina broadened at end but not at all bulbous) . 7 (*Obscura* group)
7. Male with two weak tarsal combs on first leg, the upper (on metatarsus) with from 4 to 7 irregularly curved teeth, the lower (on 2nd joint) with 3 to 6 regular teeth. Both combs set at an angle of approximately 45° to long axis of the joints. Female with two outstanding long bristles on edge of each ovipositor guide near tip, one on upper edge and one on lower, as well as short spines. All bristles and spines on guide are sharp pointed. Female with fairly extensive somewhat triangular yellow areas on lateral anterior edges of tergites 4 to 7, being largest on segment 5 and small, often hidden, on segment 7. (These characters distinguish this species from all others of the *obscura* group) *DROSOPHILA SILVESTRIS*, new species (p. 630)

   (Further description. ♂♀. Arista, besides end fork, with 3 to 5 branches above and 2, rarely 1 or 3, below. Antennæ light brown, 3rd joint black-brown, short haired, about 1½ times as long as wide. Facial carina rather narrow in male, usually broader in female, rounded in profile and sloping gently down to above mouth border. Face greyish or brownish, a little shining. Frons black-grey or black-brown, matt. Orbital plates and ocellar triangle lighter, somewhat shining. Frons widens behind, across its centre it is four-ninths to half width of head. Middle (smallest) orbital bristle set a little outside of and above the lowermost and more than one-half the length of latter, and just about one-half, or less, the length of uppermost orbital. Only one strong vibrissa which, in male, is the same length as the lowermost orbital; in the female it is longer, being the same length as the uppermost orbital. The remaining oral bristles short and weak, hairlike. Cheeks light brown, narrow. At their narrowest (from lowest point of eye to mouth border) they are distinctly narrower than 3rd antennal joint and from one-fifth to one-eighth the longest diameter of eye. Eye bright red in life. Palpi yellow

or brown, with one long bristle at tip below, with sometimes a second shorter much weaker bristle on ventral edge. Mesonotum and scutellum unicolorous greyish black with golden-brown pollinosity, slightly shining. Pleuræ greyish black with reddish-brown areas, which extend to humeral region; more shining than mesonotum and the pollinosity more greyish and not so evident. Sterno index (length of anterior sternopleural bristle divided by length of posterior) 0·5 to 0·7. Legs light brown, in males often with first or all femora darkened and sometimes first coxæ darkened; in females femora always darkened. All tibiæ with a dorsal preapical bristle; only mid-tibia with ventral apical bristle, with a less obvious one, part of terminal fringe, on 1st tibia. Metatarsus of first leg 1·4 to 1·9 times longer than 2nd joint in males, and 1·5 to 2·0 in females. Males with small comb on inner dorsal surface of 1st and 2nd tarsal joints of first leg. Each comb set obliquely at about 45°, with the base of comb lowest on the outside of leg. Teeth of upper comb longer, tapering to a bluntish point, the outer teeth slightly outturned, the others sometimes slightly upturned. Lower comb more regular, the teeth shorter, curved downwards and not so tapering. Abdomen in male unicolorous black-brown, greyish-brown pollinose and shining matt. Sixth tergite in both sexes completely shining and not pollinose. Female abdomen similar except not so pollinose and more shining and with yellow lateral areas, which are broadest at the bottom and extend from near lowest posterior corner of segments to and along anterior border.

Male genitalia: clasper comb longer than wide, with 8 to 11 regular, bluntly rounded teeth, and is inserted in inner posterior edge of the prominent, concave secondary clasper (median process). This projects ventrally (usually plainly visible without dissection), shining brown on the outside, rounded (because concave), and somewhat triangular, with a rounded point, and with a series of sharp short spines around its distal half, these spines being about the same length as the clasper comb-teeth. The lower anterior corner (heel) of genital arch is drawn out into a very short sharp point. The lowest, posterior corner (toe) rather broadly rounded and with 3 equally long bristles and about 6 to 8 shorter ones at the tip, with 7 to 10 longish bristles fairly evenly spaced from just above toe, across base of secondary clasper, to top of genital arch. Genital sternal plate as broad as long, broadly rounded at its free end. The longest paired penial processes* are strongly curved backwards at the tip and narrowed to a point. These are normally visible ventrally without dissection. The shortest are twisted and flattened and thus appear barbed at their ends.

Female ovipositor guide yellow, broadly rounded at end with two outstandingly long, pointed bristles on its edge close to the tip, above and below. The upper one is usually a little anterior to and shorter than the lower. Both are approximately 4 to 6 times longer than the remaining spines on the guide, these shorter spines being fairly equal in length and all are sharp pointed. The short spines are distributed as follows: 1 to 3 at the tip between bases of the two long bristles and on outer edge, they often being a little stouter than the rest of the short spines; 6 to 10 along outer ventral edge; and 3 (2 in one specimen) to 6 irregularly placed on the side of ovipositor guide in distal half, with sometimes 1 other nearer the base.

Wings clear, sometimes appearing slightly brownish, iridescent. Veins yellow. Stronger costal fringe extends one-third to two-fifths the distance between ends of 2nd and 3rd veins. Veins 3 and 4 very slightly converging. Costal index, 2·50 to 3·16 in ♂; 2·63 to 3·50 in ♀. 4th vein index, 1·90 to 2·36 in ♂; 1·86 to 2·56 in ♀. 5x index (not allowing for wing crease), 1·70 to 2·33 in ♂; 1·50 to 2·25 in ♀. 4c index, 0·90 to 1·11 in ♂; 0·83 to 1·10 in ♀. Wing length, ♂, 2·6 to 2·8 mm.; ♀, 3·0 to 3·3 mm. Live body length (2nd antennal joint to tip of abdomen), ♂, 2·5 to 2·7 mm.; ♀, 2·9 to 3·3 mm. Smaller specimens sometimes occur) . . . . . *DROSOPHILA SILVESTRIS*, new species (p. 630)

Male combs larger and stronger and with the teeth of both regularly arranged. At least one of the two combs is set at an angle of much less than 45° to long axis of tibial joint. Female with only one long or longish bristle on each ovipositor guide, on ventral edge near tip, as well as with short spines. (A few of the latter are always blunt-ended. No lateral yellow areas on female tergites, except in *D. obscura*, where they are smaller than in *D. silvestris* and not triangular). 8

8. Dorsum of thorax unicolorous greyish black with dark golden pollinosity, not striped (except in immature specimens). 9

Dorsum with dark golden pollinosity interrupted by a broad brownish stripe down either side of acrostichal area. (These stripes often indistinct in pinned *D. tristis*, which is characterised by two strong palp bristles and with fore part of male wing blackened). 10

9. The stronger costal fringe extends quite half-way, or a little more, between ends of 2nd and 3rd veins. First tarsal joint of first leg in male distinctly ($1\frac{1}{4}$ to $1\frac{1}{2}$ times) longer than 2nd joint; in female it is $1\frac{3}{8}$ to $1\frac{3}{4}$ times longer. Male genital clasper comb square-like or practically so, with 5 to 7 black teeth, it normally lying flat and exposed on ventral surface of genitalia. (No budscale-like secondary clasper (median process). Upper tarsal comb (on metatarsus) with 9 to 14 ** teeth (exceptionally fewer) and placed a little obliquely to long axis and covers one-half or slightly more than one-half of the joint. Lower tarsal comb with 8 to 14 ** teeth (exceptionally fewer), usually almost parallel to long axis, and covers up to

---

* The penial processes are the flattened processes (*processi appiattiti*) of Pomini (1940, fig. 1). He, Hsu (1949) and others have ignored these important characters in their descriptions.

** Dr A. Prevosti has found up to 16 teeth in the upper comb and 15 teeth in the lower (Dalkeith specimens).

three-quarters of the 2nd joint. Female ovipositor guide very broadly rounded at end, being broader than hind metatarsus, with a close-set regular row of 6 to 8 very short, blunt, stub-like spines of uniform length on its edge at tip. A longer delicate bristle (3 times the length of the spines) on inside edge of these and arising at base of about the 4th blunt spine from the top. There are half a dozen more short, pointed spines spaced out along ventral edge. None on dorsal edge. On side of ovipositor guide close to tip at centre there is a lone short spine. A darker, rather more blackish insect than *D. ambigua*, with sometimes only palpi, proboscis, halteres, and ovipositor guide yellowish, but legs and base of frons also often yellowish) . . . . . *Drosophila subobscura* Coll. (p. 624)

The stronger costal fringe extends one-third to two-fifths the distance between ends of 2nd and 3rd veins. First tarsal joint of first leg of male less than $1\frac{1}{4}$ times longer than 2nd joint, often no longer; of female not $1\frac{1}{2}$ times longer, usually only $1\frac{1}{3}$ times longer. Male genital clasper comb obviously longer than wide, with about 7 or 8 teeth. (Clasper comb inserted on the inner side of the concave scale-like, bluntly pointed secondary clasper (median process), which usually projects ventrally, so that the comb is hidden from the outside and stands at an erect angle to ventral surface of genitalia. Tarsal combs set at the same angles as in *D. subobscura* but are usually shorter, the upper with 7 to 11 teeth and the lower with 6 to 10 teeth. Female ovipositor guide narrower, its end being no wider than hind metatarsus, and sometimes slightly upturned at end. The spines are thinner and slightly longer than in *D. subobscura*, only the 3 to 5 on edge at tip being stout and bluntish. The up to 10 or 11 rather hair-like ones on ventral edge are sharp-pointed. 2 to 6 sharp spines on side of ovipositor guide near tip so that the guide has a more bristly appearance than in *D. subobscura*. Sometimes also 1 or 2 spines on dorsal edge near tip, these often pointed. One long weak bristle at lower edge of tip, up to 4 times as long as the spines near its base. A somewhat more brownish insect than *D. subobscura* especially on frons and humeri, and legs light yellow, rarely darkened. Cheeks and carina often broader than in *D. subobscura* but these are variable in width) . . . . . *Drosophila ambigua* Pom. (p. 629)

10. Only one strong palp bristle, this at tip below. Wing of male without any blackening along fore edge. Female with small yellow lateral areas on anterior part of tergites 4 to 6. In pinned specimens and sometimes in living autumn-caught females these are not always evident or often appear reddish brown. (Male tarsal combs shorter, the lower with 5 to 9 (exceptionally 10) teeth and set at an angle of approximately 7° to 17° to long axis of second tarsal joint. Upper comb with 6 to 10 teeth and set at 12° to 22° to long axis of metatarsus. Genital clasper combs longer than wide, only partially obscured exteriorly by secondary clasper, the teeth being readily visible posteriorly. The longest paired penial processes curve backwards at tip and are there a little but distinctly flattened laterally and enlarged, not sharp-pointed.* Female ovipositor guide similar to that of *D. tristis*, except more broadly rounded at end, being as broad or broader than the hind metatarsus, yellow; the one long bristle is $1\frac{1}{2}$ times longer than in *D. tristis*, is often curved, and is about 6 times longer than the short spines near its base. The thicker spines on edge at end of guide are not so blunt and usually not so stout as in *D. tristis*)
Drosophila obscura Fall. (p. 626)

Two almost equally strong bristles on ventral edge of palpus, the stronger at tip. Wing of male distinctly blackened at tip and along fore edge. Female with no lateral yellow areas on tergites. (Tarsal combs long. Lower tarsal comb with 8 to 12 teeth with its base set almost parallel (3° to 10°) to long axis of 2nd tarsal joint. Upper comb with 8 to 12 teeth and set more obliquely, at an angle of about 7° to 17° to long axis of metatarsus. Genital clasper combs longer than wide, enveloped in, and so hidden exteriorly by, the brown, shiny, somewhat triangular secondary clasper, which usually projects ventrally. Between these the light yellow paired penial processes curve backwards at their ends, the tips being narrowed to a sharp point and not enlarged. Female ovipositor narrow at end, being narrower than hind metatarsus; often darkened. On its lower edge at end are 4–6 blunt spines, the uppermost often a little longer and often pointed; with about 6 thinner, sharp-pointed, slightly longer spines along remainder of ventral edge. One outstanding long straight hair-like bristle arises between the 3rd and 4th blunt spines at tip below, the bristle being about 4 times longer than the spines near its base. From 1 to 3 short spines on side of guide near tip) . . . . . *Drosophila tristis* Fall. (p. 628)

11. A characteristic row of about 8 to 11 short sharp spines on lower inner surface of front femur in apical half. (Mesonotum matt, on the whole uniformly light khaki brown. Wings with slight shading at ends of 1st, 2nd and 3rd longitudinal veins and on posterior X-vein. Male first two tarsal joints of first leg with a dense felt-like brush of hairs along whole of ventral surface) . . *Drosophila immigrans* Sturt. (p. 643)

With none of the above characters. Wings quite clear 12

12. Light to darkish brown, larger (3·0 to 3·5 mm.). Third antennal joint almost twice as long as wide. Dorsum not very shiny and with one or two enlarged dorso-central hairs in front of the transverse suture. (Legs long and slender. Costal index (shortest length from end of 1st vein at 2nd costal break to end of 2nd vein, divided by shortest length between ends of 2nd and 3rd veins) 3·0 to 4·0. Female ovipositor guides triangular, a little rounded at tip. Male with no tarsal sex combs, and ventral genitalia with a spiky clump of about 12 strong black sharpish spines) . . . . *Drosophila funebris* (Fabr.) (p. 633)

---

* The ♂ of the very similar *D. bifasciata* Pom. (not found in Britain) is immediately distinguished from *D. obscura* by these penial processes being regularly narrowed to a point. This distinction has previously been overlooked.

Yellow brown, smaller (2 mm.). Third antennal joint at the most 1½ times longer than wide. Dorsum shiny, no enlarged dorso-central hairs in front of transverse suture. (Legs stout, shorter. Costal index not more than 2·8. Ovipositor guides rounded. No obvious spiky clump of bristles on ♂ genitalia) . 13

13. Costal index 1·5 to 1·7. (The strongest costal fringe extends a little more than half-way between ends of 2nd and 3rd veins. The first two oral vibrissæ weaker, the lower one the shorter. Cheeks to mouth border, below lowest point of eye, very narrow, sometimes barely wider than the width of first metatarsus. Male with the dorsal preapical tibial bristle of first leg curved (bent) downwards at the end (straight in female), and with inner ventral surface of first two tarsal joints of first leg with a series of short pale "combs" placed a little obliquely across their long axis) . . . *Drosophila ananassæ* Dol. (p. 638)

Costal index about 2·2 to 2·8. (The stronger costal fringe does not extend to half-way between ends of 2nd and 3rd veins. The first two oral bristles strong, of equal length and strength. Narrowest part of cheeks distinctly wider than width of first metatarsus. Male with dorsal preapical bristle of first tibia shorter, and straight or barely curved. Male with only one simple, dorsal sex comb, of about 9 to 12 closely adpressed black teeth, placed obliquely to long axis at distal end of first metatarsus) . . 14

14. Width of cheek from lowest point of eye to mouth border broader, at least as broad as widest part of first tibia. The stronger costal fringe often does not extend more than one-third the curved distance between ends of 2nd and 3rd veins. Male genitalia with a not very conspicuous brown, scale-like, broad *hook*-like posterior process (resembling a bluntish *Rubus* or *Rosa* prickle) . *Drosophila melanogaster* Mg. (p. 636)

Cheek narrower, barely as broad as widest part of first tibia. The stronger costal fringe extends one-third to two-fifths the curved distance between ends of 2nd and 3rd veins. Male posterior process of genitalia larger and conspicuous, broadly *hood*-like, pointed anteriorly (resembling a section through the uppermost sepal of Monkshood, *Aconitum*) . . . . . *Drosophila simulans* Sturt. (p. 638)

15. Wings quite clear, veins not clouded. Arista with only one branch below, just behind end fork. (Dorsum with a grey smudge down the centre, it being broadest between the 2 pairs of dorso-central bristles) *Drosophila cameraria* Hal. (p. 642)

At least posterior X-vein clouded and with 2 or 3 ventral aristal branches behind end fork . . . 16

16. Frons dark reddish brown. Carina shallowly grooved. (Mesonotum light brown, only obscurely shining, with 2 distinct dark brown stripes just within acrostichal region and 2 outside them interrupted by the transverse suture. Anterior X-vein, in my specimens, not shaded. Abdomen unicolorous blackish brown. Dark insect) . . . . . *Drosophila littoralis* Meig. (p. 643)

Frons yellow. Carina smooth, not grooved. (Mesonotum usually unicolorous yellow or yellow-brown, shining, occasionally with brownish striping. Anterior X-vein always shaded. Abdomen largely yellow with black markings. Yellow insects, although old or winter specimens may be brown) . . . 17

17. Browner yellow, mesonotum rather less shining. First oral bristle at least twice the length of next. Cheeks at lowest point of eye not wider than 3rd antennal joint. (Upper humeral bristle strong, usually not less than three-quarters length of lower. Male first metatarsus at distal third, and all of next tarsal joint with a brush of extra long hairs on inner posterior surface. Genitalia more black-bristly and clasper comb long, with about 16 to 18 microscopic teeth. Last two tergites of abdomen wholly or extensively black. Female ovipositor guides broader, with a small brown chitinised plate immediately above it (not always readily seen in pinned specimens). Black abdominal markings in bands or irregular blotches, 6th tergite extensively black) . . . . . *Drosophila phalerata* Meig. (p. 639)

Brighter yellow, mesonotum more shining. The 2nd oral bristle at least half length of 3rd. Cheeks wide, at narrowest part quite as wide as or wider than 3rd antennal joint. (Upper humeral weak and not more than two-thirds the length of lower. Male first metatarsus and 2nd tarsal joint uniformly short bristly haired. Genitalia not appearing black-bristly, clasper comb short, with only about 10 or 11 teeth. Last two (5th and 6th) tergites extensively yellow, with black spots. Female ovipositor guides narrower. No chitinised plate immediately above it. Abdomen with the black markings in four well-defined rows of spots) . . . . . *Drosophila transversa* Fall. (p. 641)

18. The most anterior of the 3 strong upper sternopleural bristles longer than the middle one; the posterior one the longest of the three. (Arista below with only 1 ray behind end fork and in distal half. Male fore tarsi uniformly short haired) . . . . . 19 (*Scaptomyza*)

The most anterior sternopleural shorter than the middle one; the posterior one the longest. (Arista below with 2 or 3 rays behind end fork, one being in basal half. Male fore metatarsus ventrally with a tuft of pale long hairs at end, and a less obvious tuft on 2nd tarsal joint) . . . 23 (*D. fenestrarum* group)

19. (19 to 21 mainly from Collin, 1953.) A distinct nose-like keel to face (as usual more conspicuous in ♀) and a short black almost spine-like bristle on hind trochanters beneath, instead of the usual bristly hair. Male anal lamellæ (cerci) hairy on basal half but almost bare on apical half, with a slight indentation between . . . . . *Scaptomyza trochanterata* Collin (p. 648)

At most only a slight facial ridge in male, and not nose-like even in ♀. Only bristly hairs on hind trochanters. ♂ anal lamellæ hairy all over 20

20. A minute bristle sometimes present, sometimes absent on frontal orbits between upper reclinate orbital and vertical bristles; if absent the species is entirely yellow or greyish yellow. Hairs on *front* side of arista longer than usual. Apical scutellar bristles long, extending rearwards quite as far as lateral bristles . 21

No minute bristle between upper reclinate orbital and vertical bristles. Hairs on front side of arista shorter. Apical scutellars shorter, not extending rearwards to the ends of lateral bristles . . . 22

21. Shortest distance between eye border and the *small* peristomal bristles as wide as end of front femur. Body often entirely yellow with only anal cerci black (typical), or body yellowish grey, or grey (varieties). Ovipositor plates stouter, broad to the truncated end . . . *Scaptomyza apicalis* Hardy (p. 645)

Shortest distance between eye border and peristomal bristles as wide as *end* (in my specimens) of front tibia. Thorax and abdomen always quite dark grey. Ovipositor plates less stout, narrowing more appreciably towards the end . . . . . *Scaptomyza ? montana* Wheeler (p. 648)

22. Lighter grey species with obvious dark stripes on thorax, narrower cheeks and large male claspers. Clypeus and proboscis yellowish in both sexes . . . . . *Scaptomyza graminum* (Fln.) (p. 646)

Darker species (especially in female) without or with only faint stripes on thorax, wider cheeks (as in *apicalis*) and often with darkened femora. Male anal cerci entirely hairy and smaller than in any other species. Wings rather short and brownish yellow. Female usually with antennæ, median line of face, proboscis, and tip of palpi, darkened . . . . . *Scaptomyza griseola* Zett. (p. 648)

23. Male claspers large, at broadest 1·6 times broader than hind femur, no heel at base. Paired penial processes at their end widened and truncated. Female ovipositor plate more narrowly rounded at end, dark, concave, and with smaller spines on edge, the lower basal ones not stronger than the others, and sometimes with short spines on the side far from edge. ♀ anal tuft distinctly elongated *Drosophila fenestrarum* Fln. (p. 645)

Male claspers smaller, much narrowed at distal half, at broadest same breadth as hind femur, with a projection ("heel") near base. Paired penial processes at their end curved and pointed. Female ovipositor plate broadly rounded at end, yellow or dark, not concave, with strong, though not long, spines on edge, the lower basal one or two the stronger, and with a curved row of 3–6 short spines on side of ovipositor near edge. Anal tuft of female short, normal length . *Drosophila forcipata* Collin (p. 644)

24. The uppermost of the 3 orbital bristles is placed above the level of lowest ocellus and near vertex. (The lower upturned (reclinate) orbital is placed between the two other orbitals and is shorter than these. Arista not forked at end, with long branches only on upper side and mainly in basal half, rest of arista short-haired. Wing cells and veins not darkened. Second basal and discal cells separated by a pigmented X-vein. Head (dull) and body (shining) black, with a milk-white blotch on humeri and beneath base of wing and a milk-white stripe across bottom of face (these white areas sometimes indistinct in pinned specimens). Femora and tibia often darkened. Tarsal joints yellow and, especially on hind legs, shortened. Body length 2·5 to 3·5 mm.) . . . . . *Amiota alboguttata* (Wahl.) (p. 651)

All 3 orbital bristles placed below level of lowest ocellus. (The lower reclinate orbital is placed at the bottom of the three orbitals and is quite as long or longer than the downwardly and inwardly turned orbital next above it. Arista forked at end and with 5 or 6 more long rays above and below. Second basal and discal cells confluent, not separated by a pigmented X-vein. Leg joints normal. Body length 2·0 to 2·75 mm.) 25

25. A dull blackish-grey insect with some yellow about the head and legs. (Wings with costal and humeral cells smoky blackened, costal vein very dark. Front leg, except the yellow coxa, black) *Chymomyza costata* (Zett.) (p. 650)

A mainly yellow-brown insect. (Humeral and costal cells clear, brownish but not blackened. A small smoky cloud at end of 2nd vein. Costal vein dark. Tip of wing with a very small light ("white")patch—this often best seen with naked eye. Femur, tibia and tarsi of first leg brown) *Chymomyza distincta* Egg. (p. 651)

(c) *Notes on the Scottish Species.*—The information in this section is arranged under each species according to the following plan.

