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REPORT TO THE NATURE CONSERVANCY COUNCIL
ON
THE INVERTEBRATE FAUNA OF DUNE AND MACHAIR SITES
IN SCOTLAND

Vol I

Introduction, Methods and Analysis of Data

(63 maps, 21 figures, 15 tables, 10 appendices)

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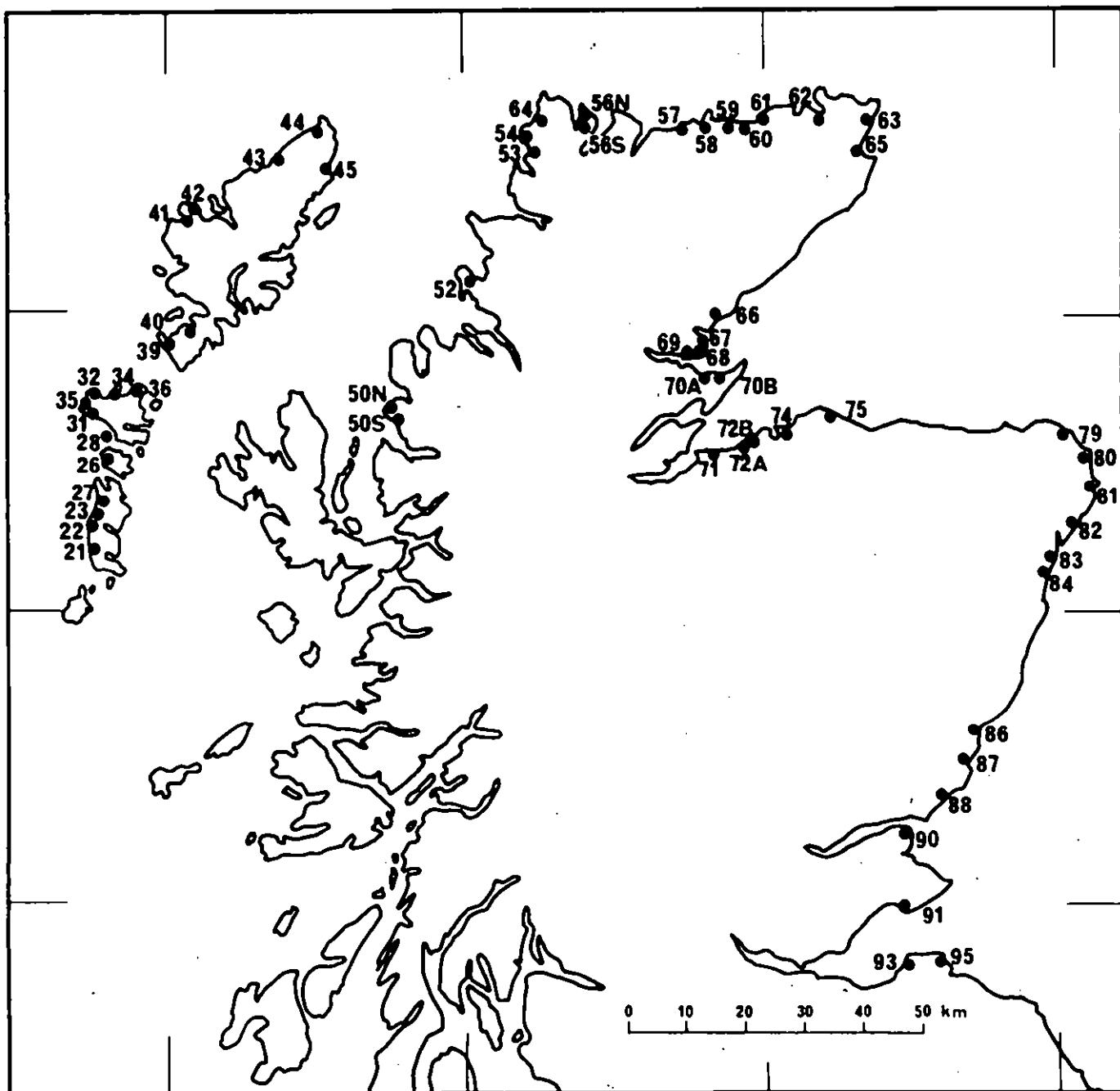
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- Appendix 10 List of species of Lepidoptera recorded at only one site or from sites within one Region.



MAP 1. DISTRIBUTION OF NUMBERED SITES INCLUDED IN
THE INVERTEBRATE SURVEY
(see table 1 for site names)

Table 1 - List of site names and numbers agreed with the Nature Conservancy Council including grid references of locations of light traps.

Outer Hebrides

Number	Name	NGR
21	DALIBURGH	08/7222
22	ORMICLATE	08/7332
23	HOWBEG	08/7436
26	BORVE	08/7749
27	STILLIGARRY (SOUTH)	08/7536
28	BALESHARE	08/7958
31	PAIBLE	08/7266
32	HOSTA	08/7172
34	LEATHANN	08/8076
35	BALRANALD	08/7069
36	ROBACH	08/8776
39	NORTHTON	08/9891
40	LUSKENTYRE	18/0698
41	UIG	19/0432
42	VALTOS	19/1035
43	BARVAS	19/3451
44	EOROPIE	19/5164
45	TOLSTA	19/5349

North Coast

50S	RED POINT - SOUTH	18/7367
50N	RED POINT - NORTH	18/7268
52	ACHNAHAIRD	29/0113
53	OLDSHORE MORE	29/2058
54	SHEIGRA	29/1859
56S	FARAID HEAD - SOUTH	29/3968
56N	FARAID HEAD - NORTH	29/3870
57	BETTYHILL	29/6861
58	FARR BAY	29/7162
59	STRATHY	29/8365
60	MELVICH	29/8864
61	REAY	29/9665
62	DUNNET	39/2169

Number	Name	NGR
63	FRESWICK	39/3767
64	SANDWOOD	29/2164
65	SINCLAIRS BAY	39/3358

Moray Firth

66	FERRY LINKS	28/8196
67	COUL LINKS	28/8195
68	DORNOCH	28/8087
69	CLASHMORE	28/7486
70A	MORRICH MORE 1	28/8184
70B	MORRICH MORE 2	28/8184
71	WHITENESS	28/8158
72A	CULBIN BAR 1	28/9260
72B	CULBIN BAR 2	28/9964
74	FINDHORN	38/0564
75	LOSSIEMOUTH	38/2668

East Coast

79	FRASERBURGH	48/0264
80	STRATHBEG	48/0759
81	ST. FERGUS	48/1053
82	CRUDEN BAY	48/0835
83	FORVIE	43/0328
84	DON TO YTHAN	38/9922
86	ST. CYRUS AND MONTROSE LINKS	37/7463
87	LUNAN BAY	37/6850
88	ARBROATH	37/6138
90	TENTSMUIR	37/5026
91	DUMBARNIE	37/4401
93	GULLANE	36/4984
95	TYNINGHAME	36/6281

1. INTRODUCTION

The work described in this Report was commissioned by the Nature Conservancy Council to assess the scientific interest of the invertebrate faunas associated with the same range of Scottish dune systems studied by Institute of Terrestrial Ecology botanists from 1975 to 1977 (N.E.R.C./N.C.C. Contract no. HF3/03/61 Sept. 1978). The Scottish Coastal Survey was first planned as a botanical exercise to provide the N.C.C. with information on the conservation importance of particular sites in relation to the future demands of industrial development in connection with the exploitation of North Sea oil. Dunes, saltmarshes and shingle formations were included but when it was decided, a year later, to extend the survey by carrying out a zoological study of selected invertebrate groups, the work was confined to dune systems because comparisons are easier between relatively similar habitats. Most of the zoological field work was done during June and July 1976 but 11 sites (situated around the Moray Firth) were surveyed in June/July 1977.

The botanical study included 94 sites on the east, north and west coasts of mainland Scotland together with the Inner and Outer Hebrides, Orkney and Shetland. After consultation with the N.C.C. the zoological work was confined to 58 sampling areas (54 sites) including four localities where two trapping stations were established. These were Red Point, (Site 50, north and south), Faraid Head, (Site 56, north and south), Morrich More, (Site 70, A and B) and Culbin Bar, (Site 72, A and B) (table 1 and map 1). The 54 sites fall naturally into four geographical regions. The Outer Hebrides, North Coast, East Coast (part) and Moray Firth. For each a Survey Team of 2 people was organised and during 1976 they worked simultaneously on the first three regions. The fourth team surveyed the 11 Moray Firth sites in 1977, approximately during the same season of the year.

A summary of the weather characteristics recorded during the sampling periods appears later in this report. Generally speaking it was wetter and windier on the west coast than on the north or the east but this is probably a normal characteristic of the differences between these geographical regions. The unusual drought conditions of 1976 compared with the more "normal" year of 1977 must be borne in mind when assessing the faunal characteristics of the Moray Firth sites in relation to those on the rest of the east coast. There was no summer drought in the Outer Hebrides in 1976.

Standard names of sites were adopted by both botanists and zoologists and have been used in this report to maintain uniformity (table 1). This makes cross-reference easier for the reader who wishes to consult both botanical and zoological site reports. The 58 individual site dossiers are included in volume II of this report (February 1979), part 1 Outer Hebrides, part 2 North Coast, part 3 Moray Firth and part 4 East Coast. Each dossier is provided with a map showing trapping location, descriptions of vegetation adjacent to pitfall and light traps and brief accounts of each invertebrate group together with a species list. General descriptive material about the site as a whole is not included because this is dealt with in the botanical site dossiers.

The botanical report (N.E.R.C./N.C.C. contract no. HF3/03/61 Scottish Coastal Survey: A report on Selected Soft Coast Sites in Scotland. Sept. 1978) on the classification of sites and vegetation types has been consulted in the following account where it is relevant to the interpretation of the results.

2. OBJECTIVES

The objectives defined in the Project Plan were:-

- (i) To provide information which together with the botanical data, (I.T.E.) Project 340), will form the basis for conservation evaluation of individual sites, and groups of sites, on sand dune formations and machair along the east, north and west coast of Scotland including the Outer Hebrides.
- (ii) To extend the existing knowledge of the occurrence and distribution of Lepidoptera, Carabidae and Araneae on Scottish sand dunes. (This objective was modified during later consultation with the Nature Conservancy Council to include all Coleoptera, the terrestrial Isopoda, Mollusca (Land snails) and Diplopoda).
- (iii) To assess the validity and practicability of extensive "quick" survey for groups of widely separated sites in logistically difficult situations.

3. METHODOLOGY

Extensive zoological surveys in which it is planned to sample simultaneously as many as 47 sites during one season posed problems in not only standardising the sampling procedure but also ensuring that the selection of sites in the field and the operation of the one light trap and 8 pitfall traps per site (see Section 3.2) varied as little as possible. Simultaneous

trapping was necessary to establish comparability between the results from different sites. In order to achieve synchrony the three (1976) teams covering the Outer Hebrides, North Coast and East Coast regions planned their travelling schedules, siting of traps and collection of catch so that variation between operating periods was reduced as far as possible.

However several other factors probably caused local variations in the catching efficiency of the traps. These are described in later sections but can be listed as:-

- (a) Mechanical failure of light trap mechanism.
- (b) Variation in the operating efficiency of the batteries for the light trap.
- (c) Vandalism causing destruction or damage to light and pitfall traps.
- (d) Differing weather conditions from one part of the coast to another affecting the traps, particularly wind, rain, light or dark nights depending on cloud cover.
- (e) Small mammals in pitfall traps reducing catching efficiency yet attracting certain species (e.g. carrion beetles) selectively.
- (f) Sand blow or rabbit disturbance to pitfall traps.
- (g) Habitat and topographical differences between trapping sites.
- (h) Seasonal differences between the 47 sites sampled in 1976 and the 11 sites (Moray Firth area) sampled in 1977.

3.1 Invertebrate groups studied

The selection of invertebrates for study was determined by, (i) those groups which would provide the most useful information for site assessment, (ii) the expertise available for identifying the catch and (iii) those invertebrates most easily taken by the use of light and pitfall traps. The Macrolepidoptera (larger night-flying moths), Carabidae (ground beetles) and Araneae (spiders) met these criteria most readily. The moths were easily attracted to an ultra-violet light and the last two groups include many species which move actively over the ground surface and fall into pitfall traps. It was also agreed at a later stage that all other families of Coleoptera, terrestrial Isopoda, Mollusca (land snails) and Diplopoda should be included. The first group was likely to include a large number of species but expertise to determine them was available in the Institute as it was for the determination of terrestrial Isopoda and land snails (both groups with few species) and arrangements could be made to determine the Diplopoda with outside help. Sight records of butterflies were also listed.

3.2 Description of traps, siting and operating efficiency.

Each pitfall trap consisted of a plastic beaker measuring 7 cm diameter across the open end by 10.5 cm deep. Two drainage holes were pierced at 7.5 cm from the bottom and after being sunk into the sand so that the rim was at ground level, the trap was $\frac{1}{3}$ filled with preservative. Full-strength ethylene glycol was used because it is odourless, both kills and preserves and is still effective when reduced to a 20% solution by dilution with rainwater.

At the end of each trapping period the contents were poured into a second beaker with a screw-top for transport to Monks Wood Experimental Station where 90% alcohol was added to ensure adequate preservation until the catch could be sorted and determined.

The pitfall traps were grouped within a fairly confined area on the dunes, usually in association with the light trap which had to be sited where it was relatively inconspicuous (see below). After the Survey Team had selected the trapping location the pitfall traps were arranged in pairs, each member of which was situated two metres or more from the other. In many instances the four pairs were arranged at the corners of a square having a diagonal of 15-20 m with the light trap in the middle. In other cases it was possible to place the traps along a transect of 60-70 m or even more (see site dossiers, volume II), particularly on some East Coast sites.

Within the limited trapping area the pitfalls were sited to sample the greatest range of habitat diversity. However much could not be included, for example the fore dune and yellow dune stages (fig. 1) because traps situated in mobile sand soon become filled by wind action and are made inoperative. Within the range of animal habitats shown in fig. 1 the traps were most often situated in what is described as the "marram transition zone", that is, the landward side of the main dune ridge where marram grass gives way to a more diverse mixed vegetation. In some instances this zone covered a wide area and was rich in plants and animals while in other cases, depending on the locality and substrate, the marram dunes flattened out rapidly to form a uniform dune meadow so that the transition zone was relatively narrow. Colour slides are available which show the range of habitat diversity on each site and the position of most pitfall trap pairs. The considerable differences in floristics and vegetation structure between sites and regions probably had a marked influence on the fauna recorded in the traps. Some examples are described in the sections dealing with the different invertebrate groups.