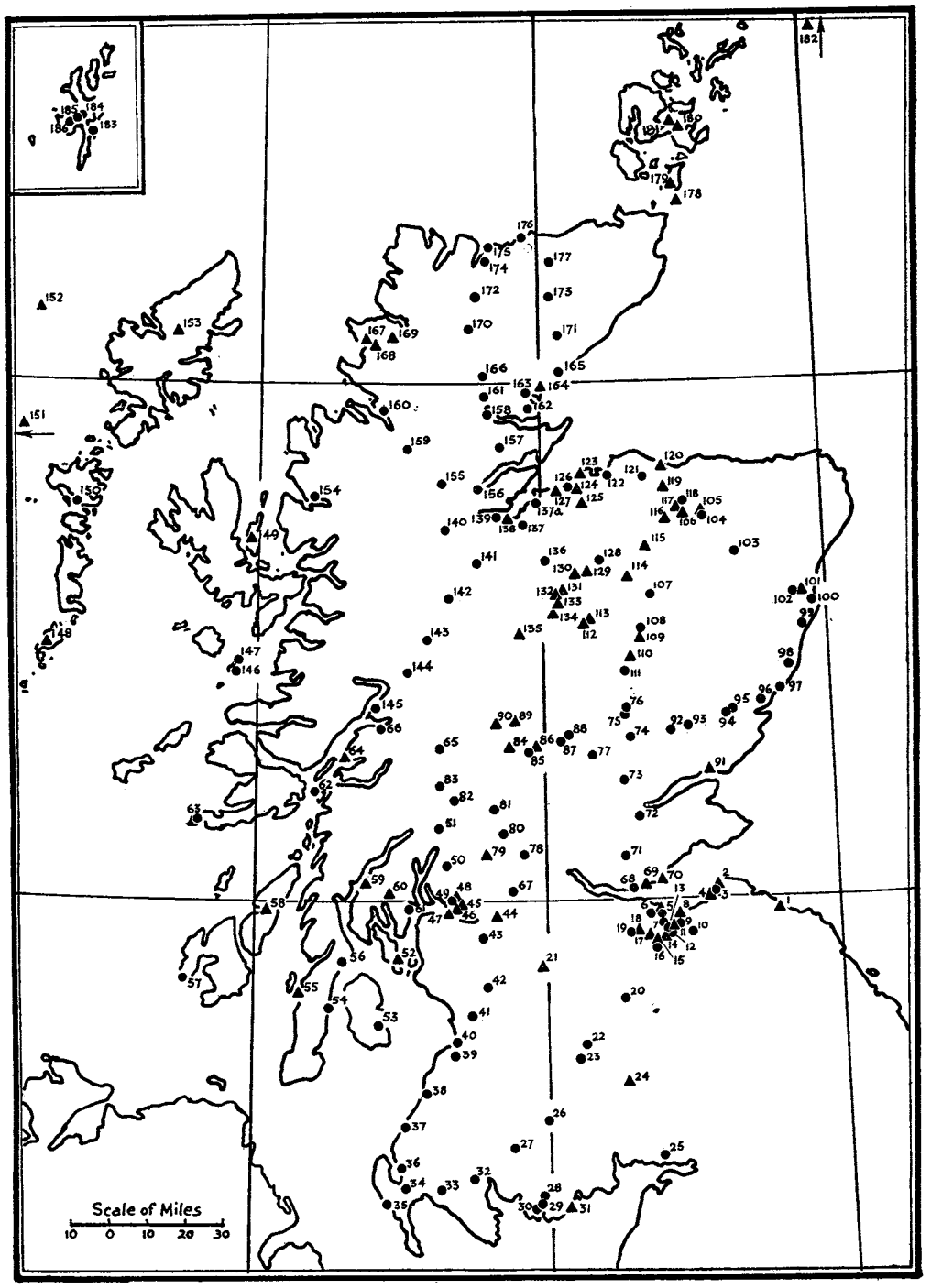
(i) *Previous Scottish Records and Specimens, i.e.* the published accounts of the species and details of the specimens collected by previous workers. A few published records have probably been overlooked. Those of Basden (1951, 1952) are mostly passed over.

(ii) *Distribution and Numbers in Scotland.*—This includes the general Scottish distribution of the species and the types of habitats frequented by the adults; a comparison of abundance with other species; seasonal abundance; and the sex-ratio of wild-caught adults. Text-fig. 1 shows the localities where Drosophilidæ have been captured.

(iii) *Natural History in Scotland.*—This includes seasonal occurrences; the baits the species has been found at or reared from; and seasonal reproduction in nature.

It is sometimes convenient to combine (ii) and (iii).

(iv) *Laboratory Breeding.*—This includes general notes on how successfully the species breeds in the laboratory and, if successfully, the approximate minimum and maximum times for the appearance of the first young adults after the parent adults have been added to the culture bottles. Unless otherwise stated, all my laboratory stocks have been bred on the ordinary Drosophila medium (molasses, agar, maize meal, yeast, water) with crumpled paper or cotton waste. Most cultures have been kept at a constant temperature of 18° C. and only very few of one or two species at 25° C. Adults are initially placed in vials (1 inch diameter) or milk bottles ($\frac{1}{4}$ pint or $\frac{1}{2}$ pint) containing the culture medium and are transferred to fresh vials or bottles at weekly intervals. The length of life of adults is sometimes also noted.



TEXT-FIG. 1.—Key to collecting sites.

1. ● Localities where traps were exposed or where collections were made during this survey.
2. ▲ Localities where Drosophilidæ were captured by others independently of the survey.
3. The localities where no Drosophilidæ were captured during the survey have their numbers in brackets in the list below.
4. Acknowledgment is made to those people who exposed traps in areas they visited. Their names are given after the respective localities.
5. Some of the localities given by other workers cover a general area, such as Glen Lyon, Barra, Raasay, Jura, Lewis, Loch Rannoch, etc. In such cases, except for Nos. 188–190 at the end of the list, the symbol is placed in the centre of the general locality.

Berwickshire

1. Nr. Dunglass (East Lothian).

East Lothian

2. Gullane. **3.** Aberlady. **4.** Gosford.

Midlothian

5. Edinburgh. **6.** Corstorphine. **7.** Liberton. **8.** Musselburgh. **9.** Dalkeith. **10.** Pathhead Ford. **11.** Eskbank. **12.** Bonnyrigg. **13.** Lasswade. **14.** Roslin. **15.** Milton Bridge (Bush estate). **16.** Penicuik. **17.** Glencorse. **18.** Balerno. **19.** Kirknewton.

Peeblesshire

20. Nr. Broughton.

Lanarkshire

21. Gorge of Avon, nr. Hamilton. **22.** Nr. Leadhills.

Dumfriesshire

23. Wanlockhead (Miss K. Strachan). **24.** Beattock. **25.** Creca, nr. Annan (Mrs C. Wearmouth).

Kirkcudbrightshire

26. Holmhead, nr. (N.E. of) Dalry. **27.** Nr. Clatteringshaws Loch. **28.** Cumstoun Bridge, nr. Kirkcudbright (G. Knight). **29.** Kirkcudbright (Barrhill) (G. Knight). **30.** Doon Bay, nr. Kirkcudbright (G. Knight). **31.** Rascarrel Beach.

Wigtownshire

32. Nr. Newton-Stewart. **33.** Nr. Glenluce. **34.** Stranraer. **(35).** Portpatrick (Prof. C. H. Waddington). **36.** Cairn Ryan.

Ayrshire

37. Nr. Ballantrae (Drummore Shore). **38.** Chapeldonan, nr. Girvan. **39.** Minishant. **40.** Ayr (Miss S. Sinclair). **41.** Nr. Craigie. **42.** "North Drumboy", nr. Kingswells.

Renfrewshire

43. Between Paisley and Renfrew.

Dunbartonshire

44. Milngavie. **45.** Bonhill. **46.** Murroch Glen, nr. Dumbarton. **47.** Cardross. **48.** Alexandria. **49.** Balloch Pier, Loch Lomond. **50.** Inverbeg Inn, Loch Lomond. **51.** Ardlui, Loch Lomond.

Buteshire

52. Mount Stuart, Isle of Bute. **53.** Lamlash district, Isle of Arran (W. S. Russell).

Argyllshire

54. Carradale, Kintyre (Prof. C. H. Waddington). **55.** Tayinloan, Kintyre. **56.** Claonaig, Kintyre (Prof. C. H. Waddington). **57.** Cladville, Portnahaven, Islay, Inner Hebrides (Drs B. M. Slizynski and H. Slizynska). **58.** Isle of Jura, Inner Hebrides. **59.** Lephinmore, Cowall. **60.** Glen Massan, Cowall. **61.** Hunter's Quay, Cowall (G. R. Knight). **62.** Isle of Insh (or Sheep Isle), Firth of Lorne. **63.** Isle of Iona, Inner Hebrides (I. Warwick). **64.** Port Appin. **65.** Black Mount, Rannoch Moor. **66.** Ballachulish (Dr G. Selman).

Stirlingshire

67. Fintry (Dr and Mrs Alan G. Ross).

Fifeshire

68. Nr. Inverkeithing. **69.** Aberdour. **70.** Kinghorn.

Kinross-shire

71. Nr. Gairneybridge, Loch Leven.

Perthshire

72. Aberargie. **73.** Guildtown. **74.** Blairgowrie-Rattray district. **(75).** Black Water Valley, nr. Dalrulzian. **76.** Nr. (N. of) Dalrulzian. **77.** Craigvinean Forest, Dalmarnock (G. Newell). **78.** Thornhill (Dr and Mrs Alan G. Ross). **79.** Aberfoyle. **80.** Falls of Leny, nr. Callander (Dr and Mrs Alan G. Ross). **81.** Balquhidder (Dr and Mrs Ross). **82.** Crianlarich. **83.** Tyndrum. **84.** Glen Lyon. **85.** Fearnan, Loch Tay (Dr and Mrs Alan G. Ross). **86.** Fortingall. **87.** Aberfeldy (Dr and Mrs Alan G. Ross). **88.** Grandtully (Dr and Mrs Ross). **89.** "Rannoch". **90.** Loch Rannoch.

Angus

91. Monifieth. **92.** Nr. Craigton. **93.** Kirriemuir. **94.** Brechin (wooded outskirts). **95.** Brechin (town).

Kincardineshire

96. North Water Bridge Station. **97.** Benholm. **98.** Fawsyde, Catterline. **99.** Newtonhill.

Aberdeenshire

100. Aberdeen, nr. Victoria Bridge. **101.** Nr. Woodside, Aberdeen. **102.** Bucksburn, Aberdeen. **(103).** Between Oyne and Insch. **104.** Bin Wood, nr. Huntly. **105.** "Falls of Tarnash". **106.** Den of Pitlurg. **107.** Cock Bridge (1 mile north of). **108.** Inver, nr. Crathie. **109.** Balmoral Forest. **110.** Loch Callater. **111.** Nr. Devil's Elbow. **112.** Ben Macdhui (summit). **113.** Loch Etchachan.

Banffshire

114. Tomintoul. **115.** Convil Braes. **116.** Loch Park. **117.** Auchindachy. **(118).** Keith.

Morayshire

119. Glen of Drumloch, nr. Fochabers. **120.** Spey Bay. **121.** Between Lhanbryde and Elgin. **122.** Newmill, nr. Forres. **123.** Culbin Sands. **124.** Brodie. **125.** Logie.

Nairnshire

126. Auldearn. **127.** Nairn.

Inverness-shire

128. Grantown Station. **129.** Nethybridge. **130.** Boat of Garten. **131.** Granish. **132.** Aviemore. **133.** Kinrara. **134.** Feshie Bridge. **135.** Spey Bridge. **136.** Nr. Findhorn Bridge. **137.** Milton, nr. Inverness. **137*a*.** Dalcross. **138.** Inverness. **139.** Bunchrew, nr. Inverness. **140.** Struy (Bridge). **141.** Loch Ness-side, nr. Drumnadrochit. **142.** Fort Augustus. **143.** Loch Lochy, nr. Laggan. **144.** Between Fort William and Spean Bridge (Great Glen Ranch). **145.** Upper Loch Linnhe (S. end). **146.** Galmisdale, Isle of Eigg, Inner Hebrides (D. Wood-Gush). **(147).** Nr. Tolain, Isle of Eigg, Inner Hebrides (D. Wood-Gush). **148.** Isle of Barra, Outer Hebrides. **149.** Isle of Raasay, Inner Hebrides. **(150).** Carinish, North Uist, Outer Hebrides (Miss M. Davies, and Mr M. J. Green). **151.** Hirta, St Kilda.

Ross and Cromarty

152. Flannan Isles. **153.** Isle of Lewis, Outer Hebrides. **(154).** Alligan (Dr F. W. Robertson). **155.** Garve. **156.** Dingwall. **157.** Ardross. **158.** Ardgay. **159.** Nr. Braemore. **160.** Ullapool.

Sutherlandshire

161. Invershin. **162.** Clashmore Wood, nr. Dornoch. **163.** Loch Fleet. **164.** Golspie. **165.** Brora. **166.** Loch Shin, Lairg. **167.** Lochinver. **168.** Glencanisp Lodge, nr. Lochinver. **169.** Loch Assynt. **170.** Crask. **171.** Kildonan. **172.** Nr. Altnaharra ($2\frac{1}{2}$ miles north of). **173.** Achentoul Forest, nr. Forsinard. **174.** Nr. Loch Craggie (northern end). **175.** Coldbackie. **176.** Armadale. **177.** Dalhalraig, Strath Halladale.

Orkney Islands

178. Pentland Skerries. **179.** Burwick, South Ronaldsay. **180.** Tankerness, Mainland. **181.** Kirkwall, Mainland.

Shetland Islands

182. Fair Isle. **(183).** Lerwick, Mainland (G. W. and W. S. Russell). **(184).** Kirgord Plantations, Weisdale, Mainland (G. W. and W. S. Russell). **(185).** Tresta, Mainland (G. W. and W. S. Russell). **(186).** Bridge of Walls, Gruting, Mainland (A. Henry).

The following places have been omitted from the map:

187. Balelone, North Uist, Outer Hebrides (Grimshaw, 1916). **188.** Spey Valley (J. E. Collin, in litt., Basden 1952). **189.** Braid Burn, nr. Edinburgh, Midlothian (specimen of *Par. disticha* in Royal Scottish Museum). **190.** Dumfriesshire (Murray, 1935). Murray wrote from Gretna, Dumfriesshire.

A total of 191 localities (including No. **137*a***).

1. *Drosophila subobscura* Collin

(i) *Previous Scottish Records and Specimens.*—Gordon (1942) records *D. subobscura* as feeding on the yeast growths of elm tree exudates near Aberdeen in the summer of 1939 and late summer of 1941. Smart (1945) says it occurs at least as far north as Inverness. Basden (1952) found that it extended to the very north of the mainland.

In the Royal Scottish Museum are sixteen specimens of this species, labelled *obscura*, all collected by J. R. Malloch * at Bonhill and Cardross (both Dunbartonshire) in the months of March to May and July to September, and November of 1906 to 1908. There are also two specimens (previously unnamed) collected by P. H. Grimshaw and F. Jenkinson at Rannoch (Perthshire), viii.05, and Logie (no county given but probably Morayshire), ix.13 respectively.

In the British Museum (Natural History) are specimens collected by Col. J. W. Yerbury at Nethy Bridge (Inverness-shire), 16.viii.04; Inverness, 12.vi.13; and Brodie (Morayshire), 7.viii.05. Also R. L. Coe took it at Tomintoul (Banffshire), 1100 ft., 8 to 11.viii.37, and Glen of Drumloch (near Fochabers), 16.viii.37; and J. Smart swept it in a garden at Eskbank (Midlothian) on 28.x.36, on the "first fair day after 3 days' gale".

(ii) *Distribution and Numbers.—D. subobscura* is without doubt the most widely and most commonly distributed species of the genus in Scotland (text-fig. 2), extending all over the mainland and to the Western Isles of Iona and Islay (long. 6° 30′ W.), but no specimens were trapped on the island of North Uist (long. 7° 19′ W.) or in the Shetlands (lat. 60° 10′ N.). The adults have been found in every type of habitat (desolate moorlands, on the seacoast, in woodlands and shrubberies, on islands off the west, in open arable country, on waste dumps, in towns and villages, etc.). Specimens have been trapped at 2400 ft., the highest altitude at which traps have been exposed.

Of the 16,188 specimens of *subobscura* collected to 31.viii.52, only 349 were found indoors, from June to October (7 ♂, 11 ♀ in house windows, 3 ♂, 9 ♀ in unheated glasshouses, 58 ♂, 259 ♀, 1? sex in an unheated fruit store in the centre of Edinburgh, and 1 ♀ in a bus).

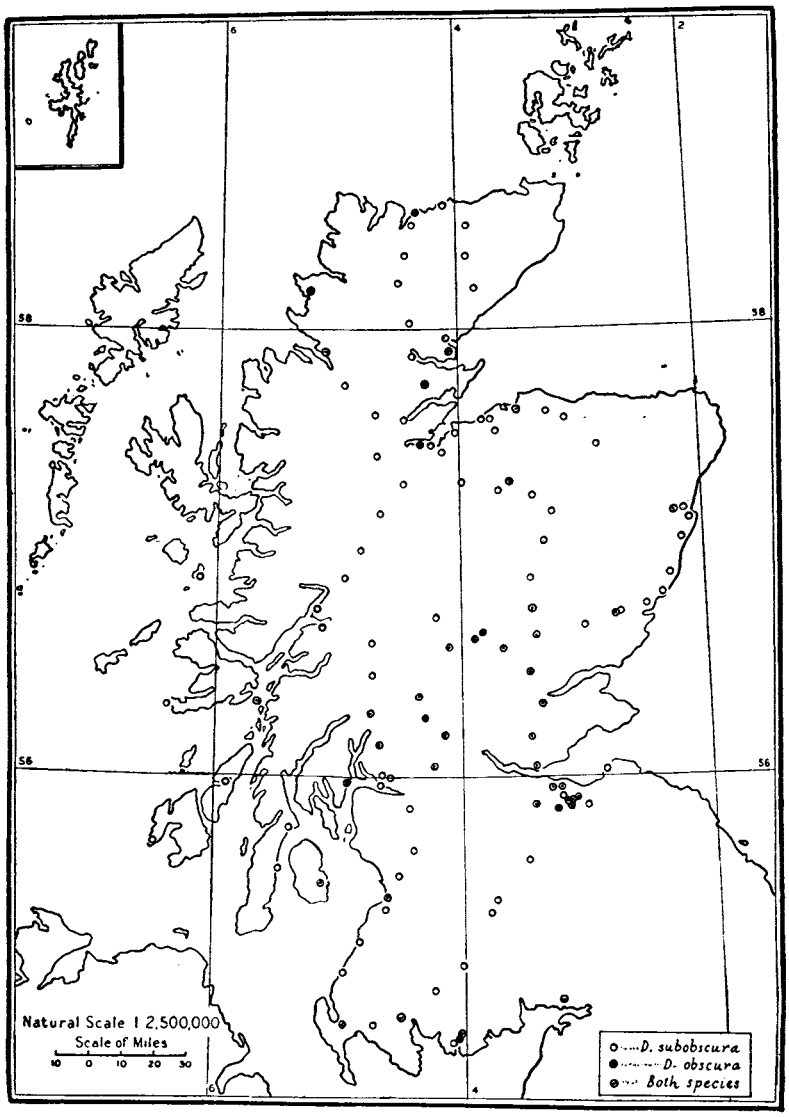
Although the figures of total specimens in Table III suggest that *D. subobscura* is practically no more abundant than is *D. obscura*, it is fairly certain that, on the whole, it is the most abundant species of the genus, being exceeded in numbers only by *D. obscura* in woodland habitats from April until July, and by *D. silvestris* in the same habitat in October and to a small extent in June. The numbers of *D. subobscura* in traps reach their peak in autumn and early winter, the "Autumn Flush" (Basden, 1953). Twice as many females as males are trapped.

(iii) *Natural History.*—Adults of *D. subobscura* can be trapped in woods in the Edinburgh district during every month of the year, but they are not active when the temperature stays below 40° F. They occur in buildings from June into October.

They have as yet been found at only two types of natural baits in Scotland—at various tree saps and at toadstools (the latter being a new natural bait record)—but it is certain they will be found on wild and cultivated fruits. I have collected them on raw bruised quinces and raspberries in trap bottles in Scotland, and on fallen apples in England; Buzzatti-Traverso (1948, 69) found adults and larvæ in September on decaying fruits of *Cornus* sp. in Italy; and they are much attracted to the prepared fruit baits used during this survey, and rather large numbers occur in the fruit-vegetable store in Edinburgh. In October 1953, 12 ♂, 32 ♀ were reared from a rotten apple as obtained early that month from a fruit shop in Edinburgh.

* Malloch dated all his specimens as, for example, 18.8.6 and 1.4.7, which I interpret as 18th August 1906 and 1st April 1907 respectively.

Gordon (1942) records the adults feeding on yeasty sap exudates of standing elm trees near Aberdeen, and Smart (1945, 53) says that J. E. Collin has taken it on exuding sap at an unnamed locality in Britain. Both sexes were common on the bleeding stumps of sycamore and *Salix* sp. during iii.52 and iv.52 (*antea*, p. 613); 1 ♀ was collected iv.53 from the bleeding stump of a large birch; and 1 ♀ was on a wet stump of Douglas Fir (*Pseudotsuga*



TEXT-FIG. 2.—Known distribution of *D. subobscura* and *D. obscura*.

taxifolia Brit.) at Penicuik (Midlothian), 16.x.52, but the wet appeared to be from rain and not from an exudation of sap. Some English records of this species at saps are given on p. 614. A small sample of sap and saturated bark from the above *Salix* stump was taken 9.v.52 and kept with Drosophila medium at 18° C., and 9 ♂, 4 ♀ *D. subobscura* began to emerge six days later. On 12.vi.52 Dr H. Graber collected sycamore and e'm exudate and sappy bark at Liberton and obtained 103 specimens of *D. subobscura* from the former and 1 ♀ from the latter. Some of the 103 may have been an F2 generation that had developed in the Drosophila medium added to the sycamore sap. On 16.x.52 sappy bark from a sycamore stump at Penicuik (Midlothian) was placed on Drosophila medium at 18° C., and on 4.xi.52, 3 ♀ *subobscura* were out, and 2 ♂, 1 ♀ emerged within the next 6 days.

Some toadstools collected 21.vii.50 from under beech trees at Liberton (Midlothian) were kept in an unheated insectary and 33 *D. subobscura* emerged. On 26.vii.50, 1 ♂ was caught on a fresh toadstool at the same site and some of the toadstools were there collected into a small heap. They were brought to the insectary 1.viii, when they were well decayed, and 1 ♂, 1 ♀ *D. subobscura* emerged. On 29.vii.52, 1 ♀ of this species was collected on a healthy toadstool at the same site. Also on 1.viii.50 some growing toadstools were collected in another beech wood on the Liberton estate, one mile east of the other site, and 4 *D. subobscura* emerged from them in the unheated insectary between 15 and 21.viii.50. From this same site on 3.x.50 more fresh toadstools were collected, and 1 ♂ *D. subobscura* emerged from them at 18° C. on 23.x.50.

The natural breeding media of *D. subobscura* known to date are the saps and toadstools mentioned above, diseased iris root in England (reared by J. E. Collin), decaying *Cornus* fruits in Italy (reared by A. Buzzati-Traverso), and fermenting oak galls of *Biorrhiza pallida* (Oliv.) in England (reared by O. W. Richards, with a further record *antea*, p. 614) (Basden 1952).

Adults were more or less plentifully trapped at the following prepared baits, viz. middlings, Drosophila breeding medium, plum, apple, tomato, raspberry, orange, fruit-wine waste, fermenting rhubarb jam, and wetted (fermenting) bread. The larvæ have developed successfully on the first six foods and doubtless would do so on the remainder. Adults have been seen in cop in nature during April, June, July and August. Pale-bodied (? recently emerged) specimens have been caught in May and August. Adults have been reared from prepared baits exposed every month from March to early November inclusive, showing that they are capable of reproduction in nature during these months at least.

(iv) *Laboratory Breeding.*—*D. subobscura* breeds readily on Drosophila medium. At 18° C. the first adults appear 19 (exceptionally 18) to 25 days after the original adults are added. At 25° C. they appear after 14 to 17 days (exceptionally 18). In the unheated insectary during May and June (min. temp. 43°–59° F., max. temp. 60°–77° F.) the first adults appeared after 31 to 33 days. The larvæ pupate on top of or close to the culture medium (Pl. I, fig. *c*), and since the medium softens after a time, many pupæ sink into it and are drowned. An extra quantity of sterilised cotton waste added to each new bottle prevents this.

Of 364 wild adults of both sexes trapped 14.xi.50 and kept with food in one jar in the unheated outdoor insectary, 174 were still alive 5.ii.51 and 1 ♂, 5 ♀ on 2.iv.51. These 6 were transferred to 18° C. for $3\frac{1}{2}$ weeks and returned to the insectary 27.iv.51. Copulation was observed 6.iv. and 7.iv. and many F1 progeny were subsequently obtained at 18° C. and in the insectary. The male died between 22.v. and 6.vi.51 and the last female between 15 and 18.vi.51, having lived at least 7 months. Many of the others probably died prematurely of starvation when the food occasionally moulded over.

2. *Drosophila obscura* Fallén (=*D. obscuroides* Pomini)

(i) *Previous Scottish Records and Specimens.*—Yerbury (1913) collected "*D. obscura* Fall." at Lochinvar (Sutherland) on 8.vii.11, and Gordon (1942) recorded the adults and the larvæ feeding at yeasty sap exudates of standing elm trees near Aberdeen, actually near Woodside according to Dr F. W. Robertson.

The specimens labelled as *D. obscura* in the Royal Scottish Museum proved to be *D. subobscura*, *D. silvestris* and *D. deflexa*. There are no specimens of *D. obscura* from Scotland in the British Museum (Natural History). 1 ♂, 1 ♀ were caught in the Johnson suction trap at Milton Bridge (Midlothian) on 11 and 18.viii.51, at 0400 hrs. and 2000 hrs. (G.M.T.) respectively.

(ii) *Distribution and Numbers.*—*D. obscura* is almost as widespread in Scotland as is *D. subobscura*, but it appears to be somewhat discontinuous in distribution. It has been found during this survey in 43 places in Scotland compared with the 95 of *D. subobscura* (text-fig. 2), but the two main general surveys of Scotland (*antea*, pp. 605, 606) were carried out in September, when the adults are declining in numbers. It ranges from the northernmost part of the mainland, to the south-east, and to the extreme south-west, and extends to at least some of the islands on the west (Arran, Insh).

It has been trapped in all types of outdoor habitats except moorlands and open coast dunes, but these two habitats have not been sampled during April to June, when the numbers of *D. obscura* are at their highest. It is most abundant in woodland, and it is in deciduous woods and timbered parks that it surpasses *D. subobscura* in numbers during April to July inclusive. It was previously recorded (Basden 1952) as not entering buildings, but in July and August 1952, 2 ♀ were in a house window, and 10 ♂, 14 ♀ were in the Edinburgh fruit store. These numbers are, however, negligible compared with the 15,289 specimens caught outdoors.

In total numbers (Table III) it would appear to be as common as *D. subobscura*, but the very great majority of specimens were from wooded habitats. If all habitats were worked an equal amount, it is probable that *D. obscura* would prove to be the less abundant. As soon as winter set in the numbers trapped declined sharply, so that from December to March very few specimens were obtained, with January of 1951 and 1952 being completely blank. In April its numbers build up rapidly to reach their peak in May, and high numbers are maintained from then until about August.

A higher proportion of males to females of this species is caught than of *D. subobscura* (Table III), the ratio being 0·74 ♂ : 1·00 ♀.

(iii) *Natural History.*—Adults of *D. obscura* have been recorded at elm sap at Aberdeen (Gordon 1942); at unnamed saps in Britain (Smart 1945, 53); at oak, elm, lime and birch saps, and on a freshly felled stump of alder in Europe (Duda 1935, 91); and at oak sap in England (*antea*, p. 614). (Some of Duda's specimens could be *D. subobscura*, which had not then been described, or *tristis*, which he treats as a variety of *obscura*.) Forbes W. Robertson appears to have discovered the first definite breeding site in Scotland (Gordon 1942), which was, I believe, the first breeding record for the species. In the late summer of 1941 he found larvæ on the inner side of bark from a yeasty sap exudate on elm at Woodside, near Aberdeen, and reared 20 ♂, 29 ♀ flies from the 150 larvæ that were transferred to normal Drosophila medium. *Drosophila* sp. eggs were also present on the sappy bark.

During v.50, 1 ♀ was at a wet sap patch at the base of a large beech tree, and 4 ♂, 13 ♀ at a copious elm exudate, both at Dalkeith (Midlothian); and adults frequented sappy stumps of *Salix* sp. and sycamore (*antea*, p. 613). Some exudate from the *Salix* on 9.v. was kept with Drosophila medium at 18° C., and 10 ♂, 14 ♀ *D. obscura* emerged 21–27.v.52. Dr H. Graber reared 2 ♂, 1 ♀ from sycamore sap collected 12.vi.52 at Liberton.

The above three tree saps (elm, sycamore, *Salix* sp.) are the only natural breeding records of *D. obscura* known to me. It has been reared, however, from prepared baits (Drosophila medium, plum, apple, raspberry with orange, and middlings) when exposed outdoors during the months of April to September inclusive. The adults have also been trapped at fermenting bread, wine waste, orange and raspberry. Pale-bodied (? recently emerged) specimens have been caught from the beginning of August to the end of October.

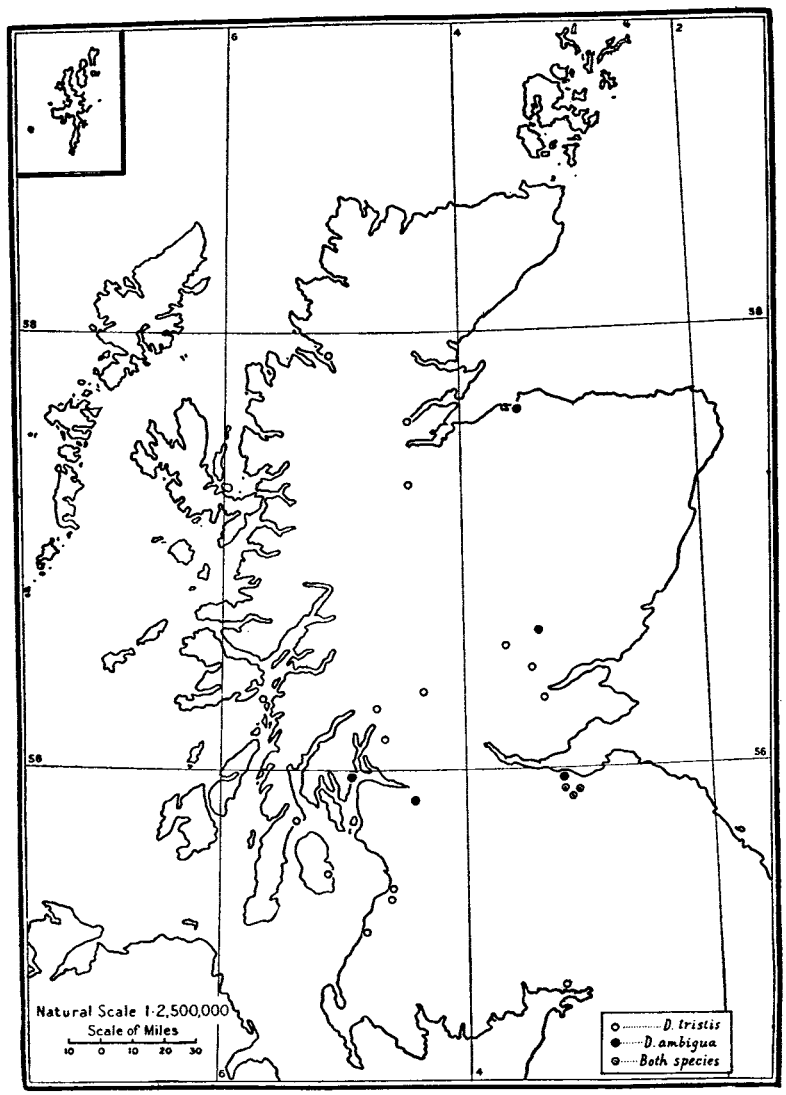
(iv) *Laboratory Breeding.*—This species is less easy to maintain on Drosophila medium than is *D. subobscura*. The first bottles and sometimes the second to which adults of a new generation are added often do not "take", suggesting that the pre-oviposition period is longer

in *D. obscura* than in *D. subobscura*, in which species the first bottles take almost without exception. In the successful cultures at 18° C. the first progeny adults emerge 19 to 25 days after parents are added.

The adults can live for at least 9 months. Eleven isolated females, probably virgin, that emerged 28.ix and 29.ix.50 from trap-bait were kept with changes of food at 18° C. until 2.xii.50 and afterwards in unheated outdoor insectary. The oldest one died 23.vi.51 (after 38 weeks 1 day) and the others sometime between 21.v. and 6.vi.51, and probably then only because the food moulded over. Some wild-caught females kept similarly from 14.xi.50 lived well into May 1951.

3. *Drosophila tristis* Fallén

(i) *Previous Scottish Records and Specimens.*—*D. tristis* has not previously been recorded from Scotland, except in Basden (1951, 1952), and I have seen no Scottish specimens of this species apart from those collected during the present survey.



TEXT-FIG. 3.—Known distribution of *D. tristis* and *D. ambigua*.

(ii) *Distribution and Numbers.*—*D. tristis* has been trapped during this survey at 19 places in Scotland (text-fig. 3), occurring most often in deciduous and coniferous woods, timbered

parkland, and in bushy scrubland, but also on the treeless and bushless island of Insh, in arable pasture country, and in gardens in built-up areas, but I have never taken it in buildings. In O. W. Richard's collection, however, is a male from Llandie, Cardigan (Wales), caught in a window 3.ix.43.

D. tristis is about one-sixteenth as abundant as *D. subobscura* and *D. obscura* in the Edinburgh district, and was trapped mostly in small numbers from early March until mid-December, with a definite peak in May. The sex ratio of wild-caught flies is 0·63 ♂ : 1·00 ♀.

(iii) *Natural History.*—Although the adults have not been caught by me during January and February they may be active then during a mild winter, as two caught in traps exposed 1–3.iii. and two others also trapped early in March had probably passed the winter as adults.

The only natural bait on which I have found this species was a bleeding stump of *Salix* (*antea*, p. 613). Exuding sap is probably the usual attractant in Britain and the one in which it probably breeds, as Collin (1911, 230) found the adults at a *Cossus*-infested tree at Barton Mills (Suffolk) in v.09 and on "exuding sap" in an unnamed British locality (Smart 1945, 53). It is attracted to the fruity types of prepared baits (plum, apple, raspberry, wine waste, and apple with orange) with only one specimen (♀) from a trap of Drosophila medium. It has been reared from plum and apple baits exposed during the months of June, August and September. d'Assis-Fonseca (1952, *Ent. Rec.*, **67**, 361) found it on a *Cossus*-oak, New Forest.

(iv) *Laboratory Breeding.*—Although *D. tristis* was obviously not attracted to Drosophila medium in the traps, it will breed fairly well on it at 18° C., though it is usual for the first bottles of a new generation to produce no progeny. The first progeny adults appear 21 to 26 days after the parent adults have been added.

Five females that emerged from trap-bait on 28.ix.50 lived 8 months, until the end of May 1951, in an unheated outdoor insectary.

4. *Drosophila ambigua* Pomini

(i) *Previous Scottish Records and Specimens.*—My earliest captures in Scotland (Basden 1951, 1952) were the first specimens recorded from Britain since it was originally described by Pomini (1940, 159) from London.

(ii) *Distribution and Numbers.*—*D. ambigua* has been caught in only eight localities in Scotland (text-fig. 3). In a trap between Paisley and Renfrew the original adult was not recovered but progeny were reared from the trap-bait. *D. ambigua* is decidedly a rare species in Scotland, only 21 specimens (6 ♂, 15 ♀) having been trapped (22 specimens if 1 ♀ is allowed for the Paisley-Renfrew trap noted above). It was first trapped at raspberries flavoured with orange exposed 13–16.viii.50 in a small garden at Bonnyrigg, and at plum exposed 30.viii.–4.ix.50 in a grove of lime (*Tilia*) trees in the built-up area between Paisley and Renfrew. In xi.50 it was trapped at apple in deciduous woodland at Liberton, and subsequently in other deciduous and coniferous woods and small copses away from built-up areas, Edinburgh district. My only captures indoors have been in the Edinburgh banana-ripening store (1 ♂, 1 ♀, xii.51; 2 ♀, vii.–viii.52).

In addition I have had the privilege of examining the following specimens caught alive in England by Inspectors of the Infestation Control Division of the Ministry of Agriculture and Fisheries:—Hull, 1 ♂, 7.viii.52, on Russian barley in a warehouse, and 1 ♂, 1 ♀, 15.viii.52, in another warehouse and associated with cases of damaged tinned fruits (D. Burgess): London, 1 ♂, ix.52, around blown tins of jam and fruit in wharf (E. M. Brick); 1 ♂, 28.ix.52, on walls of vaults of another wharf (H. W. Howroyd); and 1 ♀, 6.ix.53, around blown tins of fruit in a store (B. Stott): Leeds, 2 ♂, 4.viii.53, around cases of mixed fruit in a warehouse (D. Burgess): Liverpool, 2 ♂ 1 ♀, 16.xii.53, around sacks of figs in an almond-paste factory (K. G. Smith).

Additional unpublished records from England are (all at prepared apple bait): 1 ♀, vii.52, 6 ft. up apple tree in garden of small town, Ware (Herts) (Mrs I. M. Harris); 2 ♀, vii.52, near house on outskirts of new housing estate,

Lyme Regis (Dorset) (A. F. Purser); 1 ♂, viii.52, 4 ft. up elder tree in wooded garden-park, Newcastle-upon-Tyne (J. H. Watson).

Outside Britain (Basden, above, and 1952, 200) it is known from Italy (Pomini 1940, 157), Switzerland (Burla 1951, 94), Holland (Lever and Sobels 1951), France, Spain and Portugal (Hadorn *et al.* 1952, 157), and Austria (Mainx *et al.* 1953, 355).

(iii) *Natural History.*—June is the earliest month of the year in which *D. ambigua* has been trapped in Scotland. This and the fact of its being caught in warehouses and a banana store, together with its being frequently found in built-up areas, suggest that it is not a native (over-wintering) species with us but is introduced anew each year. It occurred during June–August and November–December.

This species has not been found at any natural bait in Scotland, but it has occurred in traps baited with plum, apple, raspberry with orange, and raspberry alone. It has been reared from the first three when exposed in August and September. It has also been trapped on wine waste, and caught by net at overripe bananas in the banana store.

(iv) *Laboratory Breeding.*—*D. ambigua* breeds with the greatest facility on ordinary Drosophila medium at 18° C., and it appears to be more prolific than other species of the *obscura* group (*D. subobscura, D. obscura, D. tristis, D. silvestris*). The larvæ usually pupate well up on the sides of the bottles, thus showing a marked difference from the other species (Pl. I, fig. *c*). The first progeny adults at 18° C. can be expected 19 to 25 (exceptionally 26) days after the parent adults have been added.