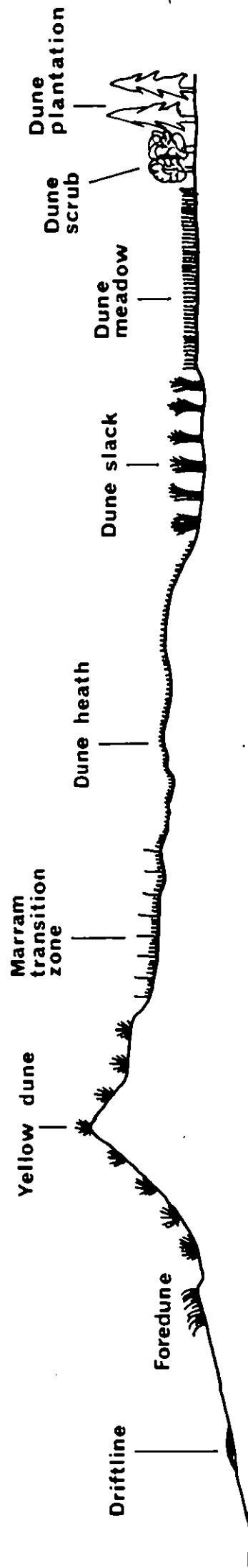
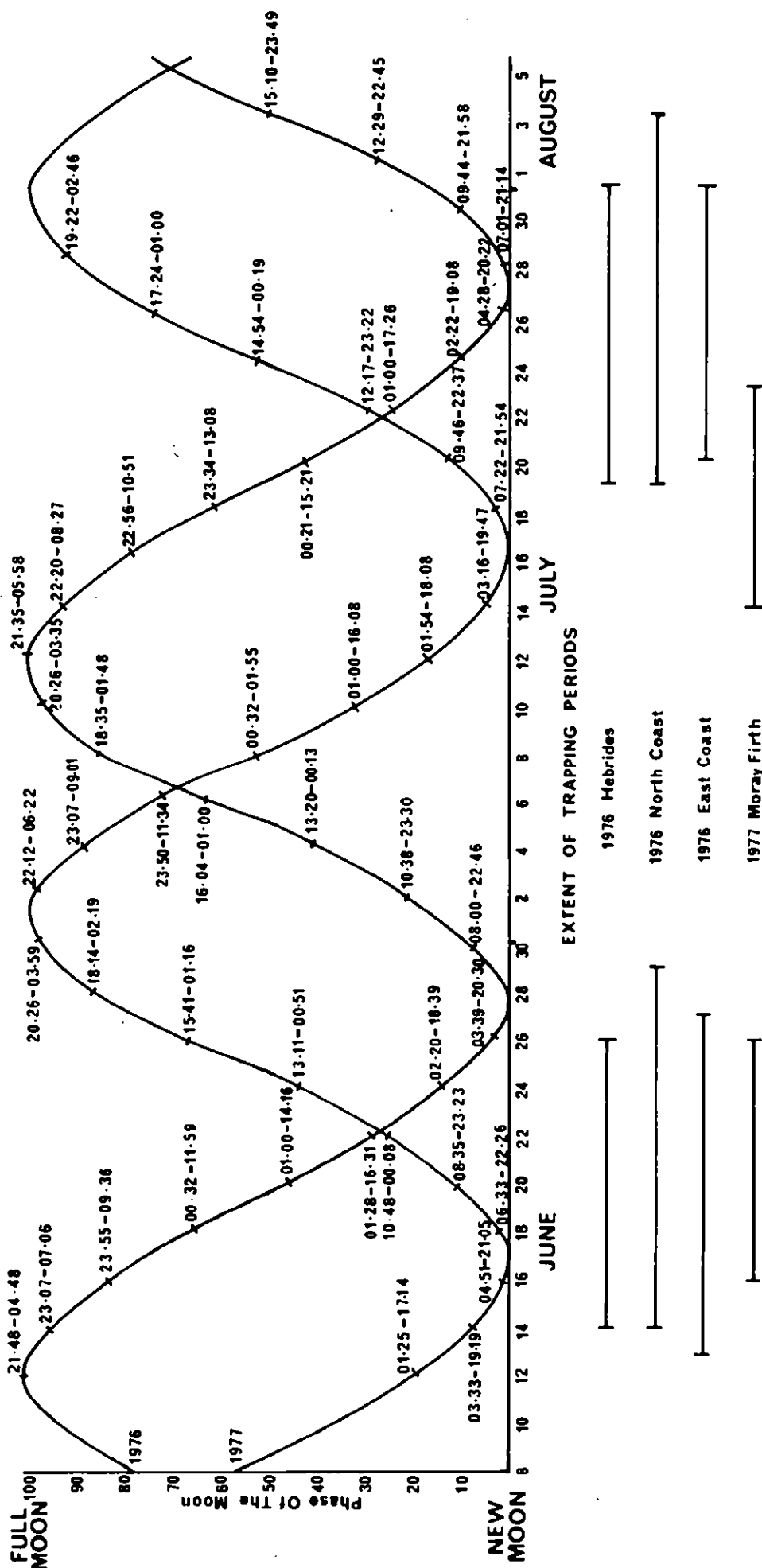


Figure 1 Diagrammatic representation of animal habitats on a dune system showing the position of the marram transition zone

FIGURE 2 PHASES OF THE MOON OVER THE PERIOD 8th JUNE TO 5th AUGUST 1976 & 1977



Numbers on graph indicate time of moonrise and moonset on alternate dates, adjusted to British Summer Time.

x	=	traps operating at end of period
Δ	=	pitfall trap interfered with. Incomplete record.
-	=	trap not installed (Vol II pt.1 Site 32 page 2)
φ	=	traps contained small mammals but were operative

[illegible]

Site Number	Light trap periods	
	1	2
66		
67	x	
68		
69		
70A		
70B		
71		
72A		x
72B		x
74		x
75	x	x
79		x
80		x
81		x
82		x
83		x
84	x	
86		x
87		x
88		x
90		x
91		x
93		x
95		x

Site Number	Light trap periods	
	1	2
66		
67	x	
68		
69		
70A		
70B		
71		
72A		x
72B		x
74		x
75	x	x
79		x
80		x
81		x
82		x
83		x
84	x	
86		x
87		x
88		x
90		x
91		x
93		x
95		x

[illegible][illegible]

1A	1B	2A	2B	3A	3B	4A	4B
	ϕ			ϕ			
	ϕ			ϕ			
	ϕ						
ϕ		ϕ	x		ϕ		
						ϕ	

1A	1B	2A	2B	3A	3B	4A	4B
	ϕ			ϕ			
	ϕ			ϕ			
	ϕ						
ϕ		ϕ	x		ϕ		
						ϕ	

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The light trap selected for use in the field was based on the model devised by Heath (1965) and was operated by a 12 volt car battery. The trap was designed and manufactured at short notice and this may account for the subsequent faults, mainly in the switch mechanism, encountered in the field. A further uncertainty was whether the battery would operate with maximum efficiency for 7 to 8 days, the shortest period which could be fitted into the programme of each survey team (see below).

The moths attracted to the light fell into a metal container through a plastic funnel 20 cm in diameter, situated beneath the filament, and 7 cm diameter where it opened into the container. The latter measured 33 x 33 cm and was 32.5 cm deep. The lower half was filled with sections of egg boxes to provide sheltered corners into which the moths could crawl otherwise they risked damage to their wings by constant fluttering before the killing agent took effect. The moths were killed by vapour from a "Mafu" strip (similar to the domestic fly-killer "Vapona"). Its action seems to have been slow because many specimens were found to have worn wings. On some sites large numbers of earwigs and snails entered the traps and they appear to have been responsible for damage to the moths before they were made inactive by the "Mafu" strip. In 1977 three "Mafu" strips were placed in each trap on the 11 Moray Firth sites and a more effective kill was obtained.

The siting of the light trap was partly determined by its conspicuousness at night although its intensity was low. It was also necessary to observe the requirements of the local coast-guards and police who were consulted. To ensure that the U/V light could not be mistaken for a navigation light it was agreed to place the traps in sheltered areas which were, for the most part, hidden from the sea. For these reasons each trap was placed in a slight depression in the dunes. In some cases the depressions were steep-sided so that the catching area was probably limited. Elsewhere, particularly in the Outer Hebrides, sheltered depressions hidden from the sea were often not available and more open situations had to be accepted.

Although the summer nights are short at the latitude of northern Scotland with perhaps no more than 4 to 5 hours of darkness, the light intensity depended on the cloud cover and it is possible that when the sky was clear the photo-electric cell triggered on the lamp later than when the sky was overcast. In June the difference in night-length between the most southern and the most northern sites was nearly 30 minutes. By July the period of darkness at all sites had increased by over an hour, thus lengthening the potential trapping time, and also using up the battery power supply more quickly. Moonlight is another major factor which has to be taken into

consideration when light trapping (Williams 1936, 1956, Williams and Singh 1951, Bowden 1973, Bowden and Church 1973, Douthwaite 1978). The trap efficiency is greatly reduced at or near full moon because the brightness of the light, relative to the illumination of the surrounding area, is considerably reduced. As far as possible the trapping periods were selected to coincide with the new moon period (fig. 2) although ideally the June trapping period in 1976 should have been about 6 days later.

The chief cause of failure when operating the light traps was a faulty switch mechanism, consequently the duration of each trapping period is not known precisely. In the Outer Hebrides there was a fairly high failure rate; 9 out of the 18 traps were found to be inoperative when the Lepidoptera were collected at the end of the first trapping period. At the end of the second trapping period 11 out of the 18 were not working. In some instances the size of the catch suggested recent failure but in others it was not possible to make any assessment. On the North Coast only one trap was found to be inoperative in the first week but at the end of the second week 5 out of the 16 traps were not working. On the Moray Firth sites in 1977, 2 out of the 11 traps were inoperative at the end of the first week and 4 at the end of the second week. On the East Coast one out of 13 was not working at the end of the first week but at the end of the second week all but one of the light traps had ceased to function. A contributory factor could be that by late July there were more hours of darkness per night and the battery became exhausted in less than a week.

In table 2 the malfunctioning of all the traps (light and pitfalls) is shown for each site. Only a few pitfall traps were damaged, probably by interference from people staying on nearby camp sites, or were dug out by rabbits. However, some loss in catching efficiency may have been caused by the numerous small mammals (mice, voles and shrews) which fell into some of them. A few invertebrate animals may have been able to climb out by using the small mammal as a platform. For this reason the traps which caught small mammals have also been indicated in fig. 3. A clear trend is discernible; the traps in the Outer Hebrides caught no small mammals, those on the North Coast caught them frequently, and on the East Coast many traps were found to have mice, voles and shrews in them.

3.3 Trapping period and number of collections

The first light trap operating period was for 7-8 days in early June and the second for a similar period in late July. The pitfall traps operated

continuously over the whole period with catches taken after the first 7-8 days, at the end of the following three weeks and finally after the last 7-8 days. The trapping periods varied slightly by a day or two in 1976 because the survey team was not always able to maintain a fixed routine of setting up a series of traps on several sites and then returning to each one exactly 7 days later. On the Outer Hebrides ferry schedules sometimes determined the movements of the survey team travelling between islands.

At the end of 1976 94 separate collections from the light traps and 1,128 separate collections from the pitfall traps, including those which did not function properly, had been accumulated. The pitfall traps at the 7 sites on Harris and Lewis were left in position for 3 more weeks and were emptied by the botanists but the results are not included in the totals or subsequent analysis. Only the Coleoptera included species which had not been recorded previously. They are listed in the appropriate site dossiers under "Additional Species". In 1977 survey work on the 11 Moray Firth sites added 22 light trap catches and 264 from the pitfall traps. There was a grand total of 116 light trap catches and 1,392 pitfall trap catches to be sorted and determined. This part of the work was extremely time-consuming because many of the catches also contained much dirt and debris. The six invertebrate groups were removed and put in separate labelled tubes ready for identification while the residue of the material was preserved separately. The Lepidoptera catches included specimens which were too damaged for determination as well as numerous insects from other orders which have been kept for future reference. The sorting and determination of the material began in September 1976 and was completed in the spring of 1978.

4. THE STATE OF KNOWLEDGE OF THE SCOTTISH SAND DUNE FAUNA AT THE BEGINNING OF THE SURVEY

The urgency of the survey work and the time required to determine the material and write up of the results, has not permitted a review of current knowledge, apart from reference to a few major sources. The Nature Conservation Review (Ratcliffe 1977) describes those dune systems included in the Survey where the conservation status is judged to be Grades 1 or 2 but the accounts tend to be generalised with the main emphasis on botanical assessments. On the East Coast the botanical richness of the Tentsmuir Point dune area which has over 400 species of flowering plants is mentioned as a feature of great scientific interest. The main entomological groups

at Tentsmuir have also been well studied and recorded. Much of this information is on the files of the N.C.C. in Scotland. Similarly the Sands of Forvie and Ythan Estuary are included in the NCR because the dune area is the fifth largest and least disturbed of such sites in Great Britain. Strathbeg and the Culbin Sands are also listed, the latter being the largest dune system in Great Britain covering over 7,600 acres (3,170 ha) although now largely afforested. The outstanding sites on the North Coast and the Outer Hebrides are briefly described but there is no detailed information about the invertebrate life. In this sense the results of the Survey complement the NCR and add to its value as an assessment of the conservation interest of Scottish coastlands.

The Biological Records Centre at Monks Wood Experimental Station of I.T.E. has prepared, under contract to the N.C.C. a series of distribution maps of some of the invertebrate animals studied during the Survey. The 31 species of woodlice which are considered by Sutton (1972) to be native or naturalised in the British Isles, have been mapped throughout Great Britain, based on over 12,500 records (Harding 1976). This Atlas shows that all the species recorded during the Survey are common and widely distributed throughout the British Isles.

The Conchological Society of Great Britain and Ireland together with the Natural Environment Research Council has produced an atlas of the Non-Marine Mollusca of the British Isles, edited by M.P. Kerney (1976) in which the distribution of all 26 species taken during the Survey is illustrated. Distribution maps also exist for the butterflies (Heath, 1970) and for 10 families (101 species) of moths (Heath and Skelton, 1973). These are now a little out-of-date and the survey has been able to extend the known distribution of several species. Distribution maps for the Coleoptera exist only for some groups and other readily available data is very out of date. A mapping scheme for Carabidae has been started but provisional maps are available only for the genus Carabus. Distribution maps of spiders are available in volume III of "British Spiders" (Locket, Millidge and Merrett 1974). Tables recording the occurrence of Diplopoda species in the vice-counties of Britain and Ireland have been compiled by Blower (1972).

Dr Welch has recently reviewed the invertebrate fauna of the machair sites in the Outer Hebrides incorporating data from the two Rothamsted light traps which were operated on Benbecula and Harris in 1976 and 1977 respectively. This, together with much other information, is to be published jointly by the N.C.C. and Royal Society of Edinburgh in a review of

"The Natural Environment of the Outer Hebrides". The spider faunas of the very large dune system at Dunnet on the north coast of Caithness and at the Tentsmuir NNR are fairly well known. The first was surveyed by Dr E. and Mrs R. Duffey for a week in 1974, and the second was studied for a week in 1966 by members of the British Arachnological Society (Duffey 1968a). The results of these studies are on the files of the N.C.C. in Scotland. The University of Aberdeen Field Station at Bettyhill on the north coast of Sutherland, has attracted a good deal of field work in this area including the dune system. Dr M.G. Morris and Dr R.C. Welch studied the Coleoptera of the West Sutherland dunes during 1974.

All these sources have, as far as possible, been taken into account in writing up the general assessment of the representation of the six invertebrate groups on the 58 sampling sites.

5. SYNOPSIS OF WEATHER CONDITIONS DURING THE SAMPLING PERIODS

5.1 Outer Hebrides (1976)

Trapping commenced on 14 June with strong winds and rain. Mist and frequent rain persisted during the next 2 days. 17 June, was clear and sunny with a cloudless evening which was still light at 2315 hours. On 18, 19 June there was frequent rain, cloud and mist. 20 June was cloudy in the morning but clear and sunny for most of the afternoon and good weather continued until 1500 hours on 21 June when it began to rain. Next day was sunny until 1030 hours when rain began to fall. Bad weather continued until 25 June when the trapping period ended but on that day it was sunny and warm until mid-afternoon.

During the second trapping period in the Outer Hebrides the weather improved somewhat by July. It was generally fairly windy and rained every day, at least for a short period. However the rain was light and there were sunny spells on most days especially on the Uists.

5.2 North Coast (1976)

The weather was mostly dry and warm at the north and north-east sites but cloudy and windy with frequent rain on the north-west and west coasts.

14 June, the first day of the trapping programme, was dry and warm with light cloud. The next three days were overcast but dry and warm. On 18 June the weather became cool and windy with persistent light rain. The rain ceased in the evening and on 19 June it remained cool and cloudy but dry. For the next 6 days, until the evening of 25 June the weather remained dry, sunny spells were frequent but there was also a good deal of cloud. On

26 June it rained hard as while travelling to the west coast sites. On 27 June at Red Point it was windy, wet and cloudy. This was the last day of the collecting period.

The first day of the second sampling period (19 July) was cool and cloudy with blustery showers and occasional sunny intervals. This was the pattern for the next 4 days. Heavy rain must have fallen near Achnahaird as the pitfall traps contained much water when emptied on 23 July. 24 July was slightly warmer and the wind had dropped completely. The next four days were cloudy and drizzly with the sun attempting to break through occasionally, although most of the time there was a cool breeze blowing. On July 29 there was a very cold wind and the sky was overcast. By mid-morning torrential rain was falling as the traps were being collected from Sandwood. The rain had eased to a slight drizzle by the next day and the temperature rose slightly as the sun tried to break through. The weather continued to improve over the next three days and on the 3 August when the trapping period ended it was sunny and hot with very little breeze.

5.3 Moray Firth (1977)

Trapping commenced on 15 June which was hot, dry and sunny. On the 16 June the weather was warm but dull in the morning, clearing during the day to become sunny and hot. This fine weather continued until 24 June when there was heavy rain during the night. The following day was dry and windy with some cloud. The weather on the last trapping day, 26 June, was windy and cloudy with warm sunny periods.