5. *Drosophila silvestris* Basden, new species

Types.—Holotype ♀, Lugton Bogs, Dalkeith (Midlothian), in trap baited with apple in beechwood, x.51. Allotype ♂, Aberargie (Perthshire), in trap baited with apple under trees on river bank, 17.ix.51. Paratypes, 22 ♂, 20 ♀, trapped at various dates at Drosophila medium, plum, or apple at:—Liberton and Dalkeith Park (Midlothian); Minishant (Ayrshire); near Lamlash (Isle of Arran, Bute); Hunter's Quay (Argyll); Ardlui (Loch Lomond); near Gairneybridge (Loch Leven, Kinross-shire); Aberargie and near (N. of) Rattray (Perthshire); Bunchrew and Loch Ness-side, near Drumnadrochit (Inverness-shire); and Ardgay (Ross and Cromarty). Holotype, allotype, and some paratypes, to British Museum (Natural History), other paratypes to Royal Scottish Museum, Edinburgh, and the writer's collection.

(i) *Previous Records and Specimens.*—Between 2.ix. and 19.ix.05, Carter (1914) caught a *Drosophila* species near *obscura* in the Aberfoyle district. In the Royal Scottish Museum there are two male specimens, which probably represent the above record, labelled "Aberfoyle, 11th September 1905, A. E. J. Carter", and determined as *nr. obscura* by J. E. Collin. Both these specimens are *D. silvestris*. Another male specimen of *D. silvestris* in the same collection and previously standing under *D. obscura*, is labelled "Bonhill, 23.7.7" (J. R. Malloch).

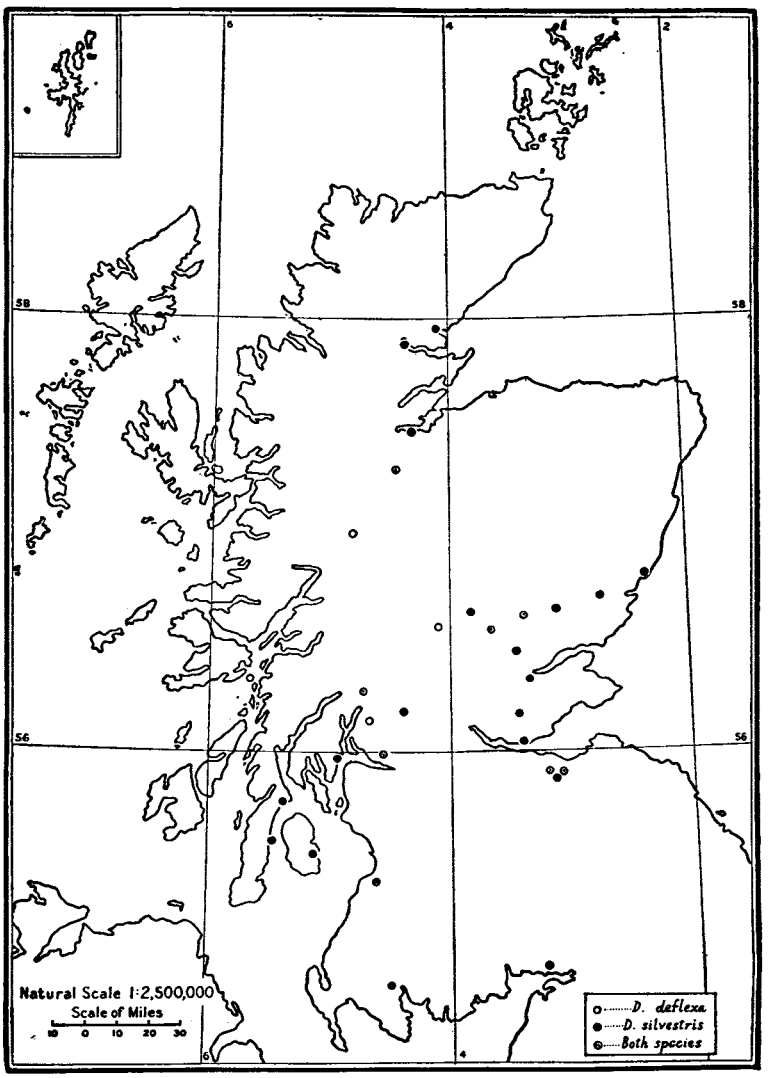
Burla (1951, 89) recorded this species, as "Obscura X", from Switzerland and gave a short description of it. Basden (1951, 1952) gave a short account of the species in Britain. Since then I have trapped it in large numbers in Phœnix Park, Dublin (Eire), during May, and Dr J. H. Watson trapped 1 ♂ specimen in a wooded garden-park in Newcastle-upon-Tyne (England) during August.

(ii) *Distribution and Numbers.*—*D. silvestris* has been caught during the present survey in 25 Scottish localities well distributed on the mainland, with one record from the island of Arran (text-fig. 4). The most northerly localities for it are Ardgay, near Bonar Bridge (Ross and Cromarty), and Loch Fleet (Sutherlandshire). The first adults (2 ♂, 1 ♀) were in a trap of Drosophila medium exposed 8–13.vi.50 amongst mixed trees bordering the garden, Liberton estate.

It has not been found away from trees or bushes, though occasionally on edges of woods and in hedgerows. Only 14 specimens have been found in gardens near houses (all containing trees or bushes), indicating that it is not a species of built-up areas. It has never been taken inside buildings of any sort. It frequents deciduous woods, coniferous plantations, the old

oak park at Dalkeith, and thickets, copses and small clumps of trees in open (arable, pasture, moorland) country. It has been found most abundantly in deciduous woodland and in the Dalkeith old oak park.

It is rather surprising to see (Table III) that this species, hitherto unnamed, is the third most abundant in numbers of the outdoor species, 4864 specimens having been obtained during this survey. In some months (June, September, October) its numbers even surpassed



TEXT-FIG. 4.—Known distribution of *D. silvestris* and *D. deflexa*.

those of *D. subobscura* or *D. obscura*. Its abundance would seem to have two peaks during the year, in June–July and again in October, with a definite drop in August. The sex ratio of the 4864 specimens trapped was 0·88 ♂ : 1·00 ♀.

(iii) *Natural History.*—Adults of *D. silvestris* have not been trapped until the latter part of April, and they are on the wing from then until November, with one specimen (♀) in a trap exposed 14–21.xii. The adult wou d appear to be less winter-hardy or winter-active than *D. subobscura*, *D. obscura* or *D. tristis*. However, of 37 ♂, 34 ♀ that emerged at 18° C. from apple trap-bait between 10 and 12.xi.51, and subsequently kept with food in an unheated outdoor insectary, 6 ♂, 6 ♀ were still alive on 4.ii.52, and the last one died between 26.iv. and 28.iv.52. Another lot of 15 ♂, 17 ♀ was kept similarly from 30.xi.51 and 5 were alive 10.iii.52,

and the last one, a male, was alive 13.v. but had stuck in the honey and died by 17.v.52. The minimum temperature in the insectary during both these periods was 20° F. (−6·7° C.) with readings below freezing-point on 29 other occasions. *D. silvestris* has not been taken at or reared from any natural baits but it has been trapped at prepared plum, apple, tomato and Drosophila medium; and reared from all four when exposed outdoors in June, July, September and October.

(iv) *Laboratory Breeding.*—Although 520 adults have been reared from trap-baits and 41 of these adults were from half a dozen traps of Drosophila medium, the early attempts to breed *D. silvestris* in the laboratory proved very difficult (Basden 1951). Many trials with Drosophila medium and prepared apple alone or together in small bottles and in large gauze cages failed except for an occasional offspring, and the original adults died within one or two weeks with often a starved appearance. So they were given water absorbed in cotton wool to drink, but there was no improvement. Then a dilute solution of honey in water on cotton wool was tried and proved successful. However, honey-water needed frequent changing as it moulded within a few days, so undiluted honey was put in one dish and a water pad in another.

Vigorous stocks are now maintained by the following method (Pl. I, fig. *b*). Into a large glass 7-lb.-size jar (known also as a 4-lb. rock jar or breffit jar) are placed a small sheet of tissue paper, as a resthold for the flies and to absorb droppings; a small dish containing a teaspoonful (4 c.c.) of undiluted honey, with a wisp of dry cotton wool on top for the flies to stand on when the honey deliquesces; a dish of water-soaked cotton wool, for drink; and a small larval food pot (5 cm. diam. × 3 cm. deep) of prepared apple and Drosophila medium in equal proportions, but unmixed, for egg-laying. Between 70 and 80 flies are then added to this *parent jar*. The muslin top to the jar is brushed with a 5 per cent solution of benzyl benzoate in 95 per cent alcohol as a precaution against mites. The wet pad needs moistening occasionally and a new food pot for egg-laying is added each week, the older one being transferred to a 7-lb. *stock jar*, which supplies the adults for the next generation parent jar. At 18° C. this is usually five weeks later, as the first food pot from the parent jar sometimes produces no adults. The first adults emerge from a successful culture 3 weeks after the parent adults have access to it. The adults can live at least 24 weeks (Section (iii)).

6. *Drosophila deflexa* Duda

Note.—Since my remarks on this species and *D. guyénoti* Burla (Basden 1952, 200), I have seen specimens labelled *D. guyénoti* from the Zoologisch-vergleichend anatomischen Institut, Zürich, through the kindness of F. X. Finsinger. Altogether they had only 4 flies, including the type. Two of these, in spirit, were sent to me as well as one slide of male legs and wings, another slide of male legs, and two slides of female genitalia. None of this was labelled as type material. The two flies had had the genitalia removed but were referable to *D. deflexa*. Each of the two slides of female genitalia carried two separate preparations and both slides were labelled "*guyénoti* ♀ Vaginalplatte". The two on the slide labelled No. 1 were definitely *D. deflexa* Duda, whereas the two on slide No. 4 were obviously different, the bristles around the tip of the ovipositor plate being shorter and less pointed than the corresponding ones on slide No. 1, and there being one bristle outstandingly longer than the others near the tip below. This long bristle was not present on slide No. 1. The figure of the vaginal plate of *D. guyénoti* in Burla (1948, 278, repeated in Burla 1951, 72) could have been drawn from slide No. 4. Obviously two species were included in this *guyénoti* material. It was this figure and details of the description of *D. guyénoti* that convinced me that, although closely allied to *deflexa*, it was not the same as that species, although it seems possible that specimens of two species were confused by Burla.

Independently of my findings, Herr Finsinger wrote (28th August 1952) that the *D. guyénoti* question was not altogether clear yet, as B. Herting had found that the cotype specimen of *D. guyénoti* was actually *D. nitens* Buzzati-Traverso. Herr Herting tells me he has prepared his findings for publication. *Note added July* 1953. Herting (1953) gives *D. nitens* as a synonym of *D. rufifrons* Loew (not a Scottish species, *antea*, p. 614), and *D. guyénoti* as a synonym of *D. deflexa*. He overlooked the obvious bristle difference of the ovipositors. Until the whole series of type specimens of *guyénoti* deposited by Burla has been examined the matter will not be cleared up. This may be done now that Herr Herting's attention has been drawn to these bristles.

(i) *Previous Scottish Records and Specimens.—D. deflexa* has not been reported from Scotland previous to this survey. I found 1 ♂ specimen of this species in the Malloch collection of the Royal Scottish Museum, under *D. obscura*, labelled "Bonhill 26.7.9", *i.e.* Bonhill (Dunbartonshire), 26th July 1909.

(ii) *Distribution and Numbers.*—According to the small number (119) of specimens trapped, *D. deflexa* is decidedly uncommon in Scotland, it being obtained from eleven localities (text-fig. 4). Except for 2 ♀ trapped on the treeless and bushless isle of Insh and 1 ♂, 1 ♀ at the foot of a lone pine tree on a grassy hillside at Dalmarnock, all my specimens have been obtained amongst trees or bushes. The habitats include a larch plantation, deciduous woods, various types of scrub (alder, birch, gorse (*Ulex*) and hazel), in yew undercover in deciduous wood, and at foot of trees at edge of arable field.

D. deflexa is probably more attracted to wet habitats than to dry ones, as six of the ten mainland localities were at lochsides or in definitely damp places, and most of the sites where this species was trapped at Dalkeith were in moist woods. In the extensive trapping carried out in the fairly open and dry old oak park at Dalkeith, and where thousands of *D. subobscura*, *D. obscura* and *D. silvestris* were caught, only two specimens (1 ♂, 1 ♀) of *D. deflexa* have been obtained. The species has not been found by me in built-up areas or in any type of building. From the figures available to 31.viii.52, *D. deflexa* would appear to be most abundant during July and August. The sex ratio of trapped specimens was 0·54 ♂ : 1·00 ♀.

(iii) *Natural History.*—The adults of this species have not been caught until June and have disappeared again by the end of October, although some adults trapped 17.viii.51 remained alive in an unheated insectary until the following December and January. The former almost certainly is due to the fact that the majority of larvæ diapause during the winter and spring months. No adults have been caught at or reared from natural baits, but they have been trapped at prepared plum and apple. Only one specimen, a female, has been reared by me from trap-baits, and this not from Scotland but from apple exposed 3–10.viii.51 in the branches of a roadside tree at Kimmage, Dublin (Eire).

(iv) *Laboratory Breeding.*—Stocks of *D. deflexa* are kept at 18° C. in 7-lb. jars as for *D. silvestris* but with no honey. The larvæ of *D. deflexa* go into diapause from about October until June, whether the cultures are kept in an unheated insectary or at a constant temperature of 18° C. (Basden 1952, and in press). This larval diapause is also indicated for *B. guyénoti* (Burla 1951, 75). Buzzati-Traverso (1943, 6) found that *adults* of the closely related species, *D. nitens*, had a reproductive diapause at 25° C. from November to March, which (Bertani 1947, 309) could be broken by exposing the adults to 2°–5° C. for ten days.

The precise period of the life-cycle at 18° C. has not been ascertained, but with apple and Drosophila medium as food for the larvæ, the minimum period from the time the adults have laid eggs to the emergence of progeny flies varies between 30 and 40 days. It may be less than this in some cases, however, as the Irish-reared specimen had emerged by 3.ix. from a trap exposed 3–10.viii, which is a maximum period of 31 days, including about 9 days at outdoor temperature.

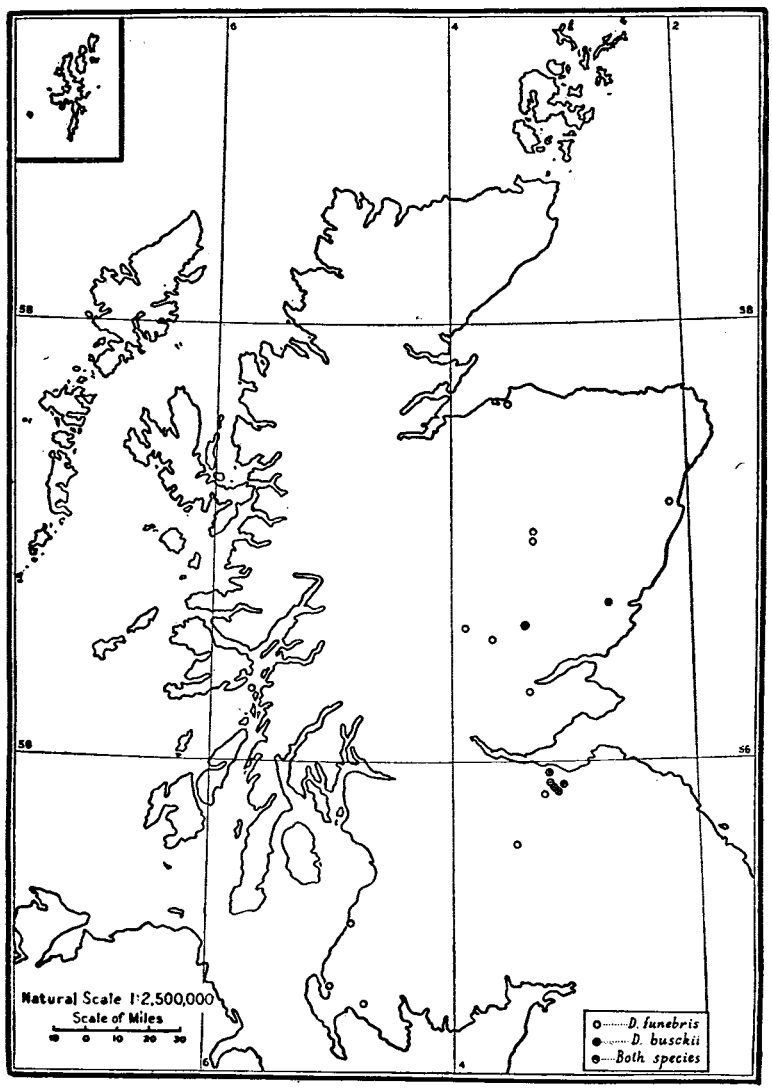
Adults of *D. deflexa* have lived at least 115 days for a male and at least 150 days for a female. Both these were trapped 17.viii.51 and were kept together in the unheated insectary in a series of 1-inch diameter vials containing Drosophila medium and apple. The male died between 10–18.xii.51 and the female between 14–19.i.52. The length of adult life at 18° C. has extended to 91 days, but usually the adults die within a week or two of capture.

7. *Drosophila funebris* (Fabricius)

(i) *Previous Scottish Records and Specimens.*—*D. funebris* has been recorded from the Aberfoyle district, ix.05 (Carter 1914); Dumfriesshire, on windows in autumn (Murray 1935); and near Aberdeen, feeding at elm sap (Gordon 1942).

[Yerbury (1913) collected "*D. confusa* Staeg." at Golspie (Sutherlandshire) on 31.vii.1900, and Walker (1853, Vol. **2**, 237) records "*D. cellaris* L" from "S" (Scotland). Although these may have been *D. funebris*, the true identity of Yerbury's and Walker's specimens are not known.]

In the Royal Scottish Museum are two specimens of *D. funebris*, both labelled Aberfoyle, 19.ix.05, A. E. J. Carter. In the British Museum (Natural History) there is one specimen



TEXT-FIG. 5.—Known distribution of *D. funebris* and *D. busckii*.

collected 19–30.vii.38 by R. L. Coe in Balmoral Forest, Aberdeen. One male was caught in the suction trap at Milton Bridge (Midlothian) between 20 and 21 hours (G.M.T.) on 23.viii.51 (*antea*, p. 609).

(ii) *Distribution and Numbers.*—This species has been found during the survey in a scattered distribution in only 16 localities (text-fig. 5). More trapping in towns and villages will have to be done before its full range in Scotland is known. The adults are found more commonly in or around buildings than in fields and woods. It is active every month of the year in the sheltered, intermittently warmed banana store in Edinburgh, but it has not been found in January in the more exposed, unheated fruit store. From less sheltered outbuildings

and ordinary domestic premises it disappears for a longer period. Although it is often found in the windows of the fruit store and of houses it has been decidedly uncommon in glasshouses, and was not found in heated plant houses during the winter at the Royal Botanic Garden, Edinburgh. It seems to prefer darker premises, and it was quite frequent in a completely dark basement vegetable store in the mansion house of the Liberton estate.

D. funebris cannot, however, be classed as an indoor species only. It occurs in gardens near houses, but it is also found farther afield in woods and groves of deciduous trees, in small coniferous plantations, in clumps of bushes and about refuse dumps. It is closely associated with animal quarters, examples being a chicken-house (one-time stable) on the Liberton estate, a cow-byre on a small farm near Dalmarnock (Perthshire), and a shallow cave used as a shelter by cows and sheep on the bare isle of Insh; and I have it from stables and pigsties in England and Ireland.

A total of 2271 adults has been collected (Table III), this being the fourth largest total of any species in Scotland. It is most abundant during July to November. The sex ratio was 1·19 ♂ : 1·00 ♀.

(iii) *Natural History.*—The adults of *D. funebris* can be trapped all the year round, but during the severest months of January and February they are active only in the more sheltered, and perhaps darker, buildings, and are not found outdoors until March. They have been caught at a wider range of baits than has any other species, being attracted to decaying substances as much as to fermenting ones. The natural baits they have frequented are bracket-type toadstools on oak, elm and sycamore trees; ground toadstools that had been allowed to decay in a heap, but not at healthy ones; rotten apples; rotten potatoes; rotten onions (in England); and Gordon (1942) records it at elm sap in late summer. It has been reared by me from all except bracken fungi on oak but never from healthy ground toadstools. Adults go to prepared baits of plum, Drosophila medium, apple, middlings, tomato, home-made wine waste, and old (fermenting) rhubarb jam, and it has been reared from the first four exposed during June to October inclusive. The adults are often to be seen hovering around or alighting upon bread at the meal-table, though none was trapped at wetted fermenting bread exposed for 15 days in a house garden. It has also been found on various out-of-condition stored products in warehouses in England.

(iv) *Laboratory Breeding.*—*D. funebris* is very easily bred on ordinary Drosophila medium. At 18° C. the first progeny adults appear 23 to 28 days after the parent adults are added to the food, and at 25° C. after about 13 to 15 days. The largest number of progeny counted from one wild-caught female has been 364.

8. *Drosophila busckii* Coquillet

(i) *Previous Scottish Records and Specimens.*—*D. busckii* has not been found in Scotland previous to this survey. Some notes on the British range of the species are given in Basden (1952).