The second trip commenced trapping on 13 July which started very cloudy with rain early in the morning but clearing later. Pitfalls collected on this day, particularly at Lossiemouth, were full of water which suggests there had been considerable rain from 27 June - 13 July. The following two days were dull but warm and dry with a slight breeze. The 16 July was wet, windy and cool. The four days 17-20 July were generally fine and dry with some cloud. On the 21 July it was windy and very cloudy with few sunny periods. The 22 and 23 July were dull, warm and showery and the trapping period finished on a cool, dull day with showers on 24 July.

5.4 East Coast (1976)

The first trip was very changeable, heavy rain followed by sunshine for most of the time, with a few generally dull days. The second trip was also fairly changeable but with longer periods of dull but dry weather.

Figure 4 Ordination of data for the Araneae Axes 1 x 2
Each site has three plot points representing each
sampling period. For site names see table 1

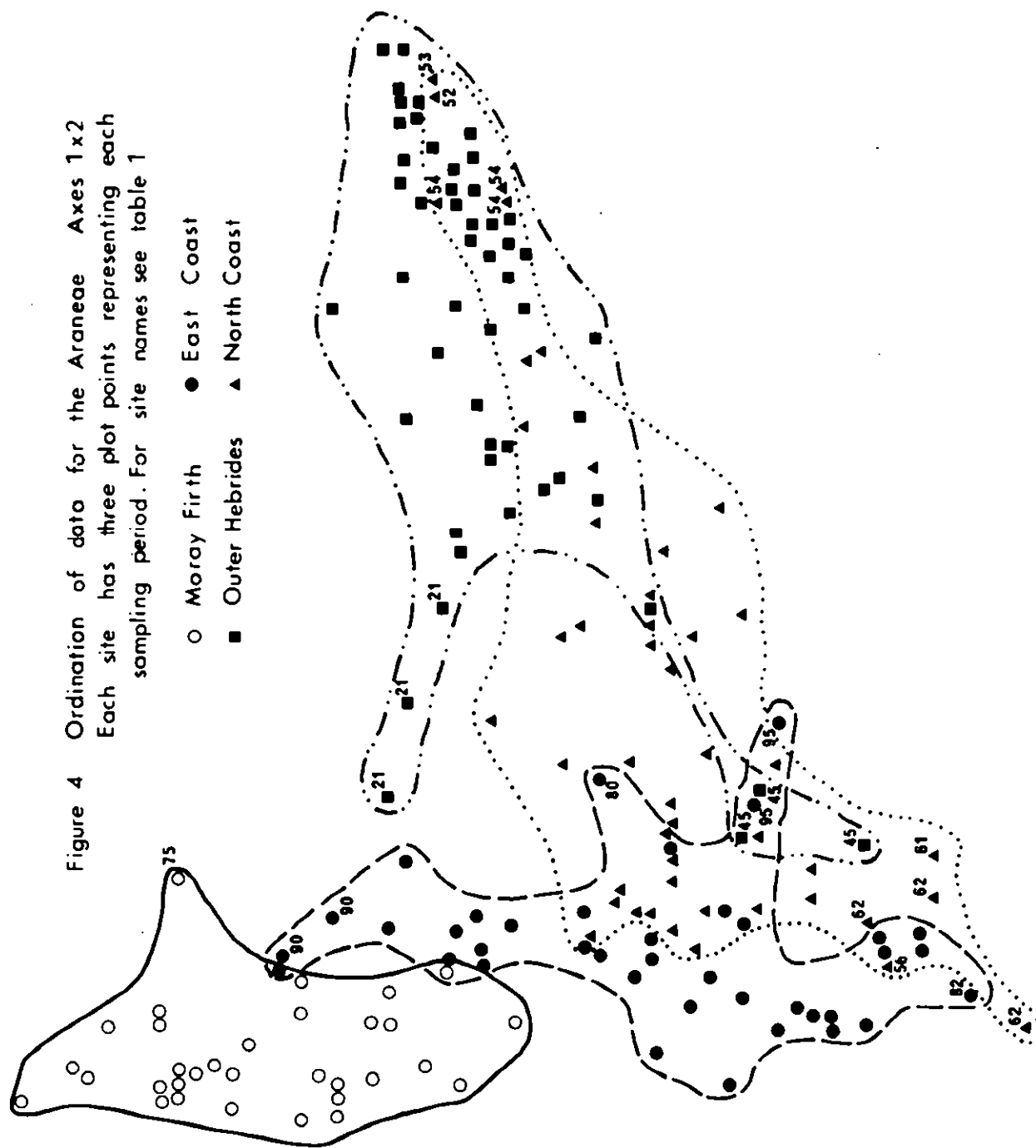
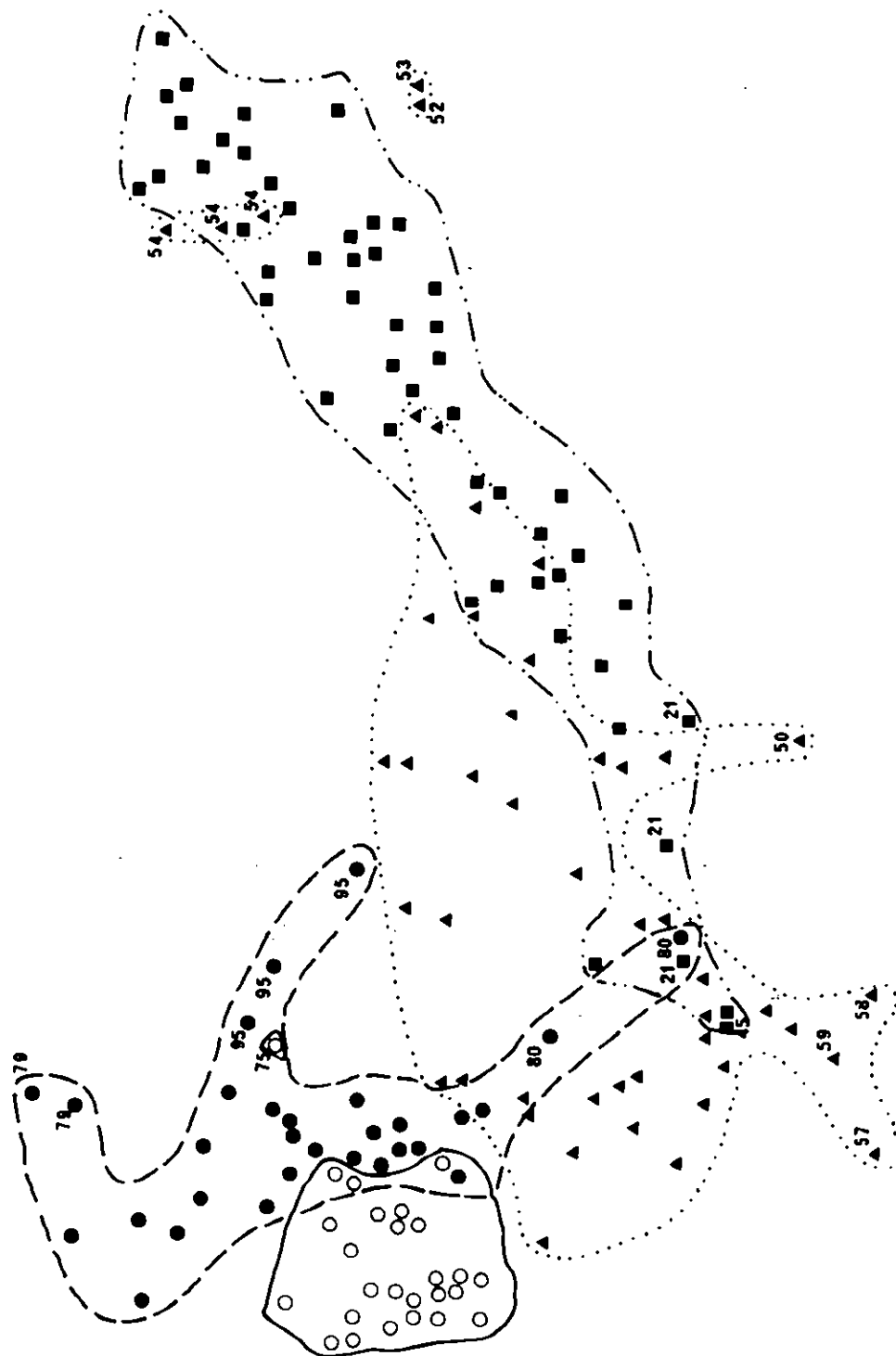


Figure 5 Ordination of data for the Araneae. Axes 1x3
 Each site has three plot points representing each
 sampling period. For site names see table 1.

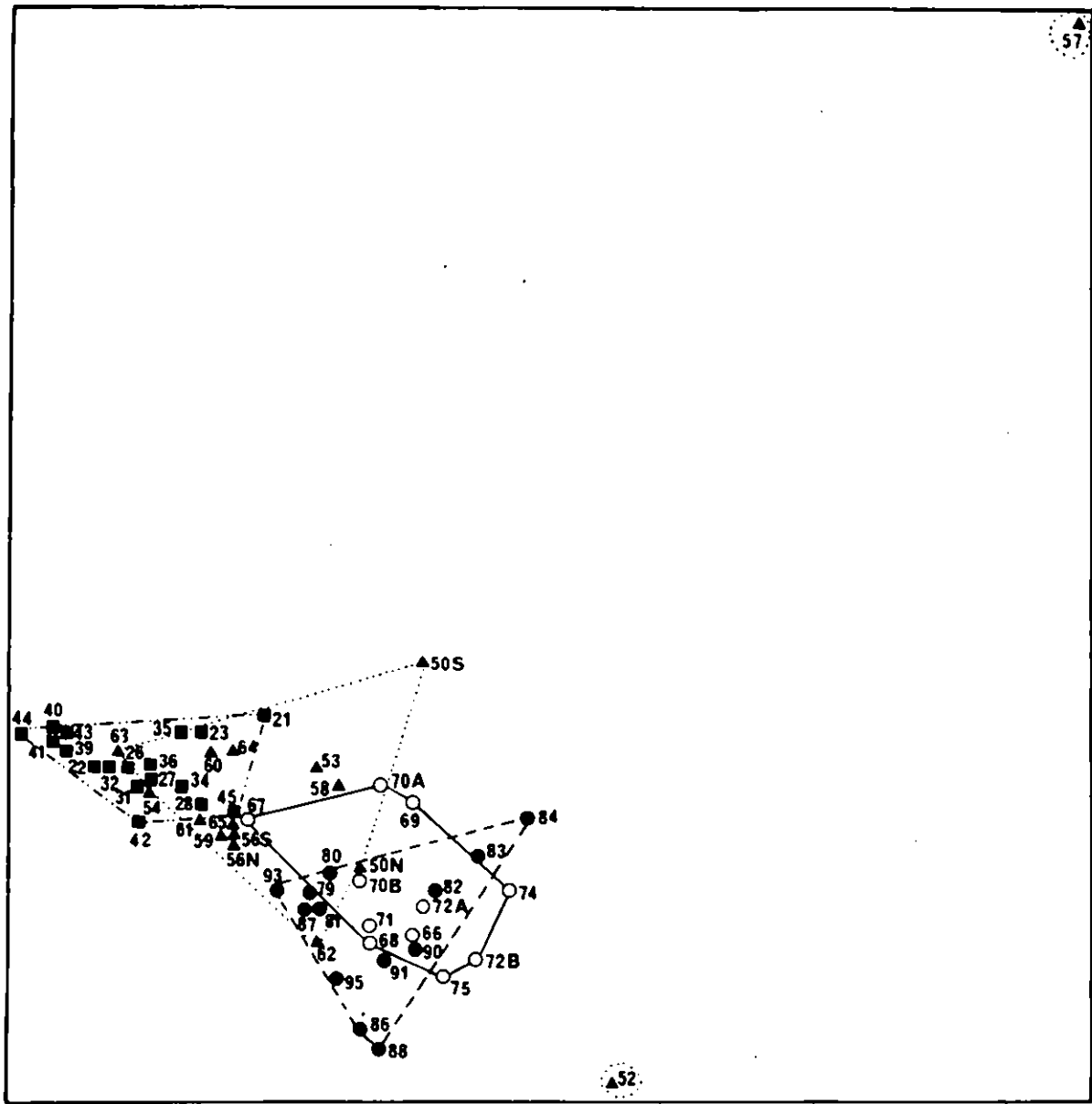
- Moray Firth, ● East Coast,
- Outer Hebrides, ▲ North Coast.



Axis 1

Axis 3

Axis 1



Axis 2

Figure 6 Ordination of data for the Carabidae. Axes 1x2.

All records for the three sampling periods are combined in one plot point per site. For site names see table 1.

○ Moray Firth ● East Coast ■ Outer Hebrides ▲ North Coast

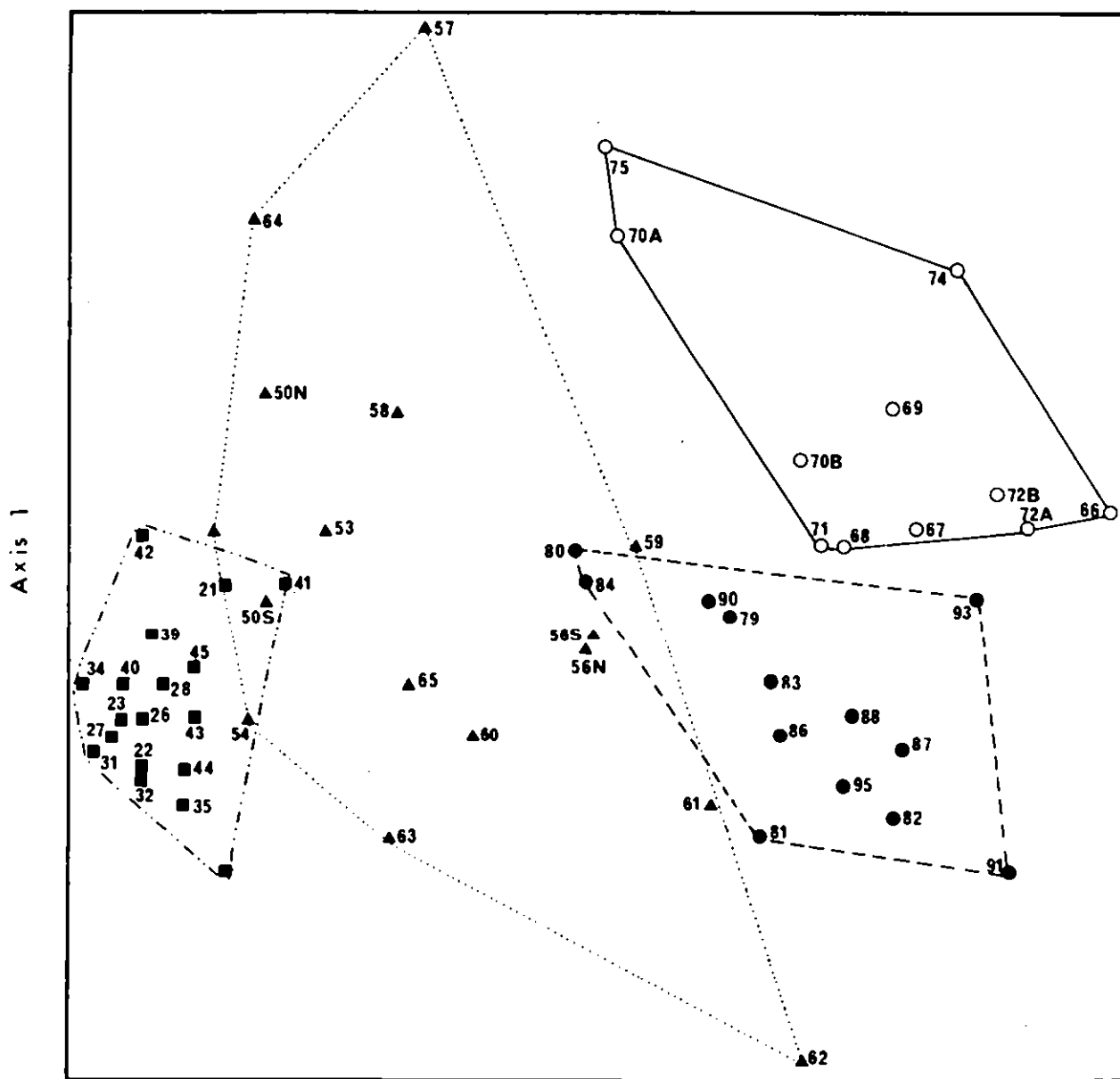


Figure 7
Ordination of data for the Coleoptera (Hydrophilidae to Scolytidae). Axes 1 x 2.

- All records for the three sampling periods are combined in one plot point per site. For site names see table 1.

○ Moray Firth ● East Coast ■ Outer Hebrides ▲ North Coast.

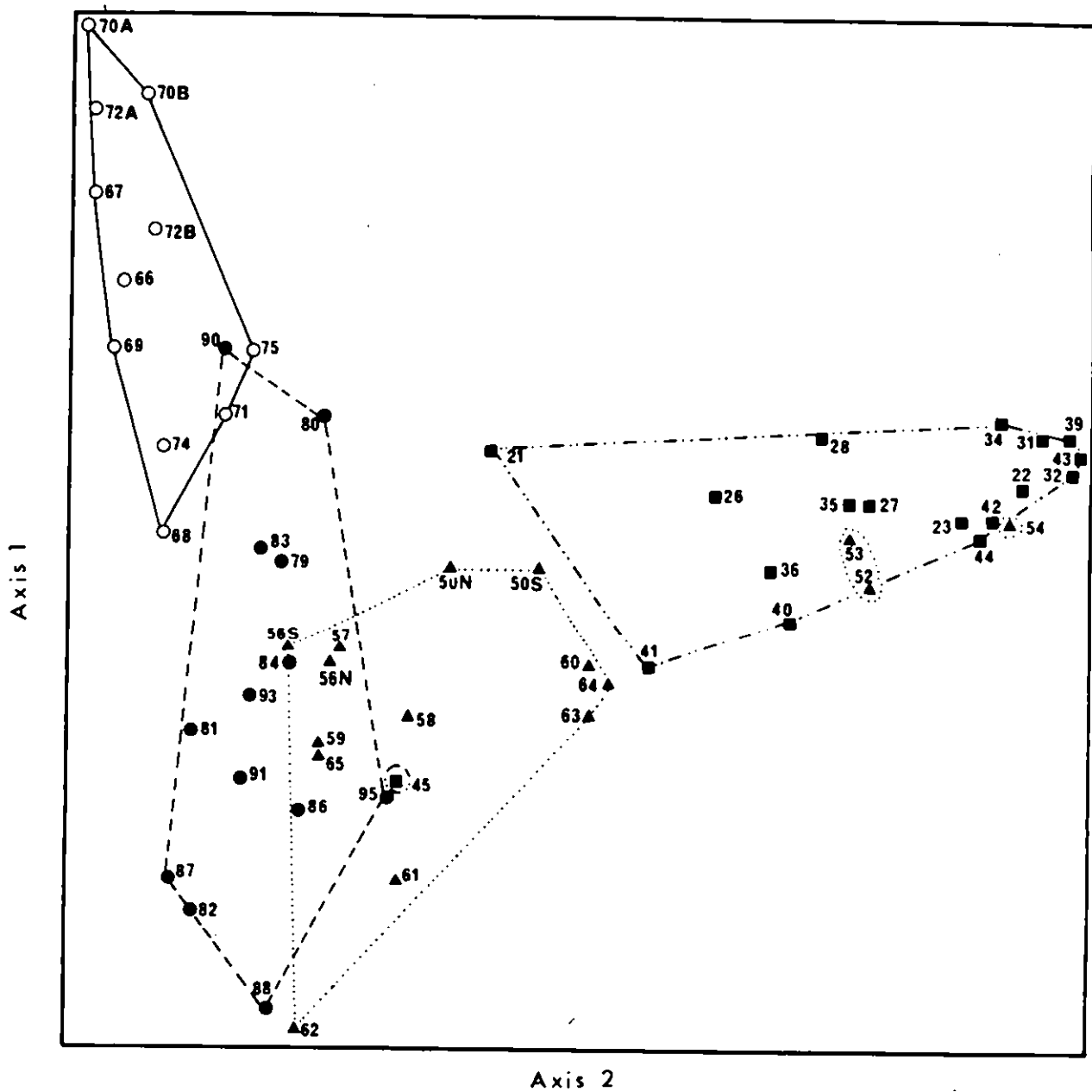
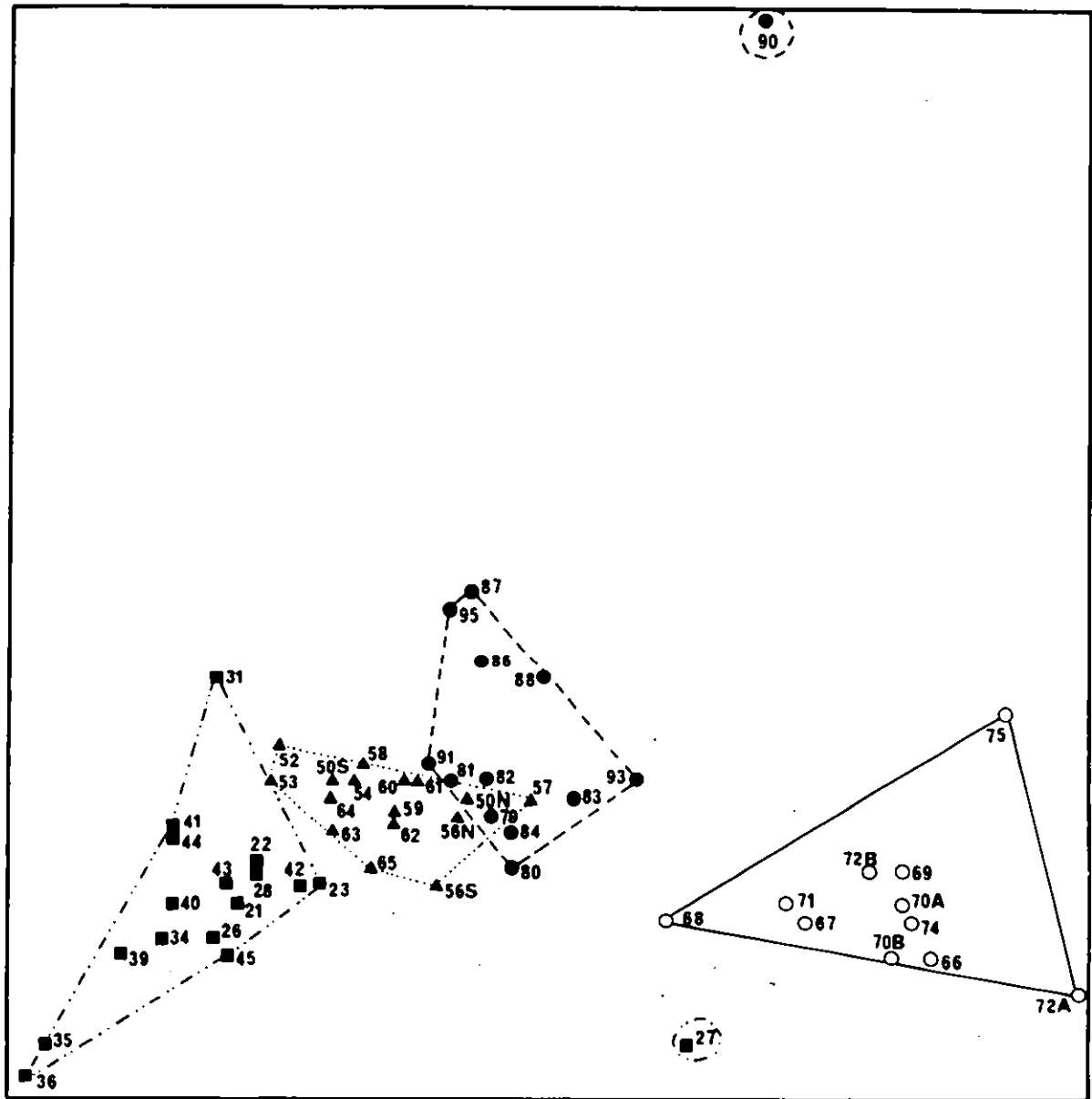


Figure 8 Ordination of data for the Araneae. Axes 1 x 2.

All records for the three sampling periods are combined on one plotpoint per site. For site names see table 1.

○ Moray Firth ● East Coast ■ Outer Hebrides ▲ North Coast

Axis 1



Axis 2

Figure 9 Ordination of data for the Lepidoptera. Axes 1x2

All records for the three sampling periods are combined in one plot point per site. For site names see table 1.

○ Moray Firth ● East Coast ■ Outer Hebrides ▲ North Coast

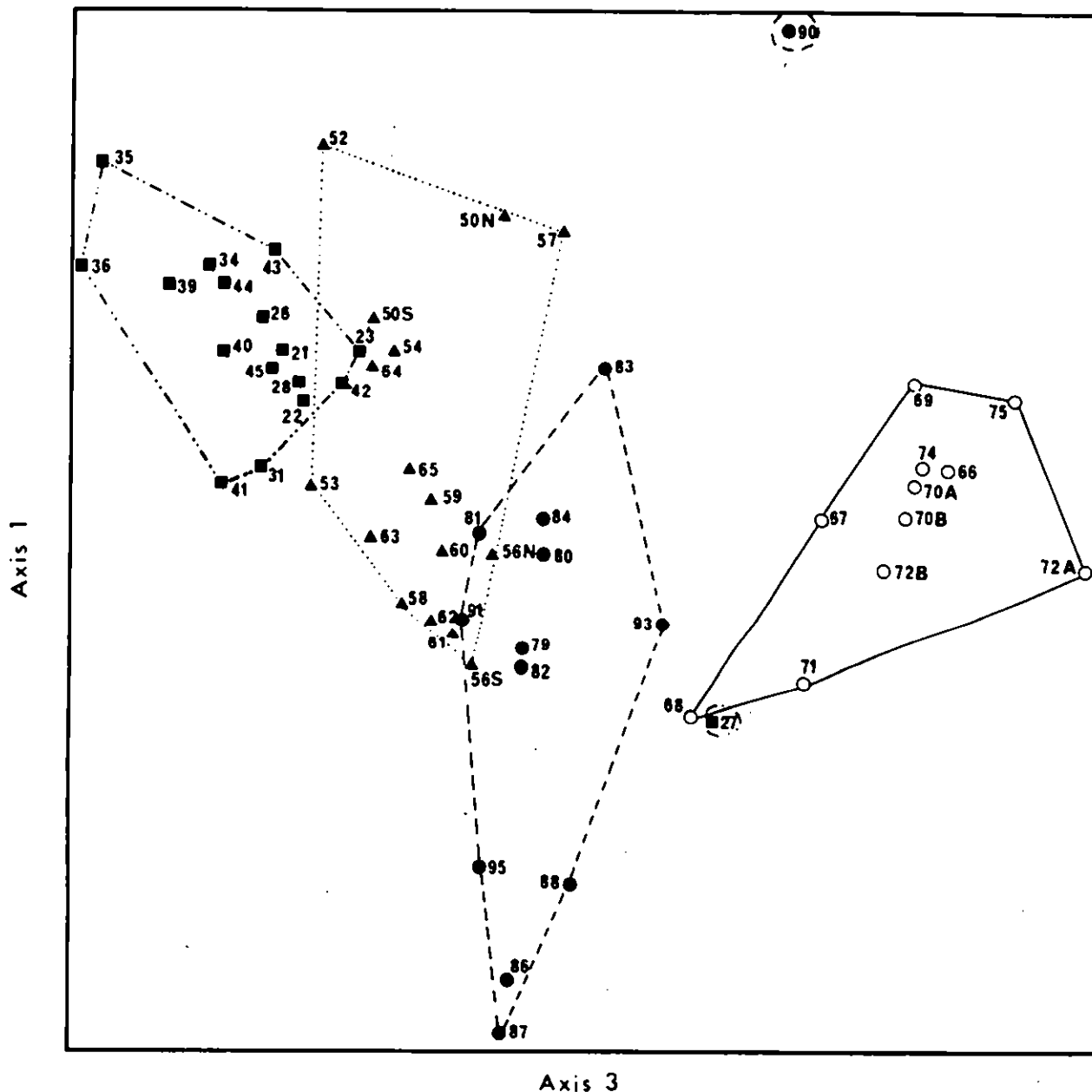


Figure 10 Ordination of data for the Lepidoptera. Axes 1x3

All records for the three sampling periods are combined in one plot point per site. For site names see table 1.

○ Moray Firth ● East Coast ■ Outer Hebrides ▲ North Coast

6. THE FAUNA AND ITS RANGE OF VARIATION

6.1 Introduction and methods of analysis

The sampling methods used during the Survey were selected to achieve comparability between sites, groups of sites and between sampling periods. Nevertheless the data obtained were subject to numerous errors (Section 3) and it is not possible to apply a suitable correction which would compensate for them. The large number of sites and records may, however, even out some of the bias. The recommended statistical treatment was ordination by reciprocal averaging followed by an indicator species analysis (Hill 1973). Diversity indices (Shannon, Simpson and Williams) were also calculated for the species totals per site for each invertebrate group and a single factor analysis of variance was calculated for the mean number of species taken in each of the four geographical regions for each well-represented group (the Lepidoptera, the Carabidae, the other families of Coleoptera and the Araneae). This was followed by a 't' test to calculate the significance level of differences between regions. In addition correlation coefficients were calculated for the number of species in each invertebrate group against latitude (all Regions, Outer Hebrides, East Coast) and against longitude for the North Coast sites.

6.2 Ordination of species/abundance data

Computer facilities at Monks Wood were insufficient for an ordination and ISA on the total fauna of 655 species (Coleoptera-Carabidae 55, Coleoptera-Hydrophilidae to Scolytidae 289, Lepidoptera 157, Araneae 115, Mollusca 26, Diplopoda 9 and Isopoda 4). These analysis were therefore made on the four largest groups i.e. Lepidoptera, Carabidae, other families of Coleoptera and the Araneae.

The first ordination analysis was based on each sample period so that in the case of pitfall trapping 3 plot points could be entered on the graph for each of the 58 sampling sites (figs. 4 and 5). The first of the 2 sampling periods for the light traps was omitted from the analysis because the data for the Outer Hebrides were too poor. In the second ordination data for all sampling periods were pooled for each site and a simplified ordination diagram was obtained.

A comparison of the second ordination (axes 1 x 2) for the four major invertebrate groups shows a number of interesting differences (figs 6 to 9). The Carabidae form the most compact grouping in each of the four regions and also show the greatest degree of overlap. This suggests that the variation in the carabid fauna from region to region was less than in other invertebrate groups. However, only 55 species of carabids were recorded, whereas the other families of Coleoptera totalled 289 species. The ordination graph

for the latter data shows four well separated groups with comparatively little overlap. The region with the greatest spread is the North Coast while there is least variation in the Outer Hebrides.

The spiders, show a clear separation between the four regions, although there is considerable overlap between the North Coast and the East Coast.

The Lepidoptera, based on the July sample taken in the light traps, display a rather different picture. The most compact group is formed by the North Coast sites and there is some overlap with the East Coast. The Outer Hebrides sites are slightly more widely spread and the Moray Firth forms a distinct group well separated from the other three regions - probably because the collections were made in a different year.

A detailed account of the ordination results for each of the four major invertebrate groups follows in which reference is made to the other diagrams derived from axes 1 x 3, 1 x 4, 2 x 3 etc where relevant.

6.3 Lepidoptera

For the most part all four regions form distinct groupings with two notable exceptions. The separation of Stilligarry (South) from the rest of the Outer Hebrides sites is exaggerated by the fact that no Lepidoptera were taken during the second trapping period. However, it was the only Outer Hebrides site at which Xanthorhoe fluctuata was trapped, a species taken elsewhere only at three Moray Firth sites including Dornoch. Stilligarry (South) and Dornoch fall close to each other in all ordinations, particularly on the plot of axes 1 x 3 (fig.10). Tentsmuir is not only separated from the remaining East Coast sites but is also isolated from all other groups. This is almost certainly because this was the only site which recorded nine species not taken elsewhere. The majority of these were "woodland" species reflecting the proximity of extensive plantations rather than any other habitat characteristic.

The North Uist sites, Balranald and Robach consistently occur at one extremity of the Outer Hebridean group, and furthest from the other geographical regions. Paible and Uig form another, slightly less distinct limit to the scatter of Outer Hebrides sites.

The sites on the north west coast of Sutherland, Redpoint to Sandwood show the closest affinity with the Outer Hebrides group (although this is less marked for Redpoint (North), particularly with the remaining South Uist sites together with Valtos on the west coast of Lewis (fig. 10).