(ii) *Distribution and Numbers.*—It has been caught by me only in the Edinburgh district (Liberton, Bonnyrigg, Dalkeith, Lasswade and Edinburgh), at Brechin (Angus) and at Blairgowrie (Perthshire), all on the eastern side of the country (text-fig. 5). More collecting and trapping around refuse dumps and in houses will almost certainly prove it to be more plentiful and widespread than the present figures (Table III) suggest.

D. busckii appears to be mainly an indoor species, 65 of the total of 76 specimens having been caught or trapped inside buildings, viz. in the chicken-house on the Liberton estate, in

houses and a glasshouse, and in the Edinburgh fruit and banana stores. The first specimen (1 ♂) to be caught in Scotland, however, was actually outdoors on a small heap of rotten toadstools under beech trees on the Liberton estate, 1.viii.50. Further specimens from outdoors were 1 ♂, 1 ♀ taken by sweeping on the Council refuse dump at Lasswade; 5 ♂ trapped at wine waste on outside window-sill of house at Bonnyrigg; 1 ♀ trapped at apple bait in a mainly oak wood at Dalkeith; and 2 ♂ trapped at apple placed close to a heap of rotting peas and pea haulm on a waste dump at Blairgowrie.

It is likely that the numbers of this species are greatest in August and September, although specimens, if any, caught during ix.52 or later are not yet examined. The sex ratio was almost unity (37 ♂ : 39 ♀).

(iii) *Natural History.*—It appears that *D. busckii* is only a summer visitor to Scotland, though capable of producing at least one generation here. It has been collected only during the months of July to October inclusive.

The only natural bait it has been found at in Scotland is decaying ground-growing toadstools. On 26.vii.50 a few healthy toadstools were collected under beech trees on the Liberton estate and placed there in a heap to decay, and 1 ♂ of this species was caught 1.viii, and 1 ♀ was later reared from them. A similar small heap was made up 1.viii. and collected 12.viii.50, and 2 specimens later emerged. If this species does not normally oviposit in healthy toadstools, the eggs must have been laid in late July and early August. It was not reared from the many collections of healthy toadstools. McFadden (1914) noted that the larvæ were found in great abundance in the thick mud-like mass of decomposed mushrooms brought into the laboratory. I collected 9 ♂, 18 ♀ on an outdoor heap of rotten onions on a farm at Halewood (Liverpool, England), 15.xi.51. Lawrence (1953) reared 1 ♂, 1 ♀ from cow dung in England.

The trap-baits that have attracted *D. busckii* are Drosophila medium, middlings, tomato, wine waste and apple. It was reared from the first two when exposed during August and September. It is similar to *D. funebris* in its liking for decaying substances or substances with a decaying or manure-like smell. Of the 35 specimens trapped in the poultry-house at Liberton, 34 were in the trap baited with middlings and only 1 ♀ was in that of Drosophila medium close by. Fermenting middlings has a somewhat objectionable, manure-like smell. If the use of this bait had been continued after September 1950, more specimens of *busckii* might have been caught than with the apple bait used thereafter.

(iv) *Laboratory Breeding.*—This species breeds readily on Drosophila medium at 18° C. and the first progeny adults emerge about 3 weeks after the parent adults have been added.

9. *Drosophila melanogaster* Meigen (=*D. ampelophila* Loew)

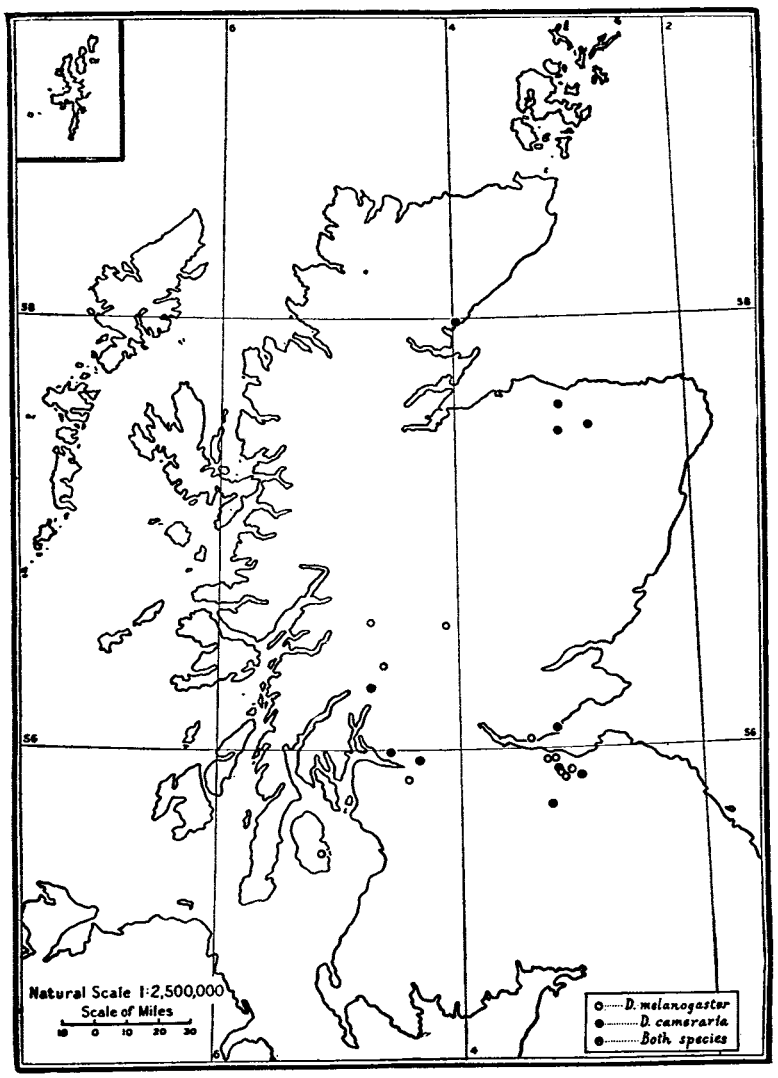
(i) *Previous Scottish Records and Specimens.*—*D. melanogaster* had not been recorded from Scotland before this survey began. Four specimens (1 ♂, 3 ♀) under *D. melanogaster* in the Royal Scottish Museum proved to be *D. forcipata.*

The first Scottish specimens (2 ♀) were collected by me in a window of a house at Bonnyrigg (Midlothian), 14.vii.50.

(ii) *Distribution and Numbers.*—The total of 11 localities where *D. melanogaster* has been found (text-fig. 6) almost certainly does not represent the limits of its distribution in Scotland. Intensive trapping and collecting in the fruit and banana stores in Edinburgh showed it to be abundant there especially during the autumn, and the very great majority of the total of approximately 1364 specimens were obtained from there. This suggests that more attention

to built-up areas in other parts of Scotland will doubtless show it to be fairly widespread. Its most northerly record is the Black Mount on Rannoch Moor (Argyllshire), but it should be expected farther north than this, in such cities as Aberdeen and Inverness.

Small numbers were regularly trapped in woods on the Dalkeith estate, a pair was caught in the window of a restaurant at Crianlarich (Perthshire), and others were trapped by the lochside at Fearnan (Loch Tay), in small bushy copse by a cornfield near Inverkeithing



TEXT-FIG. 6.—Known distribution of *D. melanogaster* and *D. cameraria*.

(Fifeshire), in wooded ravine in sparsely populated area near Lamlash (Arran), on the borough refuse dump at Lasswade (Midlothian), and on the remote Black Mount (Rannoch Moor). It has also occurred in small numbers inside a house and in gardens, including the domestic refuse bin in the Edinburgh district, and in a grove of trees in the Paisley–Renfrew built-up area.

(iii) *Natural History.*—Adults of *D. melanogaster* have been found during June to December inclusive, reaching peak numbers in October and November. It has not been found outdoors in Scotland after October, although it was active in England in mid-November on an outdoor heap of decaying onions (Halewood, Lancashire).

This species has been taken at bruised raspberries at Corstorphine (Edinburgh) and

abundantly in the Edinburgh fruit and banana stores, and on bruised apples and strawberries in England. It was attracted to prepared fruit baits (plum, apple, raspberry, raspberry with orange, and home-made fruit wine), and it was reared from apple and plum trap-baits exposed during July to early October.

(iv) *Laboratory Breeding.*—This species breeds well on the usual Drosophila medium, which was originally perfected for it. At 18° C. the first progeny adults appear after 18 (exceptionally 17 days) to 20 days. At 25° C. the period is 8 to 10 days. The largest number of F1 offspring counted by me from a wild-caught female kept at 18° C. is 224.

10. *Drosophila simulans* Sturtevant

(i) *Previous Scottish Records and Specimens.*—*D. simulans* had not been recognised in Britain before this survey started. Basden (1952, 201) gives a short account of its British distribution. The first British specimen, now recorded, a female, was obtained at Liberton (Midlothian) at plum trap-bait exposed 29.viii–6.ix.50.

(ii) *Distribution and Numbers.*—This species has been obtained only in a wooded garden on the Liberton estate (the above female); in the fruit and banana stores in Edinburgh; and two males in company with *D. melanogaster* in apple trap in a small copse of rose bushes, hawthorn scrub, and tall grasses by a cornfield just north of Inverkeithing (Fifeshire). This means that 315 of the total 318 specimens (Table III) have been taken from the fruit and banana stores, where it is quite common during the summer months, and it is extremely likely to be found in similar habitats in other parts of Scotland.

(iii) *Natural History.*—The earliest *D. simulans* in any year was 1 ♂ in apple trap exposed in the Edinburgh fruit store 14–21.v, whereas the earliest *D. melanogaster* was in apple trap in the same store 4–11.vi. *D. simulans*, however, disappears completely at the end of November, a month before *D. melanogaster* does so. Both disappear earlier in the more exposed fruit store than in the more sheltered, intermittently warmed banana store, where *D. simulans* was caught on overripe apples and around waste banana bins. It goes readily to prepared plum and apple in traps, and has been reared from both when exposed in September.

(iv) *Laboratory Breeding.*—*D. simulans* breeds as readily as does *D. melanogaster* on the usual laboratory medium. At 18° C. the first progeny adults appear 16 to 18 days after the introduction of the parents. At 25° C. the period is 9 days.

11. *Drosophila ananassæ* Doleschall

(i) *Previous Scottish Records and Specimens.*—*D. ananassæ* has not hitherto been recorded from Europe, although it is extremely widespread over the warmer parts of the world. [Note added Oct. 1953. Dr A. Prevosti kindly allows me to record his capture of *D. ananassæ* in 1950 in a house in Spain.] In Patterson (1943, 74) it is listed from Cuba, Haiti, Porto Rico, Antigua, Dominica, British Honduras, Costa Rica, Tobago Island, Panama, Brazil, Japan, Florida, Lousiana, Texas, and various states in Mexico. I have seen specimens in the British Museum (Natural History) from Malaya and Fiji Islands, and in *Drosophila Information Service*, No. 26 (1952), there are records of this species from Australia, Hawaii, Africa, Formosa, China, various Pacific islands, and Alabama. It was originally described (1858) from the Dutch East Indies (Amboina). Lamb (1914, 347) records it (as *D. similis* n. sp.) from the Seychelles (Indian Ocean).

(ii), (iii) *Distribution, Numbers and Natural History.*—This species did not appear in traps or collections until July 1952, and only in the banana store in very small numbers, as follows:

1 ♀ 16.vii, 3♂, 1♀ 13.viii, by sweeping over waste banana bins; 2 ♂ in apple traps exposed 30.vii–6.viii and 13–20.viii. During the whole of this period the bananas being ripened in the store were from the Canary Islands.

I have not yet attempted to breed *D. ananassæ*, but Sturtevant (1921, 92, as *caribbea*) bred it through many generations on fruits with comparative ease.

12–14. NOTE.—*The Toadstool-species Group of* Drosophila

The three next following species, *D. phalerata*, *D. transversa* and *D. cameraria*, can be grouped biologically as the toadstool-species, as their larvæ develop exclusively or almost so in healthy toadstools. The other species associated with toadstools (*antea*, p. 613) are more casually dependent upon them and therefore are not included in this biological group. *D. phalerata* and *D. transversa* are closely related systematically and are included in the *quinaria* group of *Drosophila*. *D. cameraria* is not closely related systematically to these.

As far as toadstools on the woodland floor or up trees are concerned, the rarest of these three species of *Drosophila* in the Edinburgh district appears to be *D. transversa* and the commonest is *D. phalerata*. It may be that *D. transversa* confines its attentions to only a limited range of fungi and these, by chance, have been only rarely collected during the survey, whereas *D. phalerata* is more catholic in its tastes. The latter species will doubtless be found to be the most adaptable of the three and to breed more frequently in other substances. Although the results of the present survey suggest that each toadstool species of *Drosophila* is confined to woodlands or copses, a wider investigation of fleshy fungi growing in pasture, moorland and other habitats away from trees may show that they frequent those open areas as well.

Plate II, fig. *a*, shows eggs of *D. phalerata* and *D. cameraria* embedded in the pileus (cap) of *Russula cyanoxantha* Fries collected from the Liberton estate 31.vii.52. The toadstool was kindly determined by Dr A. Nelson of the Edinburgh Royal Botanic Garden.

12. *Drosophila phalerata* Meigen

(i) *Previous Scottish Records and Specimens.*—*D. phalerata* was first recorded from Scotland by Henderson (1911) from the Gorge of Avon (near Hamilton, Lanarkshire), September (no year given). Yerbury (1913) found it at Golspie 28.vii.1900, and D. Lack (Edwards and Collin, 1932) collected it on the remote island group of St Kilda in vii.31 or viii.31.

In the collection of the Royal Scottish Museum are 9 specimens from Bonhill (Dunbartonshire) collected May, June and August of 1906 to 1908 (J. R. Malloch); one specimen labelled Blairgowrie, 18.viii.10 (A. E. J. Carter); 5 ♂, 2 ♀ from Golspie (Sutherlandshire), 28.vii.1900 and 21.viii.1900 (Yerbury); and 1 ♀ from Logie (Morayshire) 19.ix.10. In the British Museum (Natural History) are specimens from Golspie, 28.vii.1900 (Yerbury); Convil Braes (Banff), *c.* 800 ft., 11.viii.37 (R. L. Coe); Loch Park (Banff), 3.vii.36 and 12–14.viii.37 (Coe); Tomintoul (Banff), 1100 ft., 8–11.viii.37 (Coe).

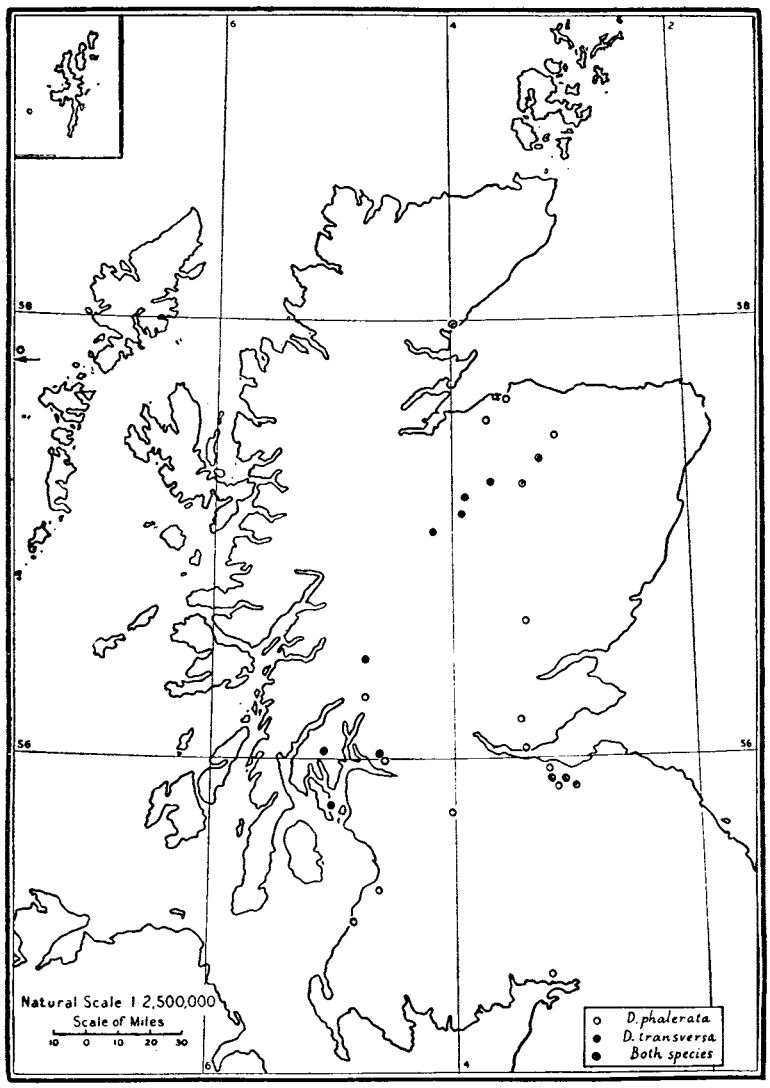
(ii) *Distribution and Numbers.*—During this survey *D. phalerata* was obtained from 13 localities, the most northerly being between Forres and Elgin (Morayshire), which, however, is not as far north as Yerbury's Golspie. It is common in wooded areas in the Edinburgh district and it appears to be so in the south and south-west of the country, and it was met with up to the north end of Loch Lomond on the west and in the Blairgowrie area on the east. The rearing of it from fungi collected from many parts of Scotland would no doubt add to its known range. Its distribution is plotted in text-fig. 7.

Only once have I trapped it in the open and that only a few yards from a wood, and one female was trapped in a small garden at Bonnyrigg (Midlothian). This latter specimen could have come from a stock of old timber brought in for firewood. *D. phalerata* is commonest in deciduous woods; but it has been trapped in larch and pine plantations; in two small copses in open arable country; in a hazel-birch thicket on moorland; and in hawthorn scrub near the coast. It was rarely trapped in the old oak park at Dalkeith. Most specimens have been obtained during July and August.

The only specimens from a built-up area are the Bonnyrigg one mentioned above, and

the surprising captures of two females in apple traps inside the fruit store in the centre of Edinburgh (August and September). Lever and Sobels (1951, 5) found a single specimen in a house in Holland. The sex ratio of the 497 adults obtained proved to be 0·81 ♂ : 1·00 ♀.

(iii) *Natural History.*—The adults of *D. phalerata* are first active in May and they can be taken or trapped from then on into December. Apart from one female caught 9.v.52 on a



TEXT-FIG. 7.—Known distribution of *D. phalerata* and *D. transversa*.

bleeding stump of a recently felled sycamore tree, the only natural bait I have associated this species with is toadstools, both ground- and tree-growing. The eggs have been found in toadstools in July (Pl. II, fig. *a*); the larvæ develop in the healthy toadstools. The adults are common on and around them, including the stinkhorn fungus (*Phallus* sp.), and although somewhat less than one-fifth of the total specimens were caught at toadstools, more can usually be obtained at these with a net or a sucking tube in a half-hour than in several apple traps in a week. The adults can be obtained in large numbers by rearing (Table III), all but 5 of the 874 specimens reared being from toadstools. These 5 were from Drosophila medium and apple when exposed in traps during June and July. A few adults have also been trapped at prepared plum and tomato. This species, however, appears to be shy of entering

traps, and usually does so only in ones or twos after a week's exposure, although on one exceptional occasion 32 ♂, 42 ♀ were trapped at apple when exposed for 6 days (15–21.ix.51) at Creca, Dumfriesshire, in a small damp wood in a deep hollow.

(iv) *Laboratory Breeding.*—Cultures of *D. phalerata* are a little tedious to maintain on Drosophila medium at 18° C., as the adults may not be ready to lay eggs during the first two weeks or more, so the first bottles to which they are transferred are usually blank. (See also Spencer 1942, 56, with reference to precautions to be taken with the breeding of other members of the *quinaria* group.) When eggs are laid, however, the first progeny adults will emerge after 18 to 21 days at 18° C. The largest number of progeny counted from one wild-caught female has been 168.

Note.—Abnormal wing venation. A few specimens of *D. phalerata* have been noticed from time to time with atypical wing venation in either one or both wings. Specimens have not been examined purposely for this abnormality. A detailed examination might show it to be of quite common occurrence. Although a small number of progeny of affected adults also showed similar wing-vein distortions, attempts to breed for these have failed. Those that have been noticed are as follows:—

1 ♀ Left posterior X-vein forked. 4.ix.50 in Drosophila medium trap near Ardlui, Loch Lomond.
1 ♀ Right posterior X-vein thickened; right 2nd longitudinal vein thickened at end. Emerged viii.50 from toadstools, Liberton estate.
2 ♀ Fifth longitudinal veins of both wings not reaching margin of wing and posterior X-vein curved backwards. Emerged 15.viii.50 from toadstools, Liberton estate.
1 ♀ Left posterior X-vein curved. 28.vii.50, in Drosophila medium trap, Dalkeith.
1 ♀ Both posterior X-veins branched **Y**-shaped. 21.vii.50, on toadstools, Liberton estate.
1 specimen in Royal Scottish Museum. Posterior X-vein abnormal. Labelled "Bonhill, 11.6.6".
1 ♀ Right posterior X-vein branched. 14.vi.51 at open bait of apple and molasses, Dalkeith estate.
1 ♀ Left posterior X-vein branched. 28.ix.51 in apple trap, Dalkeith estate.
1 ♀ Right posterior X-vein **Y**-shaped. In apple trap on Dalkeith estate exposed 25.vii–1.viii.52.