The East Coast sites tend to fall into two separate parts. St. Cyrus and Montrose Links, Lunan Bay and Arbroath together with Tynninghame form the

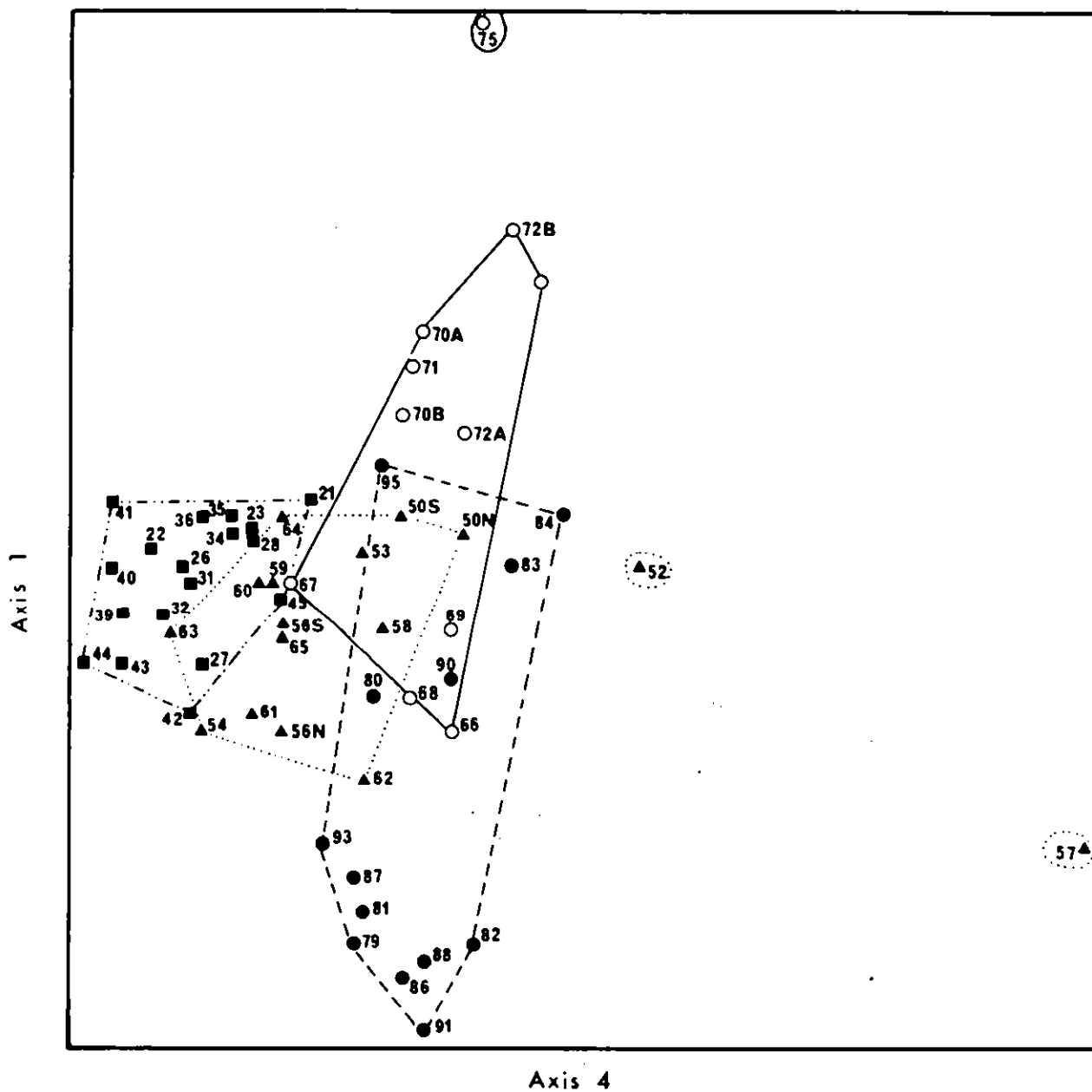


Figure 11 Ordination of data for the Carabidae. Axes 1x4.

All records for the three sampling periods are combined in one plot point per site. For site names see table 1.

○ Moray Firth ● East Coast ■ Outer Hebrides ▲ North Coast.

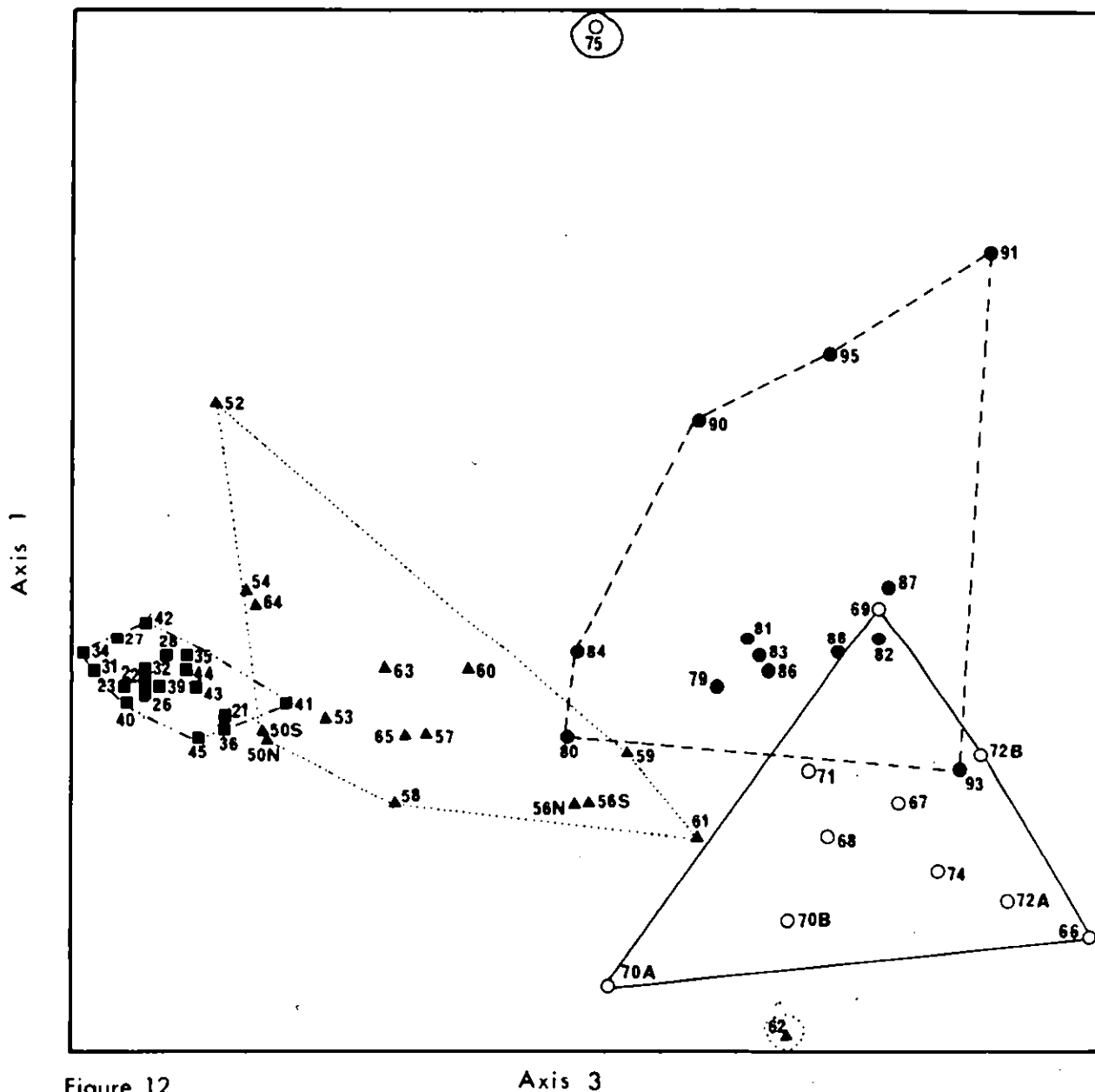


Figure 12
 Ordination of data for the Coleoptera (Hydrophilidae to Scolytidae). Axes 1 x 3.
 All records for the three sampling periods are combined
 on one plot point per site. For site names see table 1.
 ○ Moray Firth, ● East Coast, ■ Outer Hebrides, ▲ North Coast.

more isolated southern group. The remainder exhibit some affinity with a number of North Coast sites although Forvie tends to separate off, particularly in the plot from axes 2 x 3.

The Moray Firth sites form a very distinct group with Lossiemouth as an outlier from the rest. This can be seen in the plot of axes 1 x 2 (fig. 9) and is even clearer in the plot of axes 2 x 3. The two Morrich More sites show a constant close association whilst the exposed nature of Culbin Bar (Site 72A) is probably responsible for its fairly wide separation from the more sheltered mainland site (72B), and for its occurrence on the periphery of the Moray Firth group.

6.4 Coleoptera : Carabidae

The ordinations made on the carabid data provided the least clearcut groupings for the four areas, with considerable overlap and superposition.

The Outer Hebrides consistently form a very compact group although Valtos, which is peripheral in some ordinations, becomes isolated when plotting axes 1 x 3, 2 x 3 and 3 x 4. This is almost certainly due to the abundance of the two Dyschirius spp., more especially D. politus which was considerably more numerous here than at any of the other three sites at which it was taken during the survey.

The North Coast group shows some of the expected overlap with the Outer Hebrides sites although this does not include those on the north west coast of Sutherland which are geographically closest.

Achnahaird and Bettyhill are separate from the main group, to a greater or lesser extent, in all ordinations. However, Farr Bay, a near neighbour of the latter site, exhibits no separation from the main body of North Coast sites. Achnahaird is the only North Coast site where Calathus erratus replaced the usually abundant C. fuscipes. The only specimen of Asaphidion pallipes taken during the Survey was trapped here and it was one of the four sites for Dyschirius politus. Bettyhill was similarly unusual in being the only Survey site at which the usually common Pterostichus madidus was taken and the only North Coast site at which three species of Carabus were trapped.

The East Coast data are difficult to interpret since in all ordinations except axes 1 x 2 (see figs. 6 and 11), the sites split into two fairly well defined groups with Forvie and Don to Ythan, Strathbeg, Tentsmuir and Tynninghame showing closer affinities to the North Coast and Moray Firth groups. The remaining East Coast sites form an isolated group.

Again, in all ordinations except axes 1 x 2, the Moray Firth sites fall into distinct groupings with Lossiemouth totally isolated (cf. Coleoptera : Hydrophilidae to Scolytidae). The reason for this is probably due, in part, to it being the only site where Pterostichus adstrictus was taken. It also had the largest catch of the Survey of Amara aenea, and was one of three sites at which Bradycellus harpalinus was trapped.

Sites to the north of Dornoch Firth (Ferry Links - Clashmore) form one group closer to the main centre of the other three regional groupings, with a surprising apparent relationship between Coul Links and Tolsta the only site sampled on the eastern coast of the Outer Hebrides. The remaining sites, i.e. those south of the Dornoch Firth (Morrich More - Findhorn) form a separate, somewhat isolated group. The extreme location of Culbin Bar (2) may reflect the relatively large numbers of Harpalus rubripes, a species only taken elsewhere at Culbin Bar (1) and Whiteness both of which occur in this southern grouping.

6.5 Coleoptera : Hydrophilidae to Scolytidae

The Outer Hebrides consistently form an extremely compact grouping in all the ordinations. This is well shown when plotting axes 1 x 3 (fig. 12), 1 x 4 and 3 x 4.

Somewhat unexpectedly, Uig appears as a marginal site exhibiting an overlap with the north west mainland coastal sites and with Daliburgh, the most southern Outer Hebrides site, tending in the same direction. There would seem to be no clearly defined reason for this. Contributory factors to this association may be that these are the only Outer Hebrides sites at which Stenichnus collaris and Agriotes obscurus were trapped. However neither species was recorded from any site on the north west coast of Sutherland and apart from isolated records from Faraid Head (North and South) and Bettyhill all other records were from the Moray Firth and East Coast. Similarly Staphylinus melanarius, although absent from all North Coast sites, was taken at these two sites (and Tolsta). Geotrupes vernalis provides one possible link in that although most numerous on the Outer Hebrides at Daliburgh, Uig and Balranald it was trapped in low numbers at all but one of the north west coastal sites.

The North Coast group exhibits a widespread distribution of sites in all ordinations and hence, the greatest variation, which was most marked when plotting axes 1 x 2 (fig. 7). The six sites situated on the north west coast of Sutherland show the expected close affinities with the sites of the Outer Hebrides group. The two sites at Redpoint (North and South),

show a fairly close relationship in all ordinations except axes 1 x 2 (figs. 7 and 12) whilst the two sites at Faraid Head (North and South) show a consistent close association. Bettyhill and Farr Bay although geographically very close, and the only sites at which Oxypoda soror was trapped during the Survey, had as few as ten species in common out of totals of 21 and 27 respectively, consequently they do not appear particularly close on the ordinations, and indeed Bettyhill frequently occurs on the periphery of the North Coast grouping (cf. Carabidae), with Dunnet even more isolated (fig. 12). Among the large number of species recorded at this last site seven were taken at no other site during the Survey, and several others at only one or two other sites.

The East Coast sites form a fairly well defined group on the plot of axes 1 x 2 (fig. 7) but on the ordination diagrams for the plots of axes 1 x 3 (fig. 12), 2 x 3 and 3 x 4, three of the southernmost sites, Tentsmuir, Dumbarnie and Tynninghame separate off from the main group. Gullane (the remaining Firth of Forth site) also forms an independent outlier having affinities with the Moray Firth group. This may be a reflection of its more sheltered west-facing situation. Lossiemouth is totally isolated in all ordinations except axes 1 x 2 (fig. 7), not only from the rest of the Moray Firth group, but from all other sites. It is difficult to find an explanation for this. In a relatively small fauna of 21 recorded species, two, Omalius caesus and Cassida rubiginosa were unique in the Survey samples. Although taken only at other Moray Firth sites, Byrrhus pustulatus, Lagria hirta and Orthocerus clavicornis, were trapped here in much larger numbers. Relationships are not immediately apparent but the Moray Firth sites appear to have affinities with both North and East Coast sites.

6.6 Araneae

The data from the plot of axes 1 x 2 show that the Moray Firth sites formed the most compact group. However there was a slight overlap with the East Coast due to the position of Tentsmuir. This site is also an outlier in the 1 x 2 ordination of the Lepidoptera and habitat differences are thought to be the main reason. The same probably holds for the spiders because of the wide range of types of grasslands and heathlands at Tentsmuir. Previous work (Duffey 1968b) has shown that the spider fauna of this site is surprisingly rich with 49 species recorded in the marram transition zone during 5 day's work by a group of 8 arachnologists.

The ordination places the East Coast closer to the Moray Firth than to the other regions as one would expect and there was considerable overlap between

the East Coast and North Coast groups of sites.

The pooled data ordination separates the Outer Hebrides as a distinct group suggesting that the spider fauna has some special features compared with the other regions. When axis 1 is plotted against axis 3 the four regions are separated into two groups with the Moray Firth and East Coast forming the first pair and the North Coast and Outer Hebrides the second. Nevertheless the overlap between each pair is minimal and this plot again emphasises the distinctiveness of all four regions.

A few sites fall outside their geographical area of origin, the most notable for the spider fauna being Tolsta on the east coast of the Isle of Lewis which is always associated with the North Coast group (figs. 8 and 13). In addition Achnahaird, Oldshore More and Sheigra on the north-west corner of Sutherland and within the North Coast geographical group, all fall within the Outer Hebrides plot on the ordination. This is almost certainly because Erigone arctica and E. promiscua which were most frequent on the Outer Hebrides sites (maps 44 and 45) also happened to be reasonably common on the north-west mainland sites and were scarce or absent elsewhere on the North Coast. However Oldshore More is paired with Achnahaird in the ordination although the former is the geographical neighbour of Sheigra. Achnahaird lies about 80 kilometres to the south, in the old county of Ross and Cromarty. The close relationship between Achnahaird and Oldshore More and their separation from Sheigra arises out of habitat differences. The sampling sites on Achnahaird and Oldshore More were in the marram transition zone of well-formed dunes. In each case the most numerous linyphiid was E. promiscua and the commonest lycosid was A. perita. On the other hand the sampling area at Sheigra was a very short, compact turf where E. arctica was the most common spider and A. perita was not recorded. Similarly, Tolsta falls within the North Coast group because E. promiscua and E. arctica were absent and a higher proportion of the Linyphiidae recorded for the North Coast sites also occurred at Tolsta. In addition the habitat characteristics observed at Tolsta, were much closer to the type of dune system recorded on the North Coast because marram grass was dense in contrast to the short turf which was the usual vegetation in the Outer Hebrides. In these instances the minor features of habitat structure were perhaps as important as the geographical situation in determining the type of spider fauna.

The range of variation within each geographical region was demonstrated by the spread of points on the ordination diagrams (fig. 8). This was least in the Moray Firth area where Morrich More (sites 1 and 2) and

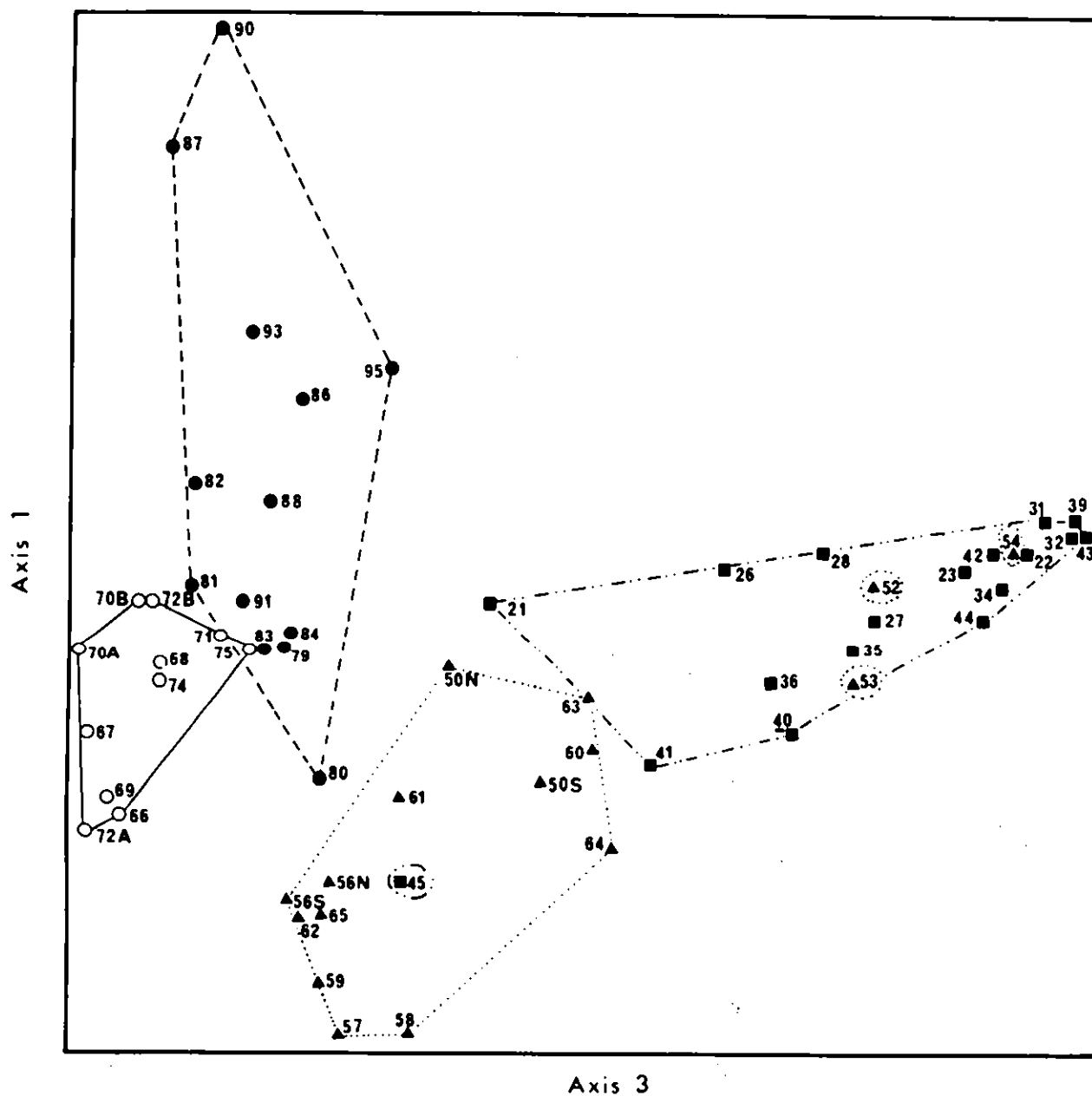


Figure 13 Ordination of data for the Araneae. Axes 1 x 3.

All records for the three sampling periods are combined
in one plotpoint per site. For site names see table 1.

○ Moray Firth, ● East Coast, ■ Outer Hebrides, ▲ North Coast.

Indicator Species Analysis

LEPIDOPTERA

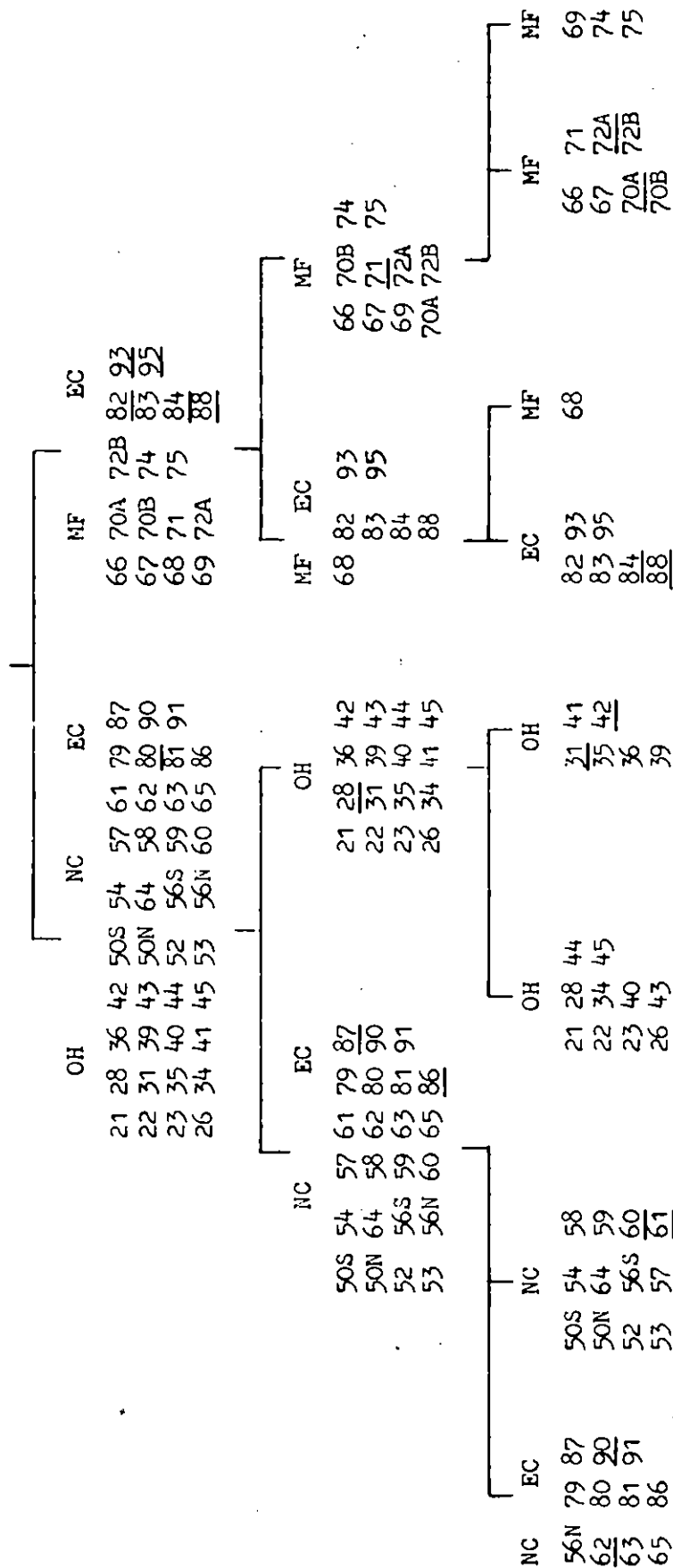


Figure 14 Underlined site numbers have been classified as "borderlines" (see text).

See table 1 for site names

- OH = Outer Hebrides
- NC = North Coast
- MF = Moray Firth
- EC = East Coast

Dornoch showed the greatest separation. The faunal differences are fairly clear. At Dornoch 9 linyphiid species were recorded against 4 and 2 species at Morrich More (1 and 2) respectively. At all three sites P. pullata and A. pulverulenta were the most common lycosids but the Gnaphosidae were more numerous and better represented at Morrich More. On the East Coast the extreme range was shown on the one hand by Tentsmuir and Strathbeg with Arbroath at the other end of the distribution. The separation of Arbroath from Tentsmuir and Strathbeg is due to the greater representation of the Linyphiidae (68% of the species recorded) in the first compared with 28% and 40% respectively in the other two. Lycosids were much less numerous in the Arbroath collection than in those from Tentsmuir and Strathbeg. The slight overlap between the Moray Firth and East Coast sites is caused by Tentsmuir falling close to Whiteness and Lossiemouth. The only features which these 3 sites seem to have in common is that in all cases there were small numbers and few species of Linyphiidae.

On the North Coast site Dunnet was separated somewhat from the remainder of the sites and this may be because it had a much richer spider fauna - one of the highest totals recorded during the survey. In the Outer Hebrides, Daliburgh (South Uist) was on the extreme edge of this group possibly because Pardosa monticola was particularly abundant whereas it tended to be absent or scarce elsewhere.

7. THE INDICATOR SPECIES ANALYSIS

7.1 Introduction

In this analysis the sites are classified by means of a dichotomous key and the basis for selection is the frequency of occurrence of not more than 10 indicator species at each division. In most cases it was possible to take the analysis down to the third level of the hierarchy (e.g. fig. 14) so that the sites are arranged in 8 groups which indicate both the relationships between regions and between sites. Further information can be obtained by comparing the species lists associated with each group of sites. This treatment was applied to each of the more numerous invertebrate groups (Lepidoptera, Coleoptera-Carabidae, Coleoptera-Hydrophilidae to Scolytidae, Araneae and Mollusca). The first division of the ISA clearly separates most of the Outer Hebrides and North Coast sites from the East Coast, including the Moray Firth, for all invertebrate groups except the Mollusca. The 94 sites surveyed botanically (Project 340) also separate into these two groups at the first division

suggesting that both fauna and flora are influenced by the major climatic features, i.e. the north and west being relatively cool, windy and wet while the east coast is drier, warmer and more sheltered.

In the second and third division differences between the invertebrate groups make the pattern less clear but the Outer Hebrides fauna preserves its distinctiveness longer than do the other geographical regions. In the third division the Outer Hebrides sites show a split in the ISA's for Lepidoptera, Carabidae and Araneae between Lewis and Harris on one hand and the North and South Uists on the other. The behaviour of certain individual sites which do not conform to the general pattern is described in the following accounts for the five invertebrate groups analysed by ISA. For example Tolsta on the east coast of Lewis in the Outer Hebrides is consistently associated with the North Coast sites rather than with the remainder of the Outer Hebrides in the analysis of the Araneae.

7.2 Lepidoptera

The ISA is based solely on the July sample because there was a very low catch (in some cases nil) during the June period especially at the Outer Hebrides sites. Even in July at Stilligarry (South) no Lepidoptera were trapped and at Hosta no trap was set (fig. 14).

First division

There is a clear split with the Outer Hebrides and North Coast sites on the one hand and the Moray Firth sites in the other. The East Coast sites, however, split evenly between the two and there appears to be no obvious geographic or climatic reason for this.

Second division

(2-1) All the Outer Hebrides sites are separated from the North Coast and East Coast sites.

(2-2) There is a clear separation between the East Coast and Moray Firth sites with only Dornoch splitting from the remaining Moray Firth sites.

Third division

(3-1) The seven East Coast sites are grouped with four on the North Coast, the latter consisting of Dunnet, Freswick and Sinclairs Bay (all in the north east corner of Caithness) together with Faraid Head (North). The other half contains all the six sites on the north west coast of Sutherland together with the six central North Coast sites. It is interesting that the two Faraid Head sites (North and South) separate in this way (fig. 14).

Indicator Species Analysis

CARABIDAE

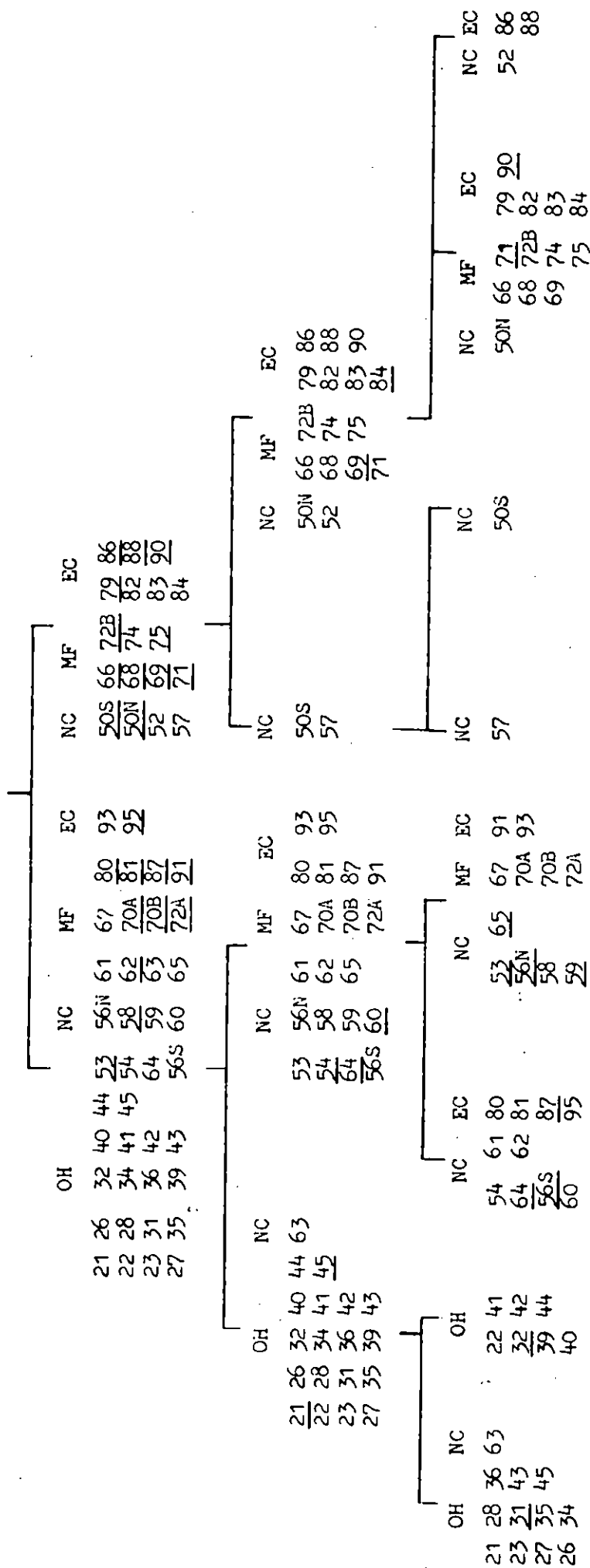


Figure 15 Underlined site numbers have been classified as "borderlines" (see text).