13. *Drosophila transversa* Fallén

(i) *Previous Scottish Records and Specimens.*—Walker (1853 Vol. **2**, 237) gives *D. transversa* as Scottish but with no details, and it is not certain that his species was not *D. phalerata* Meig. Henderson (1911, 170) found it in the Clyde area during June and July at Glen Massan, north-west of Dunoon (Argyllshire), at Northfield Moor, Alexandria (Dunbartonshire), and at Mount Stuart (Island of Bute). Yerbury (1913) collected it at Golspie (Sutherland), 28.vii.1900.

In the Royal Scottish Museum are specimens from Bonhill (Dunbartonshire) collected May and June of 1906 and 1907, and one with what appears to be the date "10.11.6", *i.e.* 10th November 1906. In the British Museum (Natural History) are specimens from Nethy Bridge and Spey Bridge (Inverness-shire), 22.vi.1900 and 31.vii.11 respectively (J. W. Yerbury); Aviemore (Inverness-shire), 13.viii.03 (J. J. F. X. King); Feshie Bridge (Inverness-shire), 1.vii.33 (R. L. Coe); and Convil Braes, *c.* 800 ft., 11.viii.37, and Tomintoul (both Banffshire), 1100 ft., 8–11.viii.37 (R. L. Coe).

(ii) *Distribution and Numbers.*—I have obtained 15 *D. transversa*, from the Edinburgh district and Tyndrum (Perthshire). Fourteen were in deciduous woodland, including 1 ♂, 4 ♀ in the more open timbered parkland on the Liberton and Dalkeith estates. The 1 ♀ at Tyndrum entered a trap, baited with normal Drosophila medium, on an open treeless moor one-fifth mile outside that village. In addition to those in Table III, 3 ♂, 1 ♀, were caught xi.52 in apple traps on the treeless Isle of Insh, Firth of Lorne. See also *antea*, p. 615. The records and specimens in section (i) above suggest that it is not uncommon and is widespread (text-fig. 7). It probably frequents open country more so than does *D. phalerata*.

(iii) *Natural History.*—One female was collected on a bleeding elm stump at Liberton, 5.vi.51, and 6 specimens (2 ♂, 4 ♀) from toadstools on or close to the ground in woods in

the Edinburgh district. At least 14 specimens have been reared from ground-growing toadstools.

The only prepared baits that *D. transversa* has been attracted to are Drosophila medium and apple. Nineteen flies were reared from the former (exposed 30.viii.–4.ix.50) but none of the apple trap-baits was kept for emergence.

I have not obtained the adults before June, though J. R. Malloch appears to have collected it in May ("4.5.7"), and they are active through into November.

(iv) *Laboratory Breeding.*—*D. transversa* is similar to *D. phalerata* in its breeding capabilities in Drosophila medium at 18° C., with the first transfers often producing no progeny. The first progeny adults appear from successful cultures 19 to 21 days (one record of 16 days) after the parent adults have been added. The largest number of adult progeny counted from one female has been 72.

14. *Drosophila cameraria* Haliday

Note.—I have examined Haliday's specimens of *D. cameraria* at Dublin and the Scottish specimens agree with them in all particulars. Duda's description (1935, 91) of *pallida* Zett. also agrees with *cameraria* Hal.

(i) *Previous Records and Specimens.*—Henderson (1911) recorded *D. cameraria* from Dougalston (North) Wood, Milngavie (Dunbartonshire), in September.

The Royal Scottish Museum has 1 ♂, 3 ♀ from Bonhill (Dunbartonshire) all collected iv.07 (Malloch); 1 ♀ (previously identified as *Scaptomyza graminum*) from Kinghorn (Fifeshire), 29.v.1896 (P. Grimshaw); and 2 ♀ from Golspie (Sutherlandshire), 21.viii.1900 (Yerbury). The British Museum (Natural History) has specimens labelled as from Banffshire and caught by R. L. Coe, viz. Loch Park, 12–14.viii.37; Glen of Drumloch, nr. Fochabers, 10.vii.36 and 16.viii.37; and Falls of Tarnash, 15.viii.37.

(ii) *Distribution and Numbers.*—I have obtained *D. cameraria* only at Liberton, Dalkeith and Pathhead Ford (Edinburgh district), and near Ardlui at the northern end of Loch Lomond. Only 34 specimens have been trapped or collected but nine times this number have been reared (Table III), so the importance of rearing from toadstools from many parts of Scotland to learn the distribution of this species cannot be over-emphasised. As in the case of *D. transversa*, the records and captures by other workers suggest that it is not uncommon and is widespread (text-fig. 6).

D. cameraria has occurred only in deciduous and coniferous woodland and in more open timbered parkland. Its choice of habitat is doubtless influenced by the presence or absence of suitable toadstools. The sex ration works out at 0·36 ♂ : 1·00 ♀.

(iii) *Natural History.*—Although adults of *D. cameraria* have not been taken during January, June and October, they probably exist in this stage during the whole of the year. The only natural bait this species has been associated with is toadstools, on the ground and the bracket types on elm and oak trees. It has been reared from the first two. Outside the toadstool season, it is occasionally trapped at Drosophila medium, apple and orange, but it has not been reared from any of these prepared baits. On one exceptional occasion 1 ♀ *cameraria* was trapped at apple in August, the trap being 54 ft. up a sweet-chestnut tree (*Castanea sativa* Mill) in a wood on the Dalkeith estate. Eggs of this species have been found on toadstools at the end of July (Pl. II, fig. *a*).

(iv) *Laboratory Breeding.*—Even though this species has not been reared from prepared baits exposed outdoors, it will breed somewhat hesitatingly on Drosophila medium at 18° C. From my few records the first progeny adults emerge in cultures about 3 weeks after the parent adults are first added.

15. *Drosophila littoralis* Meigen

(i) *Previous Scottish Records and Specimens.*—The species was unknown to Scotland until Dr H. Graber reared it in 1952 (see below).

(ii), (iii) *Distribution, Numbers and Natural History.—D. littoralis* is known as Scottish only from 4 specimens reared by Dr H. Graber from sap from the stump of a sycamore tree at Penicuik, Midlothian. The site was a small hill at the end of a damp valley of the river North Esk and quite close to a large pond. Many other trees had been cut down on the same hill. The sap was collected end of August 1952 and some of the *Drosophila* larvæ in it pupated, at 25° C., 3 days later. Four adults emerged some time in September, and many more *Drosophila*-like larvæ in the sap were heavily parasitised by an unknown hymenopteron. Dr Graber gave me a pair of flies which I kept on Drosophila medium at 18° C. until 21.x.52, but as no progeny resulted they were killed and pinned. Dr Graber (in litt. 2.i.53) reared progeny from his two flies after many changes of medium, and his stock had reached the third generation by the end of 1952. I now have some of this stock, which is easier to culture at 25° C. than at 18° C.

16. *Drosophila immigrans* Sturtevant

(i) *Previous Scottish Records and Specimens.—D. immigrans* has been found in Scotland only during this survey. Basden (1952) records it from fruit stores in Edinburgh, the first specimens being obtained there 24.ix.51.

(ii), (iii) *Distribution, Numbers and Natural History.*—This species has been found only in the fruit and banana stores in Edinburgh, where it has been collected on the windows and on overripe apples in the former, on the walls and around the waste banana bins in the latter, and trapped at prepared apple bait in both. It occurred from July until December, but was most plentiful in the autumn, with an additional male in the banana store iv.52. A total of 400 specimens has been obtained, the sex ratio being 1·31 ♂ : 1·00 ♀. Presumably it will be found in similar stores in other parts of Scotland. In England it occurred in fair numbers in November on a heap of rotting onions outdoors (Halewood, Lancashire), and 1 ♀ emerged from a sample.

(iv) *Laboratory Breeding.*—At 18° C. *D. immigrans* breeds readily on Drosophila medium and the first progeny adults appear after about 18 to 23 days. The largest number of progeny counted by me from one female has been 304.

17. *Drosophila hydei* Sturtevant

Note.—The crossing tests of Scottish ? *hydei* with American *hydei* mentioned in my previous paper (1952, 201) have been completed. A stock was sent to me in March 1952 by Professor G. H. Mickey of the Northwestern University, Evanston, Illinois. The original parents were caught on the campus of Purdue University at Lafayette, Indiana, 20.viii.51, and the identification had been checked by external and internal characters as well as by chromosome morphology from larval brain smears. Virgin males and females were used for all possible reciprocal crosses between my stock (original adults from a house window at Brechin) and the American *hydei*. Very vigorous healthy F1 and F2 cultures were obtained from all the crosses, thus proving the conspecificity of the two stocks.

Adults of these two stocks should still be compared with type specimens of *D. hydei*. The section of the identification key compiled by Patterson and Wheeler in Sturtevant (1942, 49) places *D. hydei* in the species with no long recurved hairs on male fore tarsi, and this character for *D. hydei* is repeated by Patterson and Mainland (1944, 21). It seems certain (W. P. Spencer, in litt. 2.ii.52) that the type series of *hydei* does possess these long recurved hairs, though Sturtevant (1921, 101) apparently overlooked them in his original description. The males of the stock sent by Professor Mickey have these characteristic long hairs, as have all my British males, and so does the species found in Switzerland by Burla (1951, 115) and which he decided was *D. hydei* after crossing with American-determined *hydei*. The testes in our males differ from the description by Patterson (1943, 128) by being whitish yellow and having only about 5 outer and 6 inner coils.

For the time being it is best to consider the species I have found in Scotland and England as the true *D. hydei* of Sturtevant.

(i) *Previous Records and Specimens.*—This paper records *D. hydei* definitely for the first time from Britain, though the *Drosophila* sp. near *repleta* Woll. of Richards and Herford (1930, 384) from a London warehouse must have been *D. hydei*. I previously recorded it as *D.* sp. near *bifurca* Patt. and Wheel. (*repleta* group) (1951) and as *D.* ? *hydei* (1952). My first specimens were taken at New Romney and Maidstone (Kent, England), and the first Scottish ones at Brechin (Angus) a week later. I understand that English specimens caught 1935 are in the British Museum (Natural History).

(ii), (iii) *Distribution, Numbers and Natural History.*—In Scotland *D. hydei* has been taken only at Brechin (10 ♂, 3 ♀ in house windows, 16.ix.51), in the Edinburgh fruit and banana stores (4 ♂, 5 ♀ on overripe bananas, in apple traps, and in windows, xi–xii.51 and viii.52), and at Dalkeith (2 ♀ in two apple traps in beechwood, 29.viii.52).

Recent captures in England are included to complete the knowledge of its occurrence in Britain. All except one were trapped with prepared apple. New Romney, Kent (Joan F. Basden), 2 ♂, 2 ♀, 1 ? sex, 9–28.ix.51, in a rural garden, 1 ♀ being at raw apple. Maidstone, Kent (Joan F. Basden), 1 ♂, 10.ix.51, in apple tree of small garden. Halewood, Lancashire (A. Robertson), 1 ♂, 1 ♀, in trap on large heap of decaying onions in open farmyard (another pair emerged from a sample taken 15.xi.51, the female from a pupa found on that date), and 2 ♀ in apple-plum orchard, 10.x.51. Finally, H. J. Ballinger trapped *D. hydei* at Bury St Edmunds (Suffolk), 1 ♀, 23.x.51, in farm garden, and at Little Stukeley (Huntingdonshire), 1 ♀, 23.x.51, 15 ft. up orchard tree.

The closely related *D. repleta* Woll., commonly found in London restaurants, etc. (Coe 1943; Colyer 1951), has not yet been found in Scotland. [Later note. Colyer states (in litt. 8.xii.53) that the Wood Green (London) specimen referred to (1951) is *D. hydei* and not *D. repleta*.]

(iv) *Laboratory Breeding.*—*D. hydei* develops well on Drosophila medium at 18° C., but the first one or two transfers often produce no offspring. The first progeny adults emerge after 23 to 28 days.

18. *Drosophila forcipata* Collin

(i) *Previous Scottish Records and Specimens.*—*D. forcipata* was not described as new until 1952 (Collin 1952, 198), and Collin mentions that it occurs in Scotland. It is very likely that some specimens previously recorded as *D. fenestrarum* (q.v.) were *D. forcipata*.

There are 3 ♂, 5 ♀ specimens of *D. forcipata* in the Royal Scottish Museum: 2 ♀ were under *D. cameraria*, 1 ♂, 3 ♀ under *D. melanogaster*, and 2 ♂ under *D. fenestrarum*. They were collected by J. R. Malloch at Bonhill (Dunbartonshire) during the months of March, April and May of 1905 to 1907. One date is not clear, the figures being either 14.7.7 or 14.9.7, *i.e.* 14th July or 14th September 1907. The Scottish specimens standing as *D. fenestrarum* in the British Museum (Natural History) were kindly checked by R. L. Coe but none was *D. forcipata*.

(ii), (iii) *Distribution, Numbers and Natural History.*—Only 2 ♂, 5 ♀ specimens of *D. forcipata* had been obtained by me to August 1952 and these all in the Edinburgh district: 1 ♂ at Drosophila medium exposed 1–8.v.50 in a small timbered park, and 1 ♂, 6.ix.50, in the windscreen of a car, both at Liberton; 2 ♀ in cottage windows at Bonnyrigg (15.viii.50 and 19.viii.52); and the remaining three females in windows of the fruit store in Edinburgh (7.v, 30.vii and 27.viii.52). An additional record of 39 ♂, 36 ♀ is given on p. 615.

From the results of the survey and of other collectors the species would appear to be generally rare in Scotland, though locally abundant in special habitats.

(iv) *Laboratory Breeding.*—*D. forcipata* breeds very well in Drosophila medium at 18° C., where the minimum life cycle varies from 20 to 26 days; and Collin's (1952, 198) ♂♀ association is proved correct.

19. *Drosophila fenestrarum* Fallén

(i) *Previous Scottish Records and Specimens.*—Some of the specimens on which the following records are based were probably *forcipata* and not *fenestrarum*. Walker (1853, Vol. **2**, 237) recorded "*Fenestrarum* Fal." from "S" (Scotland), and Duda (1935, 81) accepted Walker's species as the true *fenestrarum* Fln. Henderson (1911, 170) recorded it from Murroch Glen, near Dumbarton (Dunbartonshire), from April until June; Yerbury (1913) found it in Sutherlandshire at Lochinver 7.vii.11 and at Loch Assynt 7.vi.11; Haines (1936) recorded it from Granish (near Aviemore, Inverness) 26.vi.33; and the Rev. J. Waterston collected one specimen on Hirta (St Kilda) during his visit to the island, vi–vii.05 (Grimshaw 1907, 157, as *Drosophila* sp.; Edwards and Collin 1932, 266).

There are 1 ♂, 1 ♀ specimens of *D. fenestrarum* in the Royal Scottish Museum collected 1.iv.07 and 25.v.07 by J. R. Malloch at Bonhill (Dunbartonshire). In the British Museum (Natural History) there are 2 ♂, Loch Assynt, 7.vii.11, and 1 ♂, Lochinver, 7.vi.11 (J. W. Yerbury); 2 ♀, Falls of Tarnash (? Banff-shire), 9.vii.36 (R. L. Coe); and 1 ♀, Loch Etchachan (Aberdeenshire), *c.* 3200 ft., 13.vii.36 (R. L. Coe).

No specimen of *D. fenestrarum* was taken during this survey until viii.53 (see p. 615). The distribution of the species (*sens. lat.*) is widely scattered over Scotland. It is obviously a species not attracted to the usual types of Drosophila baits.

20. *Scaptomyza apicalis* Hardy (=*flaveola* (Meigen))

(i) *Previous Scottish Records and Specimens.*—Hardy (1848, 339) reported having met with a mining larva on swedes at Dunglass (Berwickshire) on 18.vii (no year given). The larva died, but he subsequently found what he presumably considered to be the same species of larva on [leaves of] yellow and white turnip, in one instance burrowing into the mid-rib of the leaf, but he gave no locality for these larvæ. On pp. 360–362 of the same volume (Hardy 1849) he described the pupa and the adult from these larvæ, the adult appearing 3.ix. The latter was described as the new species, *apicalis* Hardy, in the new genus, *Scaptomyza* Hardy, in which he also included Fallén's *Drosophila graminum*. Hardy added that the larva of *apicalis* mines the leaves of turnip and pea, and on the coast it is found as late as the end of October in the leaves of Scurvy-grass (*Cochlearia officinalis*) and of Lady's-fingers (*Anthyllis vulneraria*). Walker (1853, Vol. **2**, 238) repeats Hardy's descriptions and gives *S. apicalis* as common and only from "S" (Scotland). The name was corrected by A. H. Haliday, in Vol. **3** of Walker (1856, xiv), to *flaveola* Meig.

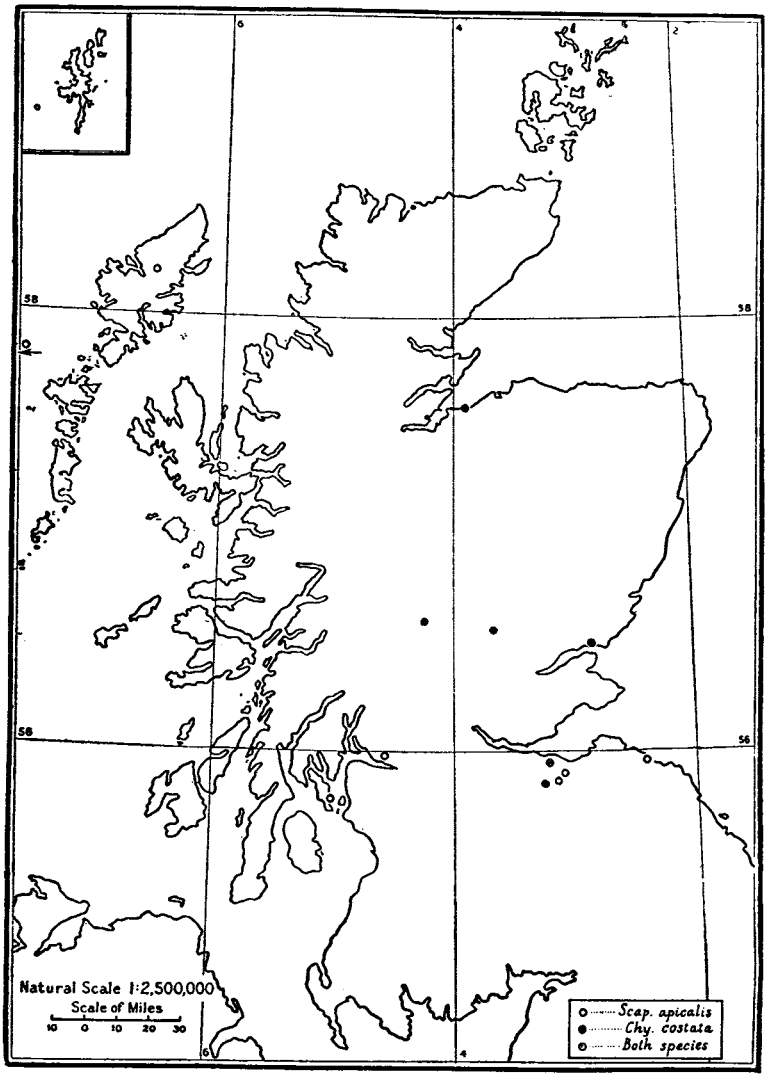
Subsequently it has been recorded, as *flaveola*, by (1) Grimshaw (1904, 28), who presumably assumed, from Hardy above, that larvæ of this species were found at Dunglass (which is actually just within the borders of East Lothian); (2) Grimshaw (1916, 134), taken by C. G. Lamb on Lewis, July 1914; (3) Henderson (1911, 169), Mount Stuart Estate (Island of Bute) July; and (4) Edwards and Collin (1932, 266), collected by D. Lack on the St Kilda group of islands some time from 22.vii to 13.viii. 31.

In the Royal Scottish Museum there are three specimens (2 ♂, 1 ♀) collected by J. R. Malloch at Bonhill (Dunbartonshire) on 13.iv.07, 7.v.08 and 15.v.05 respectively.

(ii), (iii) *Distribution, Numbers and Natural History.*—Adults of *S. apicalis* have been taken only during the months April to September. During the survey only eight specimens were at first collected, all in the Edinburgh district: 1 ♂, inside a public service bus, 31.viii.51; 1 ♀, in the window of this Institute, 2.vi.52; 1 ♂, 2 ♀, in a glasshouse 1.vii. and 15.viii.52; 1 ♂, 2 ♀,

in windows of the fruit store, Edinburgh, 9.vii. and 6.viii.52. A later capture of 4 ♂, 7 ♀ is recorded on p. 615. The distribution of this species is shown in text-fig. 8.