See table 1 for site names

OH = Outer Hebrides

NC = North Coast

MF = Moray Firth

EC = East Coast

Indicator Species Analysis

OTHER COLEOPTERA

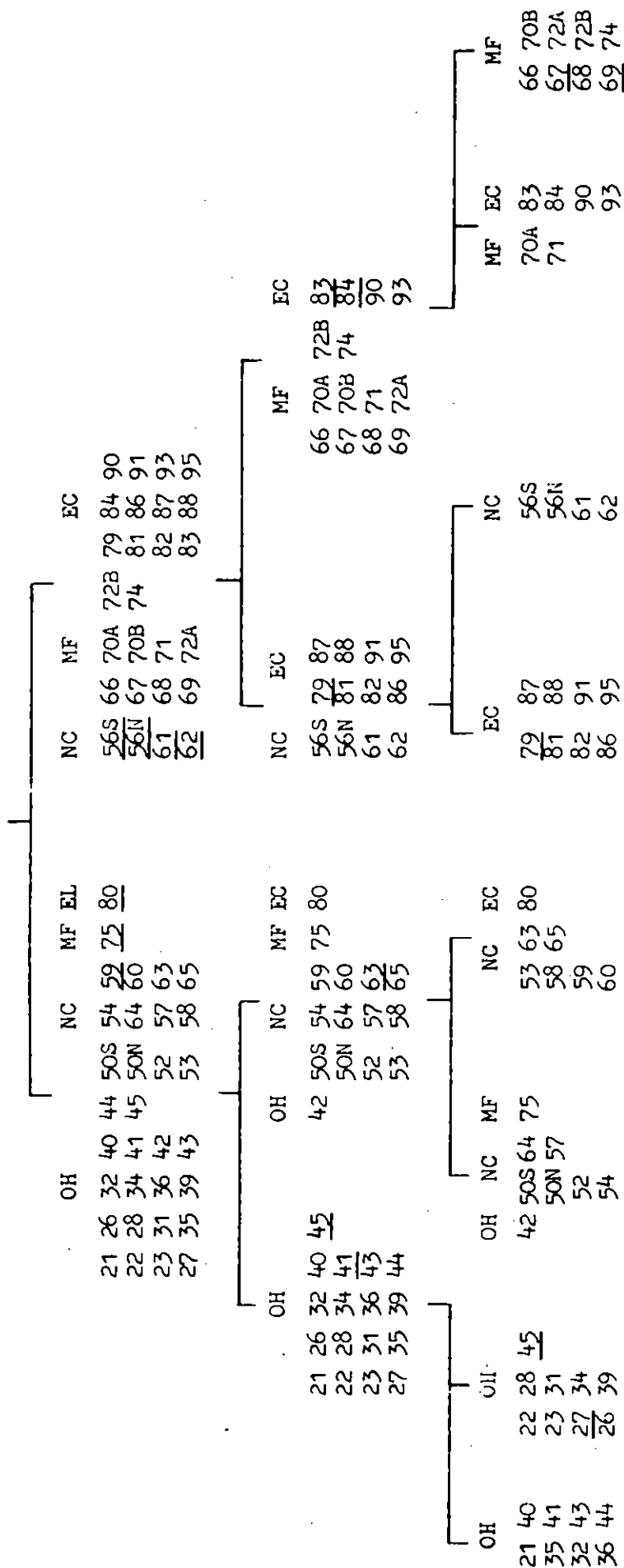


Figure 16 Underlined site numbers have been classified as "borderlines" (see text).

See table 1 for site names

OH = Outer Hebrides
 NC = North Coast
 MF = Moray Firth
 EC = East Coast

(3-2) One half contains the four, almost confluent South Uist sites plus Borge on Benbecula and Baleshare the southernmost site on North Uist, together with Leathann (also on North Uist), Luskentyre in Harris and the three most northerly sites on Lewis, Barvas, Eoropie and Tolsta. The other half contains the six remaining sites on North Uist, Harris and the westernmost pair on Lewis, Uig and Valtos.

(3-3) The single Moray Firth site, Dornoch, separates from the groups of East Coast sites.

(3-4) Clashmore the most westerly Moray Firth site and furthest from the exposed east coast, is grouped with the two most easterly sites of Findhorn and Lossiemouth.

7.3 Coleoptera : Carabidae

First division

All Outer Hebridean sites and most (12/16) of the North Coast sites are grouped together. Achnahaird and Bettyhill are separated together with Redpoint (North and South).

The overall relationship between sites of the four regions is far less distinct than with the other families of Coleoptera, due to a large number being designated as "borderline" cases (fig. 15).

Second division

(2-1), (2-2) The Outer Hebrides sites again remain distinct with Daliburgh and Tolsta as borderlines. Freswick, on the North Coast, is the only other site associated with this group. The division (2-1) includes most of the North Coast sites with a mixture of equal numbers of Moray Firth and East Coast sites. In the division (2-2) only Redpoint (South) and Bettyhill separate from the remainder leaving Redpoint (North) more closely associated with Achnahaird.

Third division

(3-1) Most of the South and North Uist sites split off together with Barvas and Tolsta plus Freswick (North Coast) and Paible as a borderline. The other group consists of the remaining Harris and Lewis sites plus Ormiclate in South Uist with Hosta as a borderline.

(3-2) This is a less clear-cut division with Farr Bay associating with Coul Links (Moray Firth), Morrich More (1 and 2), Culbin Bar (1 and 2) and the southern East Coast sites at Dumbarnie and Gullane.

(3-3) Achnahaird (North Coast, St. Cyrus and Montrose Links and Arbroath separate off from the majority of the Moray Firth and East Coast sites.

(3-4) Bettyhill and Redpoint (South) form single representatives of the two subdivisions.

7.4 Coleoptera : Hydrophilidae to Scolytidae

First division

This provides a convincing split between the Outer Hebrides and North Coast sites on one side and the Moray Firth and East Coast sites on the other. Included with the Outer Hebrides and North Coast are three borderline sites, Strathy, Lossiemouth and Strathbeg. The Moray Firth and East Coast sites included four North Coast borderline sites, Faraid Head (North and South), Reay and Dunnet (fig. 16).

Second division

(2-1) All the Outer Hebrides sites are grouped together except for Valtos which aligns itself with the sites on the north west coast of Sutherland plus four North Coast sites, together with Lossiemouth (Moray Firth) and Strathbeg (East Coast).

(2-2) The borderline North Coast sites of the first division are associated with the majority of the East Coast sites. Only Tentsmuir and Gullane together with the borderline sites, Forvie and Don to Ythan show affinity with the Moray Firth sites (all except Lossiemouth).

Third division

At this level the regional barriers tend to break down and relationships become obscure.

(3-1) A reason for the split of the Uist sites is difficult to see but most of those on Harris and Lewis fall into the same half. Northton is the notable exception taking with it Tolsta which remains a borderline site as it was in the 2-1 split.

(3-2) This division separates Oldshore More from the other north west coastal sites and Bettyhill from the other North Coast sites. Valtos in the Outer Hebrides and Lossiemouth (Moray Firth) exhibit affinities with the north west coast sites whilst Strathbeg on the East Coast is closer to most of the North Coast sites.

(3-3) There is a clear split between the East and North Coast sites although Fraserburgh is a borderline case.

Indicator Species Analysis

ARANEAE

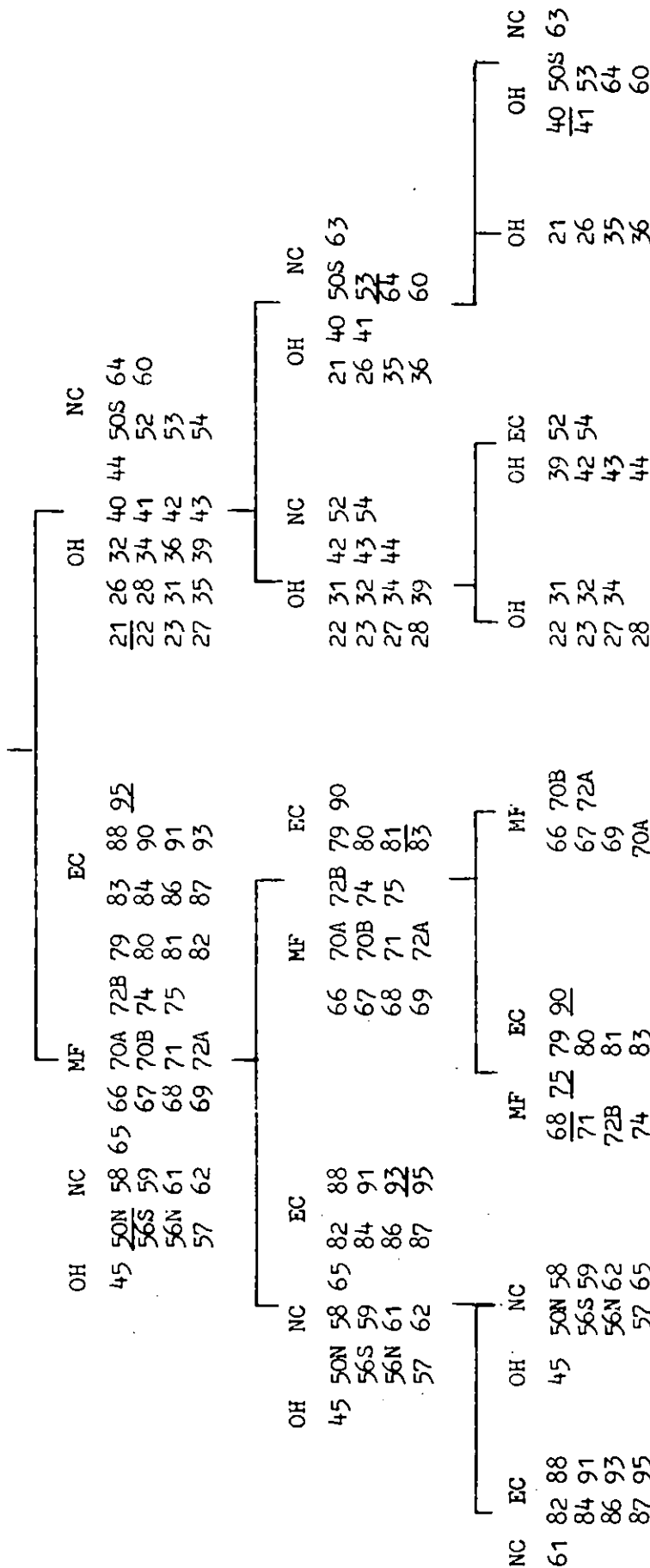
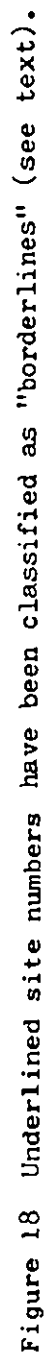


Figure 17 Underlined site numbers have been classified as "borderlines" (see text).

See table 1 for site names

OH = Outer Hebrides
NC = North Coast
MF = Moray Firth
EC = East Coast

MOLLUSCA



OH = Outer Hebrides
NC = North Coast
MF = Moray Firth
EC = East Coast

(3-4) The four East Coast sites split from most of the Moray Firth group but take Morrich More (1) and Whiteness with them.

7.5 Araneae

First division

The Outer Hebrides group of sites together with those on the north west mainland coast are clearly separated from all other sites. The exception is Tolsta in Lewis which seems to have no affinities with the other dune systems in the Outer Hebrides (fig. 17). In the botanical Indicator Species Analysis Tolsta does not behave in this way but remains with the Outer Hebrides group right through to the third division.

Second division

(2-1) At this level the Moray Firth and four East Coast sites separate from equal numbers of North Coast and East Coast sites together with Tolsta. On the other side (2-2) there is a large group of Outer Hebrides sites with two from the North Coast and a smaller group of sites from the same two regions.

Third division

The eight sub-groups formed at this level show the Moray Firth as a distinct group, except for three sites, which are associated with the East Coast. The North Coast sites are also distinct apart from those in the north west and west mainland coast while the Outer Hebrides falls into three groups which do not have clear geographical separation. Relatively slight variations in the species present and their numerical abundance seem to account for the groupings described above.

It is interesting to note that for the Araneae the Outer Hebrides group splits off first in the ISA, whereas the East and North Coast regions do not separate until the third division. They appear, therefore, on this evidence to be closer to each other than either is to the Moray Firth or to the Outer Hebrides. Tolsta maintains its association with the North Coast through all the three divisions. This seems to indicate the strong influence of habitat structure on the fauna which, in this case, runs counter to the climatic trend, for example, number of rain days (Anon, 1978). Although Tolsta is situated in the western climatic zone which is characterised by cool, cloudy and wet summers, a feature shared with other Outer Hebrides sites, its position on the east coast of Lewis shelters it from the prevailing westerly winds. Nevertheless the botanical ISA based on plant species frequencies does not show Tolsta to be different from other Outer Hebrides sites.

7.6 Mollusca

Five sites were eliminated from the analysis because no Mollusca were recorded. These are Ferry Links and Clashmore (both Moray Firth) and Forvie, Don to Ythan and Tentsmuir, all on the East Coast.

First division

This splits off Coul Links, Morrich More (2) and Findhorn (all Moray Firth) from all other sites of which Culbin Bar (1) and Lossiemouth are borderline cases (fig. 18).

Second division

(2-1) The Outer Hebrides sites stay together with only Tolsta as a borderline (cf. Carabidae and Other Coleoptera), and they take all the north west Sutherland sites with them except for Redpoint (North) and half of the North Coast sites. Dornoch in the Moray Firth is associated with this north-western assemblage.

In the other half the remaining five North Coast sites associate with all the East Coast sites (at which Mollusca were recorded) and five Moray Firth sites (four of which are in the southern group).

(2-2) Findhorn separates off from the other two Moray Firth sites, Morrich More (2) and Coul Links.

Third division

(3-1) The Outer Hebrides sites remain as a distinct group associated with five north west coast sites plus Farr Bay and Freswick (North Coast). The four North Coast sites which split off at this level are Bettyhill, Strathy, Reay and Faraid Head (North) with the last as a borderline.

(3-2) Cruden Bay separates from all other East Coast sites in association with Morrich More (1).

8. DIVERSITY INDICES, SINGLE FACTOR ANALYSES OF VARIANCE, CORRELATION COEFFICIENTS AND REGIONAL DIFFERENCES IN THE FAUNAS

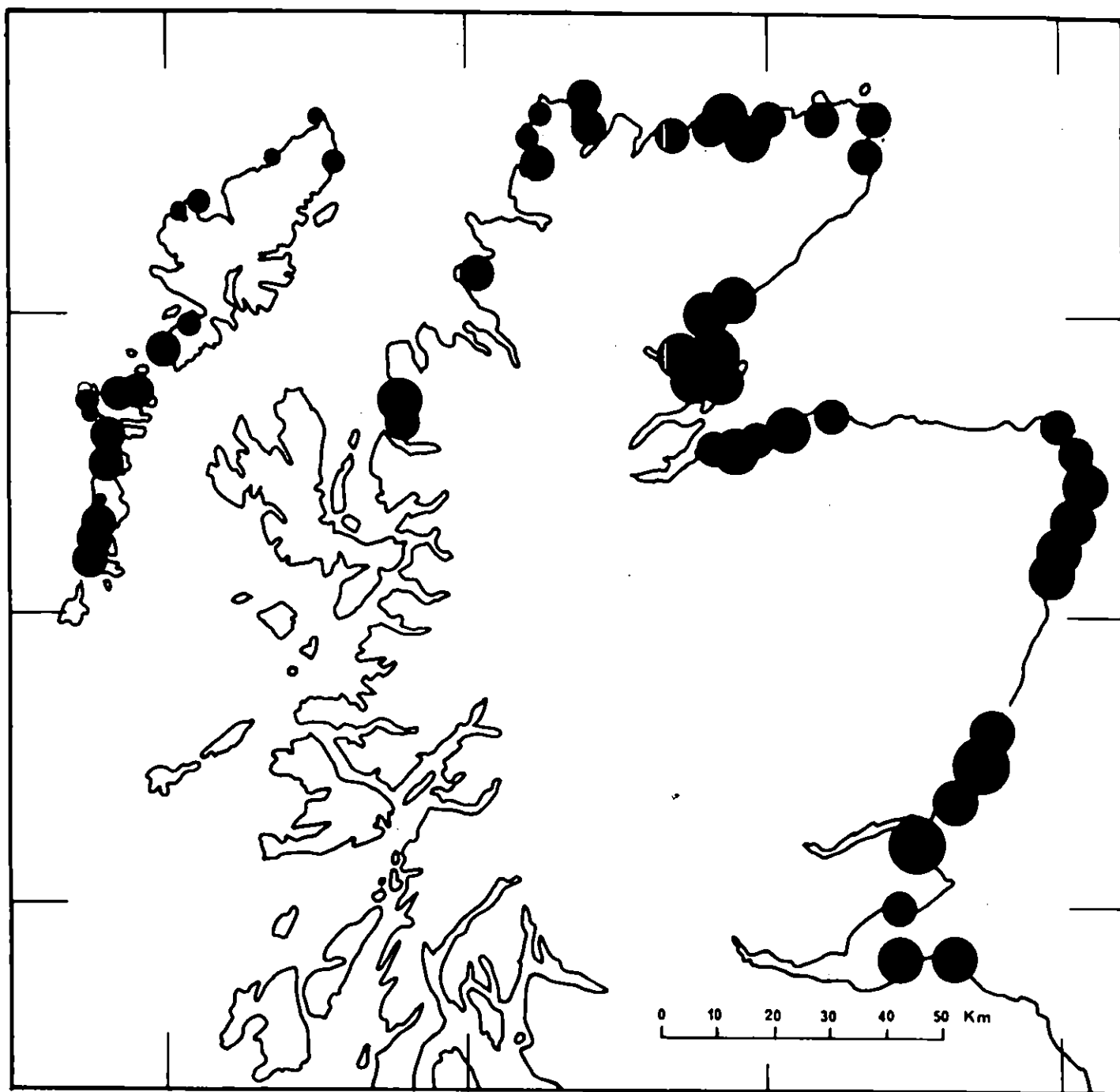
Diversity indices were calculated for each Site using the formulae of Shannon, Simpson and Williams (Southwood 1978). Inspection by eye failed to detect consistent differences between Regions and a Single Factor Analysis of variance on the indices grouped according to the 4 Regions showed on significant differences except in the case of the East Coast (Shannon Index). This Region scored a significant difference at the 0.1% level with the Outer Hebrides and marginally so (at the 5% level) with the North Coast

Table 2 Single Factor Analysis of Variance for the 4 Regions based on the number of species recorded per site. Significance levels are given by ns = no significant difference; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.