Although all the preceding are indoor records, it is apparently an outdoor species, but it was not attracted to the types of baits used during this survey. A total of 2 ♂, 11 ♀ emerged from a few mined leaves of broccoli, cabbage, various kales, and turnip collected May, June



TEXT-FIG. 8.—Known distribution of *S. apicalis* and *C. costata*.

and August from gardens at Bonnyrigg and Edinburgh. The mines were common and were obvious blemishes on the plants.

Although the records of *S. apicalis* are few in number, this species is perhaps common and widespread in Scotland. Many specimens could doubtless be obtained by rearing from or sweeping over brassicas and other larval food-plants.

21. *Scaptomyza graminum* (Fallén)

Note.—As pointed out in my 1952 paper (p. 201) there is disagreement in the use of the name *graminum*. Up to the early 1930's the name was largely given in Britain to a species with two rows of anterior acrostichal bristles, and the name *tetrasticha* Becker or *incana* Meigen to a species with four rows. However, I follow Duda (1934, 55) and Collin (1953) in considering the true *graminum* (Fallén) (=*tetrasticha* Beck, and *incana* Meig. of authors) to have four rows of anterior acrostichal bristles and our species with two rows to be Duda's *Parascaptomyza disticha*.

Therefore it is not always clear whether the older records of *S. graminum* are for *graminum* (Fln.) or for *P. disticha* (Duda). The two species were sometimes lumped under the one name of *graminum*. This obviously was done by P. H. Grimshaw, who recorded no Scottish specimens as *S. tetrasticha* or *S. incana*, and yet plenty of *S. graminum* and *P. disticha* in the Royal Scottish Museum that he determined are all labelled "*Scaptomyza graminum* (Fln.)"

(i) *Previous Scottish Records and Specimens.*—The following records definitely refer to *S. graminum* (Fln.), they having been checked from actual specimens: (1) Grimshaw (1904), Gosford Park (Aberlady, East Lothian), 4.vi.1896, as *graminum*. The number of specimens is not given but there are 3 with this data in the Royal Scottish Museum. (2) Grimshaw (1905*b*) recorded 23 specimens as *graminum* from the Flannan Islands, collected by W. Eagle Clarke 6–21.ix.04, but 20 of the specimens are *Par. disticha* and only 3 are *S. graminum*. (3) Grimshaw (1907), Hirta (St Kilda), 4 specimens, vi.05 or vii.05, as *S. graminum* (collected by J. Waterston); recorded again by Edwards and Collin (1932) as *S. incana* Mg. (4) Yerbury (1913), Loch Assynt and Lochinver (Sutherland), 2.vi and 1.vii.11 respectively, as *S. tetrasticha* Beck. (5) Walker's record (1853, Vol. **2**, 237) of *S. graminum* from "S" (Scotland) should be included here, as he obviously followed Hardy (1849, 361) in the interpretation of the species, and Hardy's generic diagnosis cannot refer to *Par. disticha*.

The following records of *S. graminum* have not been checked against actual specimens and may therefore refer to *S. graminum* or *P. disticha*: (1) Henderson (1911), generally distributed in the Clyde district from April to September. (2) Grimshaw (1916), 6 specimens from Jura, ix.07; 1 specimen from Iona, vi.06; 4 specimens from Balelone, North Uist, vi.05—all collected by J. Waterston. (3) Willis and Burkill (1895, 237, 246), Rascarrel beach, near Auchencairn (Kirkcudbrightshire), frequent, 5–7.ix.1894, sucking honey of *Matricaria inodora* L. (? var. *maritima* L. (*sic*)); near Auchencairn (Kirkcudbrightshire), 9.ix.1894, sucking honey of *Pimpinella saxifraga* L.

Other records of *S. graminum*, but which the specimens prove to be *P. disticha*, are given under the latter species.

In the Royal Scottish Museum are the following specimens of *S. graminum*: Bonhill (Dunbartonshire), 7 specimens, March, April and May of 1906 and 1907 (J. R. Malloch), Kinghorn (Fifeshire), 7 specimens, 29.v.1896 (P. Grimshaw); Gosford Park, nr. Aberlady (East Lothian), 3 specimens, 4.vi.1896 (P. Grimshaw); Aberlady (East Lothian) 1 ♂, 25.viii.04 (P. H. Grimshaw), and 1 specimen, 7.viii.05 (A. E. J. Carter); Flannan Islands, 3 specimens, September (6–21) '04 (W. E. Clarke); Isle of Barra (Outer Hebrides), 2 ♂ specimens, August (17–28) '36 (Waterston); Hirta (St Kilda), 1 specimen, 17.vi–17.vii.05 (J. Waterston); Blairgowrie (Perthshire), 1 specimen, 16.vi.13 (A. E. J. Carter); Aberfoyle (Perthshire), 1 specimen, 21.viii.06 (A. E. J. Carter); Edinburgh Botanic Garden, 2 ♂, 1 ♀, v.04 (Waterston); Edinburgh (Edin^{r} (*sic*)), 1 specimen, 29.vii.04 (A. E. J. Carter); Tankerness (1 ♀), Pentland Skerries (1 ♂, 2 ♀), Kirkwall (1 ♀), Burwick (1 ♂, 1 ♀), all Orkney, no dates (J. Waterston); Balerno (Midlothian), 1 ♂, 2 ♀, 30.v.04 (P. H. Grimshaw); Roslin (Midlothian), 1 ♂, 3.vi.1899 (P. H. Grimshaw); Tayinloan, (Argyllshire) 1 ♀, 31.viii.09 (P. H. Grimshaw).

The following specimens were seen in the College of Agriculture collection, Edinburgh: 2 ♀ in Johnson-type suction trap at Milton Bridge (Midlothian), 12.ix.51 (*antea*, p. 609); 1 ♀ swept from grass on shore near high-water mark by E. C. Pelham-Clinton, 12.ix.51, Gullane (East Lothian).

In the British Museum there are specimens of *S. graminum* from Loch Assynt (Sutherland-shire), 2.vi.11 (J. W. Yerbury); Boat of Garten (Inverness-shire), v.34 (F. W. Edwards); Loch Callater (Aberdeenshire), 28.vii.37 (R. L. Coe); Auchindachy (Banffshire), 30.vi.36 (R. L. Coe); Loch Rannoch (Perthshire), 19.vi.35 (J. Smart); Ruaival (St Kilda), 10.viii.31 (D. L. Lack).

(ii), (iii) *Distribution, Numbers and Natural History.*—Although *S. graminum* is obviously widespread (text-fig. 9) and common, only 22 specimens (7 ♂, 15 ♀) have been taken during this survey, plus the 3 mentioned on p. 615:—1 ♂, 1 ♀ (dead), in old apple trap 3.iii.52 on the open Insh Isle, Firth of Lorne, all the others being taken in the Edinburgh district (1 ♂, in apple trap xii.51 in beech wood; 1 ♀, apparently sheltering from rain on the outside of a house window, 5.viii.52; and 1 ♀, on bracket fungus on low oak stump in the old oak park, May 1953, the rest being taken in a glasshouse or in windows of a house and of the fruit store during May to August inclusive and October). The adult is known to be active during the months of March to October inclusive and December.

Only 3 specimens were trapped at fermenting bait (apple) and then only during winter. *S. graminum* has a leaf-mining larva. [*Note added August 1953.* From larvæ mining leaves of chickweed (*Stellaria media* Vill.) in garden, Bonnyrigg (Midlothian), early July 1953, 5 ♂, 9 ♀ emerged the same month at natural temperature.]

22. *Scaptomyza trochanterata* Collin

This species has only recently been described from a series of both sexes taken by J. E. Collin at Kinrara, near Aviemore (Inverness-shire), on 9.vii.36, and a male was taken by J. W. Yerbury at Nairn on 25.v.04 (Collin, 1953). No other specimens are known.

23. *Scaptomyza griseola* (Zetterstedt)

The first specimen (a male) of this species was taken in Britain by Dr D. Sharp at Lockwood Oaks, Beattock (Dumfries), vii.07 (Collin, 1953). This is the only known Scottish example.

24. *Scaptomyza ? montana* Wheeler

S. montana was described in 1949 from America, and has been added recently to the British list by Collin (1953) from specimens swept by him from watercress. He has one Scottish specimen from Kinrara, near Aviemore, 9.vii.36 (in litt. 10.ix.53). Specimens were collected by me viii.53–ix.53 from watercress at Liberton (*antea*, p. 615), and the males agreed with Collin's specimens. I prefer to record these as ? *montana* until American specimens have been compared. The species should be looked for wherever watercress grows.

25. *Parascaptomyza disticha* (Duda)

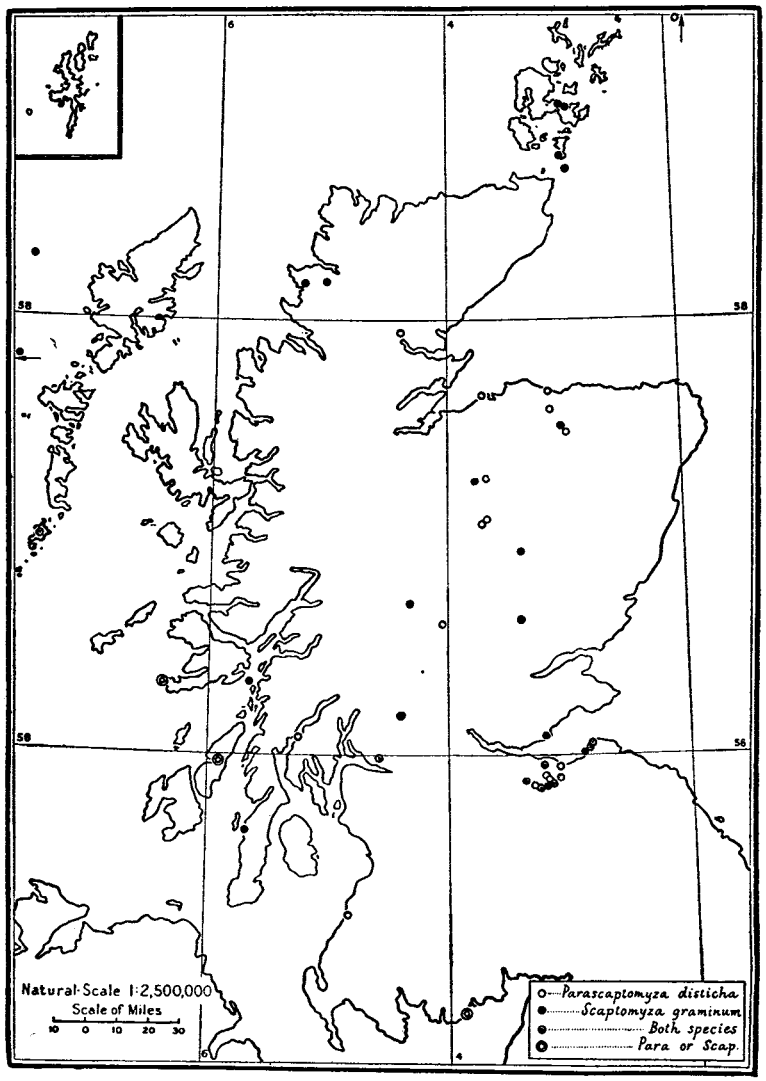
Note.—The confusion between this species and *Scapyomyza graminum* is mentioned under the latter species.

(i) *Previous Scottish Records and Specimens.*—*P. disticha* has not previously been recorded from Scotland as such, but it has been recorded under the name *Scaptomyza graminum* as follows: (1) Grimshaw (1906), 3 specimens, Fair Isles, ix.05. (2) Grimshaw (1905), 20 specimens, Flannan Isles, ix.04. (3) Yerbury (1913, 175), Lochinver, 13.vii.11, and Loch Assynt, 24.vii and 26.vii.11 (both Sutherland).

Records that refer either to this species or to *S. graminum* are given under the latter (*antea*, p. 647).

In the Royal Scottish Museum are the following 38 specimens of *P. disticha*. Most were labelled as *Scaptomyza graminum*, a few were under *S. flaveola* Mg., eight were unnamed in a spare box, and three had been correctly determined by R. L. Coe. Aberlady (East Lothian), 1 ♂, 25.viii.04 (P. H. Grimshaw) and 1 specimen 7.viii.05 (A. E. J. Carter); Musselburgh (Midlothian), 1 specimen, 24.viii.05 (A. E. J. Carter); Flannan Isles, 20 specimens, 6–21.ix.04

(W. E. Clarke); Bonhill (Dunbartonshire), 2 specimens, 8.vi.06 and v.08 (J. R. Malloch); Isle of Barra (Outer Hebrides), 2 ♂, 1 ♀, 17–28.viii.36 (Waterston); Fair Isle, 3 specimens, ix.05 (W. E. Clarke); Glencorse, 1 ♂, 8.ix.1898, Balerno, 2 ♂, 30.v.04, Braid Burn, 1 ♀, 23.vi.04, all Midlothian (P. H. Grimshaw); Edinburgh Botanic Garden, 2 ♀, v.04 (Waterston); and Aberdour (Fife), 1 ♀, 7.vii.04 (P. H. Grimshaw).



TEXT-FIG. 9.—Known distribution of *P. disticha* and *S. graminum*.

The following specimens have been seen in a collection at the College of Agriculture, Edinburgh: 4 ♂, 1 ♀ caught in the Johnson suction trap (*antea*, p. 609); 1 ♂, 1 ♀, 1.x.51, on outside of a lighted house window; 1 ♂, 20.ix.51, on ragwort flower (*Senecio jacobœa* L.), and 1 ♂, same date, on *Chrysanthemum segetum* L., all Lephinmore (Argyllshire); 3 ♀ swept from grass and sedge 12.ix.51, Gullane (East Lothian). Collected from both places by E. C. Pelham-Clinton.

In the British Museum (Natural History) are specimens from Lochinver (Sutherland), 13.vii.11 (J. W. Yerbury); Spey Bay, 7.vii.36, and Culbin Sands, 5.vii.36, both Morayshire (R. L. Coe); Ben Macdhui (on summit), 4296 ft., 13.vii.36, and Nethy Bridge (both Inverness-shire), 16.vii.36 (R. L. Coe); Loch Etchachan (Aberdeenshire), 3200 ft., 13.vii.36 (R. L. Coe);

Glen of Drumloch, near Fochabers (? Banffshire), 10.vii.36 (R. L. Coe); Den of Pitlurg (between Keith and Huntly, Aberdeenshire), 17.vii.36 (R. L. Coe); and Fortingal (Perthshire), 17.vi.35 (J. Smart).

(ii), (iii) *Distribution, Numbers and Natural History.*—The data given in the preceding section show that *P. disticha* is plentiful and very widespread (text-fig. 9), it occurring all over the mainland, to a height of over 4000 ft., and extending to the most remote islands. During this survey, however, only 24 specimens were first met with, in seven localities. In the Edinburgh district it occurred as follows: Bonnyrigg, 1 ♀, 26.iii.50, stuck to wet white paint in garden, but alive; 4 specimens, August 1950 and 1952, on marrow plant in garden, inside glasshouse, and inside cottage. Lasswade, 3 ♂, 1 ♀, 8.viii.52, by sweeping over Council refuse dump; 1 ♂, 1.viii.52, inside motor bus. Edinburgh, 2 ♂, 2 ♀, May–July 1952, in fruit store windows. Liberton estate, 5 specimens, 15.ix.50, in tomato glasshouse where the crop had just been cleared; 1 ♂, in apple trap exposed in beech-rhododendron belt 22.ii–1.iii.51. Dalkeith, 1 ♂, 1 ♀, in apple traps exposed in beechwood iii.52 and xii.51 respectively. Outside the Edinburgh area it was collected near Girvan (Ayrshire), 1 ♂, 5.ix.50, on inside of car windscreen; and at Invershin (Sutherlandshire), 1 ♀, 9.ix.51, the specimen flying into a cup of hot tea outdoors. 39 ♂, 54 ♀ more are mentioned earlier, p. 615.

P. disticha is an outdoor species, though not uncommon in various types of buildings and in motor vehicles. From the exceptional few that were found at baits, and these only during the cold months of the year, it is obvious that other methods than trapping have to be used to collect this species. Since it and *S. graminum* occur in the two Museum collections in greater numbers and are recorded more frequently than most other species of the family, and since these specimens were doubtless collected mainly by sweeping, this method would appear to be the one to adopt. This is supported by the results on p. 615. The Johnson suction trap has also given promising results (*antea*, p. 609).

Adults of *P. disticha* are probably active during every month of the year, but none has yet been found or recorded during the months of January, April, October and November.

(iv) *Laboratory Breeding.*—A female captured inside a house at Bonnyrigg 15.viii.50 was placed next day in a vial of Drosophila medium at 18° C. A copious stock was produced, which was carried through without difficulty to the ninth generation. The life cycle at 18° C. was about 20 days. The number of F1 progeny adults reared from the original female was 82.

26. *Chymomyza costata* (Zetterstedt)

(i) *Previous Scottish Records and Specimens.*—One male of *C. costata* was caught by Col. J. W. Yerbury at Nairn (Nairnshire) vii.05 (Collin, 1911, 231). Mr Collin (in litt.) has two males from Monifieth (Angus). It was recorded as Drosophilid species in Basden (1951). In the British Museum (Natural History) there are two specimens collected by F. W. Edwards from Glen Lyon (Perthshire), vi.31. In addition, 4 ♂, 4 ♀ were caught in the Johnson suction trap at Milton Bridge (Midlothian), 3–26.viii.51 inclusive (*antea*, p. 609).

(ii), (iii) *Distribution, Numbers and Natural History.*—Only three specimens, all females, have been obtained during this survey. One, ix.51, at plum trap in a very much thinned-out deciduous wood near Coldbackie (north Sutherlandshire); another in window of the fruit store, Edinburgh, 7.vii.52; and the third specimen in an apple trap near cow byre of small farm, Dalmarnock (Perthshire), viii.52.

The distribution of *C. costata* (text-fig. 8) is well scattered over the mainland, but the species appears to be rarely met with in Scotland. The Johnson type suction trap seems to

be a successful means of obtaining it. It is obviously not much attracted to fermenting fruit baits. Wheeler (1952, 173) says that adults of some American species of the genus are found on peeled trunks of aspen, alder, fir and pine. The adults have been found in Scotland only during the months of June to September inclusive.

27. *Chymomyza distincta* Egger

This species was not obtained during the survey, but I have a male and female caught in cop by Mr E. C. Pelham-Clinton at a sappy birch stump, 30.ix.51, Port Appin (Argyllshire). This is a new record for Scotland. Collin (1952, 197) discusses the synonymy of this species.

28. *Amiota alboguttata* (Wahlberg)

(i) *Previous Scottish Records and Specimens.*—The only record of *A. alboguttata* from Scotland is that of Yerbury (1913, 174), as *Phortica alboguttata*, viz. one specimen swept in the enclosure of Glen Canisp Lodge, Lochinver (Sutherlandshire), 3.vii.11. He mentions that the only other British record to date (Collin, 1911, 230) was that of two specimens taken by himself in the New Forest in (September) 1909, flying round a Cossus-infested oak tree. Mr J. E. Collin tells me (*in litt.* 24.iv.52) that he has taken it not uncommonly by sweeping in the Spey Valley (Inverness-shire) and it is the only species of the genus he has seen from Scotland.

(ii), (iii) *Distribution, Numbers and Natural History.*—A total of 163 specimens of *A. alboguttata* has been obtained during this survey, all in woods on the Dalkeith estate (Midlothian). The species was not encountered until apple traps were placed high in trees in 1952. It has been trapped at heights ranging from 27 to 52 ft. in two mature oaks and one mature sweet-chestnut quite 60 ft. tall, but not in a young 48-foot tall beech tree. Only one fly was found below 27 ft., in an apple trap on the ground in a long narrow beech wood. Although it would appear to be generally a tree-top species, the one specimen from the ground and the experiences of Yerbury and Collin above show that it does occur low down.

The majority of my specimens, up to 31.viii.52, have been trapped in the old oak park, the first specimen being in a trap exposed there 11–18.iv.52. There was a definite increase in numbers during August, even though fewer traps were out than previously. The large numbers doubtless continued into September, though these specimens have not yet been examined. The sex ratio of wild-trapped specimens was nearly unity (78 ♂ : 83 ♀) (Table III).

No attempt has been made to rear this species from the apple trap-bait or to breed it in the laboratory.

V. Summary

1. A survey of the family Drosophilidæ in Scotland was started March 1950 and continued to the end of August 1952, special attention being paid to the genus *Drosophila*. The methods used for the collecting of flies are described, the most practicable being trap bottles baited with fermenting apple.

2. The species frequenting the various types of habitats and those associated with natural foods are discussed. The most species have been found in deciduous woods and the fewest in the more open areas. Towns and villages are also very productive of species. Members of the family occur in every part of Scotland. Fungi, tree saps, and certain decaying vegetables and fruits may be the most important natural breeding sites.

3. Records of the previously known 14 species of Drosophilidæ from Scotland and the data from specimens in some collections are included.

4. A total of 28 species is now known from Scotland, this being two-thirds of the whole British total. Twenty-five species were collected during the present survey. A descriptive key to the 28 species is given and the synonymy of some species is discussed. (The total is 29 species, see Addendum, p. 652.)

5. The new species, *Drosophila silvestris*, is here described; *D. ananassæ* Dol. is recorded for the first time from Europe; and *D. littoralis* Mg., *Scaptomyza ? montana* Wheel., and *Chymomyza distincta* Egg. are here first recorded from Scotland.

6. The distribution, abundance and natural history of each species in Scotland are discussed, as well as the breeding of the species in the laboratory. The most abundant and widespread species outdoors throughout the year are *D. subobscura* Coll. and *D. obscura* Fall., and the most abundant indoors are *D. funebris* (Fabr.) and *D. melanogaster* Mg., the last one not over-wintering in Scotland.

VI. Acknowledgments

It is a pleasure to thank Professor C. H. Waddington, F.R.S., for his support during the work and for approving that the two major collecting trips be undertaken, without which our knowledge of species distribution and habitat preferences would have remained extremely limited. Mr G. R. Knight helped on these trips. Mr J. E. Collin has given much unstinted help and mature advice on the systematics of various species, which has been very much appreciated. In this same field I was fortunate to have the help of Mr R. L. Coe respecting the specimens in the collections of the British Museum (Natural History), of Professor J. T. Patterson, University of Texas, for kindly confirming my identification of *Drosophila ananassæ* Dol., and of Dr H. Burla, Munich (now in Brazil), for confirming that no *D. bifasciata* Pom. were amongst Scottish specimens of *D. obscura* Fall. and that his "*obscura* X" was identical with *D. silvestris* n.sp. Dr A. C. Stephen kindly gave me facilities for studying the specimens and records of Drosophilidæ in the Royal Scottish Museum, Edinburgh. Dr Joan F. Basden has helped in many ways throughout. Collecting methods and experimental procedure were perfected, and the great majority of specimens were caught on private premises in the Edinburgh district. The initial work was carried out on the Liberton estate, permission being obtained from Captain H. R. Trotter. The later and greater quantity of work was conducted and is still continuing on the Dalkeith estate, by courtesy of His Grace The Duke of Buccleuch, and I wish to thank Mr A. Martin, Secretary, and Mr W. Mowat, Head Forester, for their helpful co-operation at all times. Mr W. Rankin gave permission for the collecting of Drosophilidæ in his fruit-vegetable store and banana-ripening store in Edinburgh. Some trapping for *Drosophila* was done on runway intersections of Kirknewton Aerodrome by permission of Flight-Lieutenant Taylor. I am grateful to Messrs John Bartholomew & Son, Ltd., Edinburgh, for permission to photograph a copy of their General Map of Scotland to help in the plotting of species distribution. Also to Messrs W. & A. K. Johnston, Ltd., Edinburgh, for permission to use their outline map of Scotland for the same purpose. Miss Sheila C. Sinclair and Mr Alan A. Spence in turn have helped efficiently with the technical work. I am pleased to acknowledge the help of Miss S. Dare-Delaney with the preparation of the manuscript, of Mr E. D. Roberts for the distribution maps, and of Mr D. W. M. Pinkney and Mr A. Graham for the photographs. Many other people have helped in various ways, and they are mentioned in the appropriate places in the text or in the key-list to text-fig. 1.

VII. Addendum: March 27, 1954

Species No. 29. *Stegana coleoptrata* (Scopoli) Professor O. W. Richards has 6 ♂, 4 ♀ of this species caught 8.vii.53 at Beinn Eighe, Kinlochewe (Ross-shire). They were on a dead fallen birch tree on which were a lot of the fungus, *Stereum* sp. The specimens are referable to the var. *strobli* Mik. In the key to species they run to couplet 24 (p. 621) but differ from *Amiota alboguttata* and *Chymomyza* spp. as follows:

The uppermost of the 3 strong orbital bristles is on a level with lowest ocellus, the mid orbital being the shortest. Arista forked at end and with 6 or 7 long branches both above and below. Wings wholly smoky brown, especially in costal region. A distinct basal X-vein separates 2nd basal and discal cells. Front of head and dorsum of thorax shining black, with a pale brown stripe through wing bases from humeri, and a sooty black stripe across top of pleura. No milk-white blotches. Legs light brown, with femora and tibiæ darkened distally and proximally respectively. Tarsal joints short as in *Amiota*. Body length 3–4 mm.

VIII. REFERENCES TO LITERATURE

Austen, E. E., 1905. "A dipterous enemy of English hothouse grapes", *Ent. Mon. Mag.*, **41,** 276–278.

Basden, E. B., 1951. "*Drosophila* in Scotland", *Drosophila Inform. Service*, **25,** 99.

——, 1952. "Some Drosophilidæ (Diptera) of the British Isles", *Ent. Mon. Mag.*, **88,** 200–201.

——, 1953. "The Autumn Flush of *Drosophila* (Diptera)", *Nature, Lond.*, **172** (4390), 1155–1156.

—— (in press). "Diapause in *Drosophila* (Diptera, Drosophilidæ)", *Proc. R. Ent. Soc. Lond.*, (1954).

Bertani, G., 1947. "Artificial 'breaking' of the diapause in *Drosophila nitens*", *Nature*, Lond., **159,** 309.

Burla, H., 1948. "Die Gattung *Drosophila* in der Schweiz", *Rev. Suisse Zool.*, **55,** 272–279.

——, 1951. "Systematik, Verbreitung und Oekologie der *Drosophila*—Arten der Schweiz", *Rev. Suisse Zool.*, **58,** 23–175.

Buzzati-Traverso, A., 1943. "Morfologia, Citologia e Biologia di due nuove specie di *Drosophila* (Diptera Acalyptera)", *R. C. Ist. Lombardo*, **77,** (1), 1–13.

——, 1948. "Larvæ of *D. subobscura* found in nature", *Drosophila Inform. Service*, **22,** 69.

Cain, A. J., Collin, J. E., and Demerec, V. R., 1952. "Correct application of the name *Drosophila obscura* Fallén and notes on the type of *D. tristis* Fallén (Dipt., Drosophilidæ)", *Ent. Mon. Mag.*, **88,** 193–196.

Carson, H. L., 1951. "Breeding sites of *Drosophila pseudoobscura* and *Drosophila persimilis* in the transition zone of the Sierra Nevada", *Evolution*, **5,** 91–96.

——, 1952. "Contrasting types of population structure in *Drosophila*", *Amer. Nat.*, **86,** 239–248.

Carson, H. L., and Stalker, H. D., 1951. "Natural breeding sites for some wild species of *Drosophila* in the eastern United States", *Ecology*, **32,** 317–330.

Carter, A. E. J., 1914. "Perthshire Diptera—Aberfoyle district", *Trans. Perthshire Soc. Nat. Sci.*, **5,** 176–181.

Coe, R. L., 1943. "*Drosophila repleta* Wollaston (Dipt., Drosophilidæ) new to Britain, with notes on the species and some account of its breeding-habits", *Ent. Mon. Mag.*, **79** (952), 204–207.

Collin, J. E., 1910–1911. "Additions and corrections to the British List of Musidæ Acalyptratæ", *Ent. Mon. Mag.*, **46,** 47–, to **47,** –256 (discontinuous pagination); (Drosophilidæ, 1911, **47,** 230–231).

——, 1936. "Note. *Drosophila subobscura* sp. n. ♂♀", p. 60. In Gordon, C., "The frequency of heterozygosis in free-living populations of *Drosophila melanogaster* and *Drosophila subobscura*", *J. Genet.*, **33,** 25–60.

——, 1952. "Notes on some Drosophilidæ (Dipt.), including five additional British species, two of them new to science", *Ent. Mon. Mag.*, **88,** 197–199.

——, 1953. "On the British species of *Scaptomyza* Hardy and *Parascaptomyza* Duda (Diptera, Drosophilidæ)", *Entomologist*, **86,** 148–151.

Colyer, C. N., 1951. "A note on *Drosophila repleta* Wollaston (Dipt., Drosophilidæ)", *Ent. Rec.*, **63,** (12), 306.

da Cunha, A. B., Dobzhansky, Th., and Sokoloff, A., 1951. "On food preferences of sympatric species of *Drosophila*", *Evolution*, **5,** (2), 97–101.

Dicker, G. H. L., 1939. "Insects associated with cultivated forms of Rubus", *Trans. Soc. Brit. Ent.*, **6,** 115–136.

Dobzhansky, Th., and Epling, C., 1944. "Taxonomy, geographic distribution and ecology of *Drosophila pseudoobscura* and its relatives", *Carnegie Inst. Wash. Publ.*, No. 554, 1–46.

Duda, O., 1934–1935. "Drosophilidæ". In Lindner, E., 1938. "Die Fliegen der Palæarktischen Region", **6,** 58g, 1–64 (1934) and 65–118 (1935).

Edwards, F. W., and Collin, J. E., 1932. "A revised list of the Diptera of St Kilda", *Ent. Mon. Mag.*, **68,** 263–266.

Evans, W., and Grimshaw, P. H., 1916. "Notes on insects captured in the Island of Raasay", *Scot. Nat.*, No. 60, 299–300.

Fenton, E. W., 1941. "The Oak in Scotland, and two semi-natural oak woods in the south-east of Scotland", *Forestry*, **15,** 76–85.

Fox-Wilson, G., 1926. "Insect visitors to sap-exudations of trees", *Trans. Ent. Soc. Lond.*, **74,** 243–254.

Friend, H., 1927. "A new raspberry pest", *Gardeners' Chron.*, **82** (3rd Ser.), 331–332.

Gordon, C., 1942. "Natural breeding sites of *Drosophila obscura*", *Nature*, Lond., **149,** 499.

Grimshaw, P. H., 1904. "Diptera Scotica. III. The Forth district", *Ann. Scot. Nat. Hist.*, Nos. 49 and 50, 26–33, 98–102.

——, 1905*a*. "Diptera Scotica. IV. Orkney and Shetland", *Ann. Scot. Nat. Hist.*, No. 53, 22–35.

GRIMSHAW, P. H., 1905*b*. "On the Diptera of the Flannan Islands", *Ann. Scot. Nat. Hist.*, No. 56, 218–220.
——, 1906. "The Diptera of Fair Isle", *Ann. Scot. Nat. Hist.*, No. 60, 207–209.
——, 1907. "On the Diptera of St Kilda", *Ann. Scot. Nat. Hist.*, No. 63, 150–158.
——, 1916. "Diptera Scotica. VI. The Western Isles", *Scot. Nat.*, No. 54, 134–138.
HADORN, E., BURLA, H., GLOOR, H., and ERNST, F., 1952. "Beitrag zur Kenntnis der *Drosophila*-Fauna von Südwest-Europa", *Z. indukt. Abstam. Vererbungs.*, **84**, 133–163.
HAINES, F. H., 1936. "List of insects found near Aviemore, Inverness-shire, from June 20th to July 2nd, 1933", *J. Soc. Brit. Ent.*, **1**, 131–141.
HARDY, J., 1848. "On insects injurious to the turnip crop. Note E. Dipterous insects injurious to the Turnip", *Hist. Berwicks. Nat. Club*, **2**, 317–339.
——, 1849. "Notes on the remedies for the turnip-fly amongst the Ancients, and on the turnip-fly of New Holland, with a notice of a new genus and species of Diptera", *Hist. Berwicks. Nat. Club*, **2**, 359–362.
HENDERSON, R., 1911. "The Diptera of Clyde (Third List)", *Trans. Nat. Hist. Soc. Glasg.*, **8** (n.s.), 156–173.
HERTING, B., 1953. "Revision zweier europäischer *Drosophila*—Arten", *Beitr. Ent.*, **3** (1–2), 166–168.
HILL, A. R., 1952. "A survey of insects associated with cultivated raspberries in the East of Scotland", *Ent. Mon. Mag.*, **88**, 51–62.
HSU, T. C., 1949. "The external genital apparatus of male Drosophilidæ in relation to systematics", *Univ. Texas Publ.*, No. 4920, 80–142.
JOHNSON, C. G., 1950. "A suction trap for small airborne insects which automatically segregates the catch into successive hourly samples", *Ann. Appl. Biol.*, **37**, 80–91.
LAMB, C. G., 1914. "The Percy Sladen Trust Expedition. No. XV. Diptera: Heteroneuridæ, Ortalidæ, Trypetidæ, Sepsidæ, Micropezidæ, Drosophilidæ, Geomyzidæ, Milichidæ", *Trans. Linn. Soc. Lond.*, 2nd Ser. (Zool.), **16**, 307–372.
LAURENCE, B. R., 1953. "Some Diptera bred from cow dung", *Ent. Mon. Mag.*, **89**, 281–283.
LEVER, J., and SOBELS, F. H., 1951. "Some remarks on the occurrence of the genus *Drosophila* in the Netherlands", *K. Nederlands Akad. Wet., Proc.* (Ser. C), **54**, 84–88.
MAINX, F., KOSKE, TH., and SMITAL, E., 1953. "Untersuchungen über die chromosomale Struktur europäischer Vertreter der *Drosophila obscura*—Gruppe", *Z. indukt. Abstam. Vererbungs.*, **85** (3), 354–372.
MARTIN, I. H., 1934. *The Field-Club of the Lothians*, William Blackwood & Sons, Ltd., Edinburgh, pp. xix + 318.
MCFADDEN, E. T., 1914. "A fruit fly from fungi", *J. Ent. and Zool. Claremont*, **6**, 50.
MURRAY, J., 1935. "Diptera in Dumfriesshire", *Entomologist*, **68**, 42.
PATTERSON, J. T., 1943. "The Drosophilidæ of the Southwest", *Univ. Texas Publ.*, No. 4313, 7–216.
PATTERSON, J. T., and MAINLAND, G. B., 1944. "The Drosophilidæ of Mexico", *Univ. Texas Publ.*, No. 4445, 1–101.
PATTERSON, J. T., and STONE, W. S., 1952. *Evolution in the genus* Drosophila. Macmillan Co., New York, 610 pp.
POMINI, F. P., 1940. "Contributi alla conoscenza delle *Drosophila* (Diptera Acalyptera) europee", *Boll. Ent. Bologna*, **12**, 145–164.
RICHARDS, O. W., and HERFORD, G. V. B., 1930. "Insects found associated with cacao, spices and dried fruits in London warehouses", *Ann. Appl. Biol.*, **17** (2), 367–395.
SMART, J., 1945. "*Drosophila subobscura* Collin: descriptive notes on the species, with comments on its nomenclatoral status (Diptera)", *Proc. Roy. Ent. Soc. Lond.* (B), **14**, 53–56.
SPENCER, W. P., 1942. "New species in the Quinaria group of the subgenus Drosophila", *Univ. Texas Publ.*, No. 4213, 53–66.
——, 1950. *Collection and Laboratory Culture*, pp. 535–590. In DEMEREC, M., *The Biology of Drosophila*, John Wiley & Sons Inc., New York.
STURTEVANT, A. H., 1921. "The North American species of *Drosophila*", *Carnegie Inst. Washington Publ.*, No. 301, pp. iv + 150.
——, 1942. "The classification of the genus *Drosophila*, with descriptions of nine new species", *Univ. Texas Publ.*, No. 4213, 5–51.
TAYLOR, L. R., 1951. "An improved suction trap for insects", *Ann. Appl. Biol.*, **38**, 582–591.
WALKER, F., 1853–1856. *Insecta Britannica Diptera*, 3 vols., London. (Drosophilidæ, Vol. **2**, 236–239; **3**, xiv.)
WHEELER, M. R., 1952. "The Drosophilidæ of the Nearctic Region, exclusive of the genus *Drosophila*", *Univ. Texas Publ.*, No. 5204, 162–218.
WHITFIELD, F. G. S., 1939. "Air transport, insects and disease", *Bull. Ent. Res.*, **30**, 365–442.
WILLIAMS, D. D., 1953. "A simple *Drosophila* trap for wet weather collecting", *Bull. Brooklyn Ent. Soc.*, **48**, (1), 24–25.
WILLIAMS, D. D., and MILLER, D. D., 1952. "A report on *Drosophila* collections in Nebraska", *Bull. Univ. Nebraska State Mus.*, **3**, 1–19.
WILLIS, J. C., and BURKILL, I. H., 1895. "Flowers and insects in Great Britain, Part I", *Ann. Bot.*, **9**, 227–273.
YERBURY, J. W., 1913. "A list of the Diptera met with in Wester Ross, with notes on other species known to occur in the neighbouring areas", *Scot. Nat.*, No. 20, 173–177.

Index to Species.

E.B. Basden 1954. The distribution and biology of Drosophilidae (Diptera) in Scotland, including a new species of Drosophila. Tr. Roy. Soc. Edin., 62, part III, No. 15: 603-654.

---

1. The main entry for a species is underlined.
2. Some species may be mentioned more than once on a page.
3. All Scottish species (total specimens) are also listed p. 616 (Table III).
4. Synonyms are in brackets.

E. B. BASDEN, "The Distribution and Biology of Drosophilidæ (Diptera) in Scotland, including a New Species of *Drosophila*".—PLATE I.

Fig. *a*. Baited trap bottles, showing inverted trap top (centre) and gauze hood (right).
Fig. *b*. Culture parent jar of *D. silvestris* Bas., with (left to right) honey, larval food pot, and wet pad.
Fig. *c*. Cultures of *D. ambigua* Pom. (left) and of *D. subobscura* Coll. (right) to show difference of pupation sites.
Fig. *d*. Trap bottles exposed, showing the two types of shelter.

E. B. BASDEN, "The Distribution and Biology of Drosophilidæ (Diptera) in Scotland, including a New Species of *Drosophila*".—PLATE II.

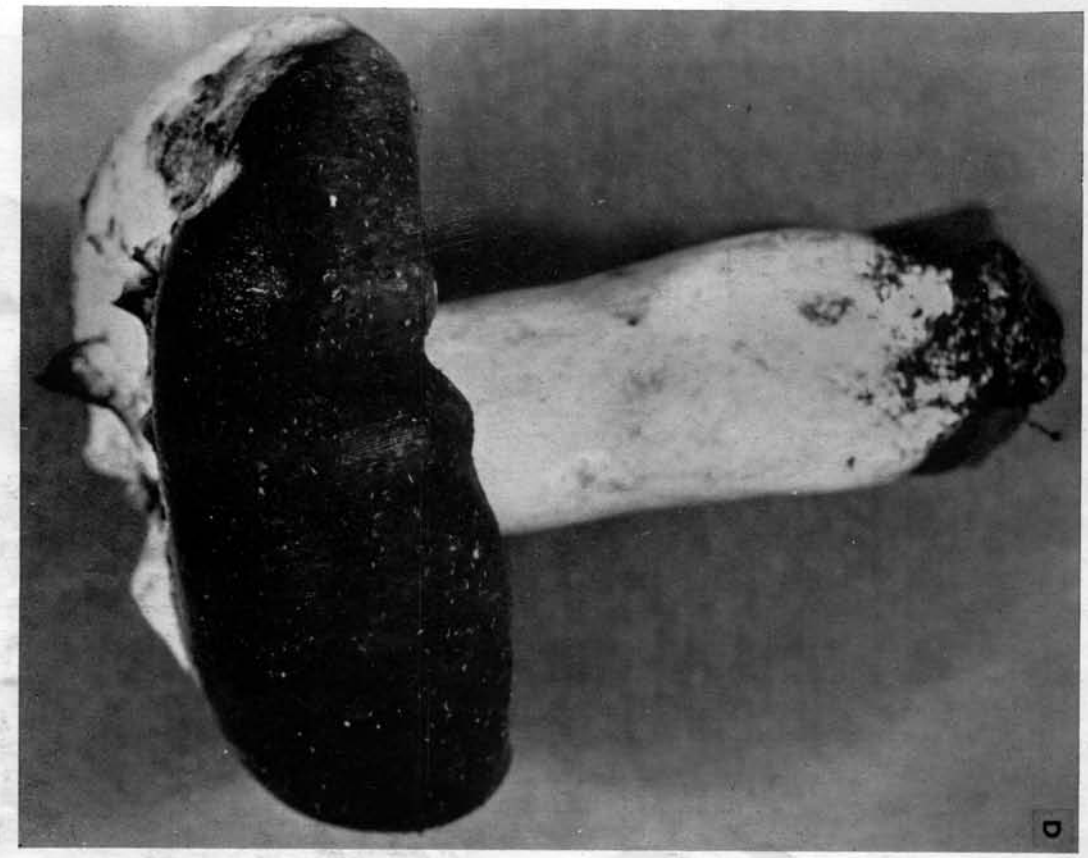


Fig. *a*. Toadstool (*Russula cyanoxantha* Fries.) with eggs of *D. phalerata* Mg. and *D. cameraria* Hal. inserted round lower part of pileus. Liberton estate.
Fig. *b*. Part of the old oak park ("Old Wood"), Dalkeith. (*By courtesy of His Grace The Duke of Buccleuch.*)