		North Coasts	Moray Firth	East Coast
Lepidoptera	(Outer Hebrides	***	***	***
	(North Coast		***	***
	(Moray Firth			ns
Coleoptera (Carabidae)	(Outer Hebrides	***	*	ns
	(North Coast		.	***
	(Moray Firth			**
Coleoptera (other families)	(Outer Hebrides	ns	**	**
	(North Coast		ns	**
	(Moray Firth			***
Araneae	(Outer Hebrides	**	***	***
	(North Coast		ns	***
	(Moray Firth			***

Table 3 Mean number of species recorded per site for each of the four geographical regions.

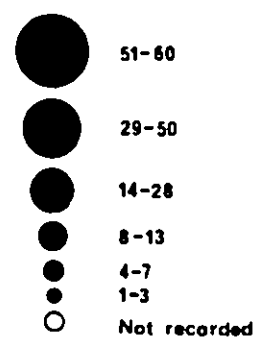
	Outer Hebrides	North Coast	Moray Firth	East Coast
All invertebrate groups	75	86	94	135
Lepidoptera	9	22	35	38
Araneae	12	18	20	24
Carabidae	11	7	9	12
Other Coleoptera (Hydrophilidae to Scolytidae)	36	31	26	49
Mollusca (land snails)	6	5	2	4

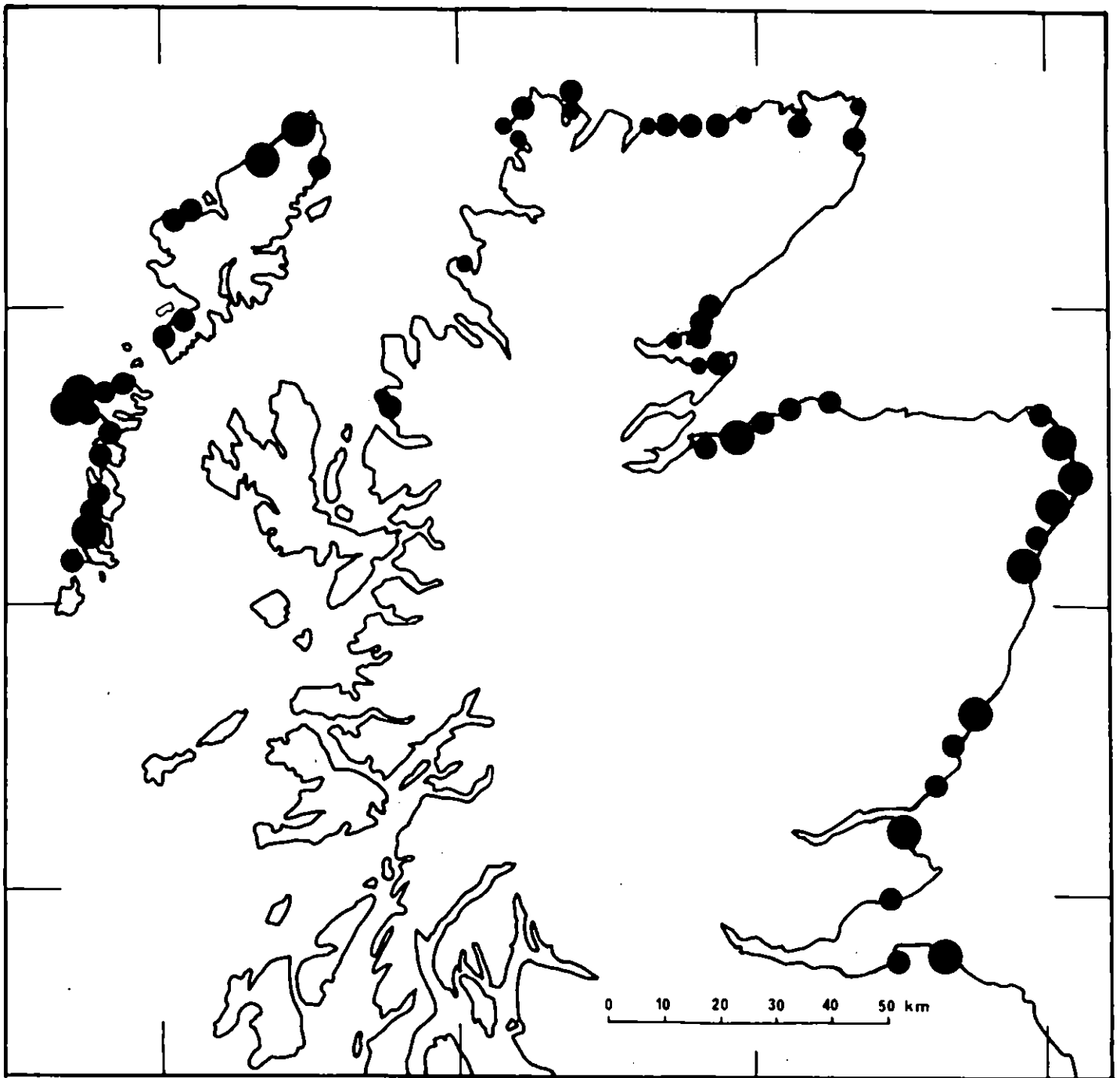


LEPIDOPTERA

Map 2

Species recorded per site

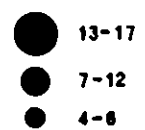




CARABIDAE

Map 3

Species recorded per site

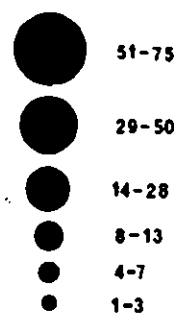




COLEOPTERA (HYDROPHILIDAE-SCOLYTIDAE)

Map 4

Species recorded per site

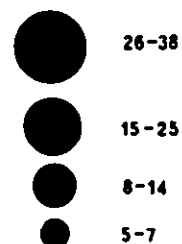


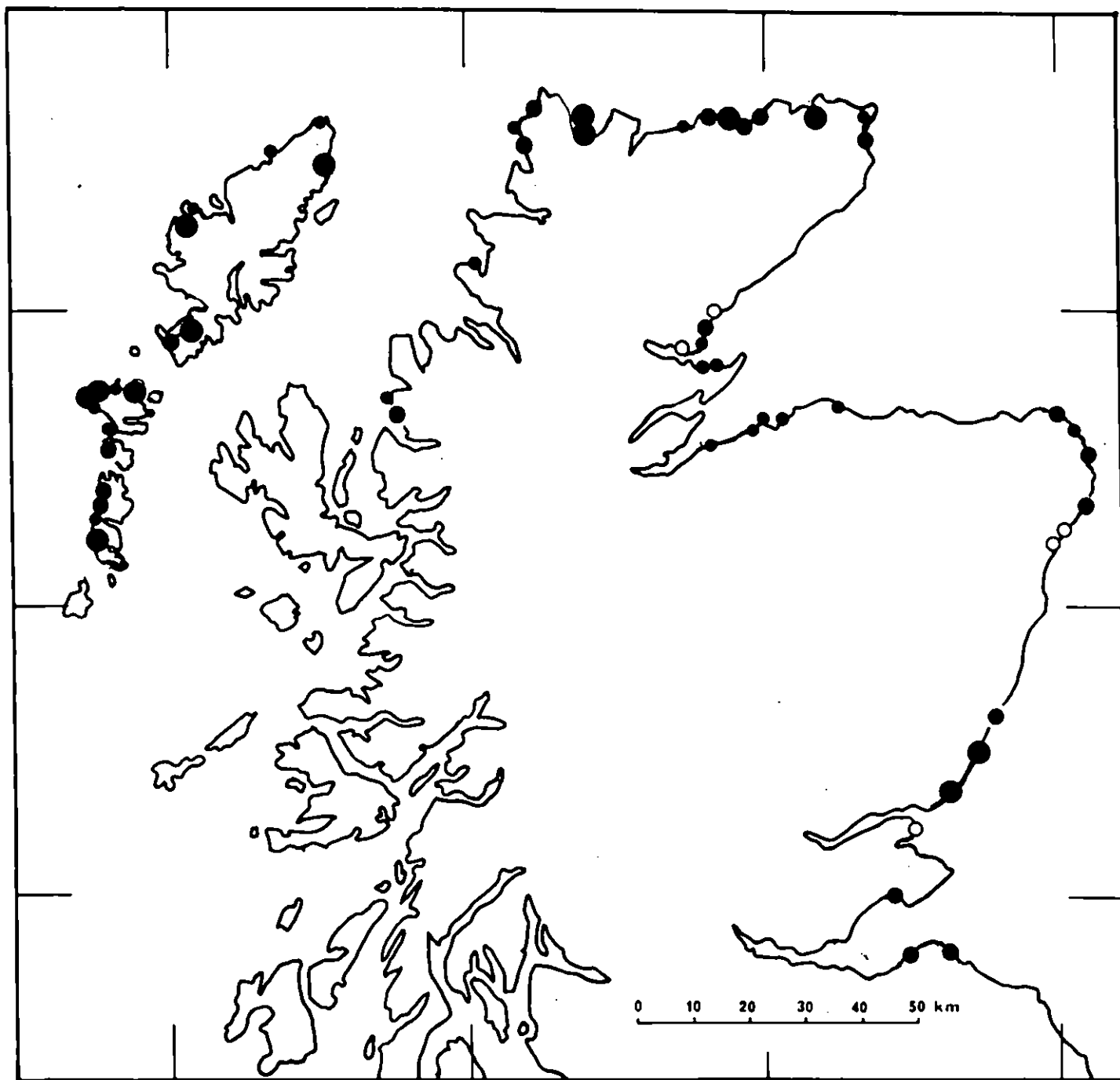


ARANEAE

Map 5

Species recorded per site





MOLLUSCA

Map 6

Species recorded per site

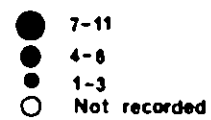
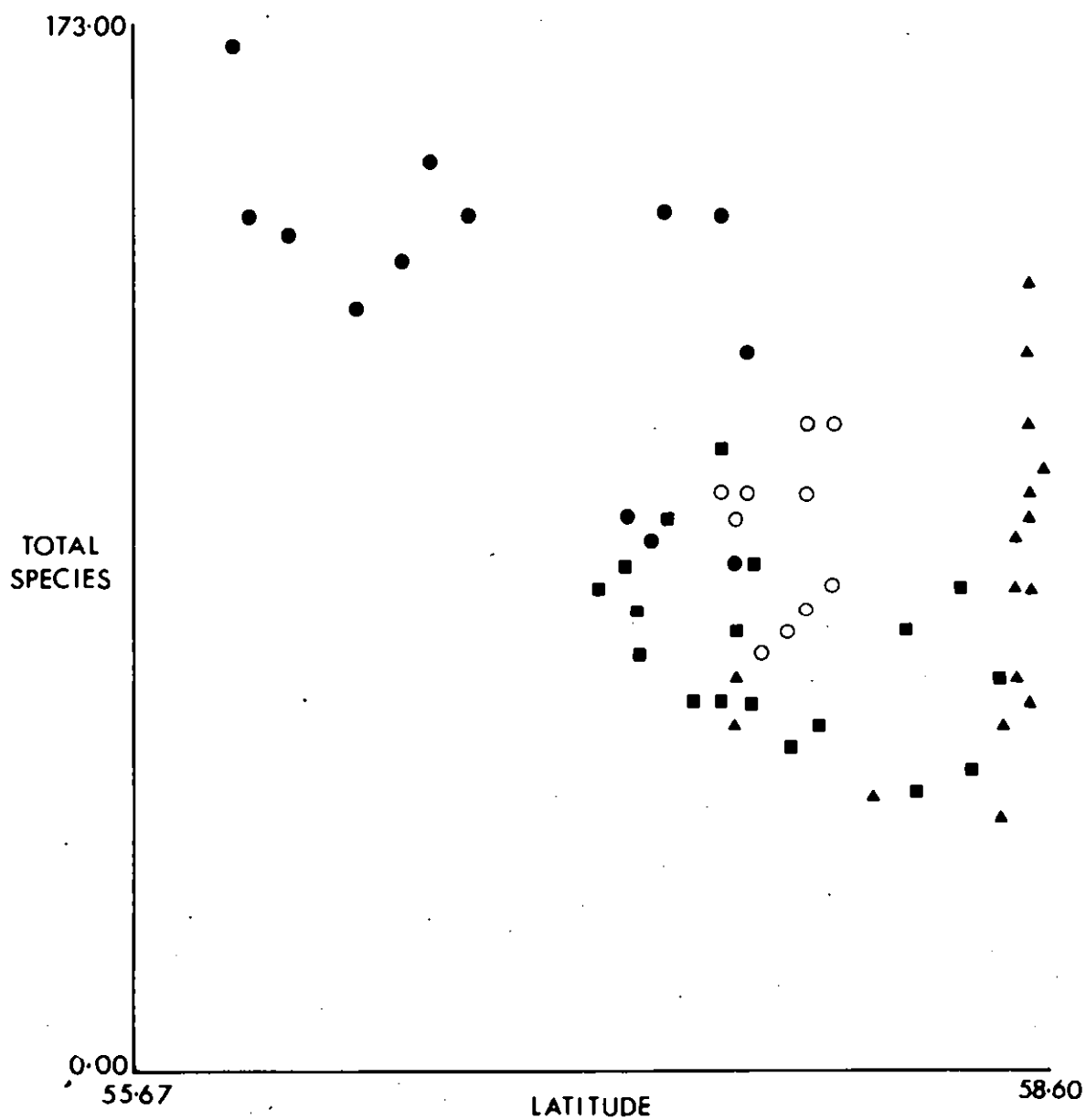


Table 4 Mean number of specimens recorded per site for each of the
four geographical regions.

	Outer Hebrides	North Coast	Moray Firth	East Coast
All invertebrate groups	3187	1242	1752	1918
Lepidoptera	132	252	423	617
Araneae	313	234	195	377
Carabidae	507	199	612	153
Other Coleoptera (Hydrophilidae to Scolytidae)	1027	322	171	479
Mollusca (land snails)	1121	156	7	46

Table 5 Correlation coefficients and significance levels for number of species recorded per site in five invertebrate groups against latitude.

All Regions combined	Lat. x Leps.	R = -0.431	(P 0.01)
	Lat. x Carabs.	R = -0.455	(P 0.01)
	Lat. x Other Col.	R = -0.397	(P 0.01)
	Lat. x Spiders	R = -0.37	(P 0.01)
	Lat. x Mollusca	R = 0.062	(N.S.)
	Lat. x Total spp.	R = -0.548	(P 0.01)



and Moray Firth sites.

A Single Factor Analysis of Variance and 't' test of (i) the total species for all groups and (ii) the total specimens for all groups for the four Regions confirmed the differences between the East Coast sites and the other three areas with $P = 0.001$ in the case of (i). The analysis for (ii) showed that the Outer Hebrides was consistently different from the other Regions, the significance level varying from $P = 0.001$ to $P = 0.005$.

This type of analysis was also calculated for each of the four major invertebrate groups (Lepidoptera, Carabidae, other families of Coleoptera and Araneae) and the four Regions again compared (table 2). The Lepidoptera show significant differences in all cases except between the East Coast and Moray Firth sites, a result not unexpected. The East Coast sites show their distinctiveness again when the other invertebrate groups are compared although the significance levels are lower except for the Araneae. In the last case the North Coast shows links with both the Outer Hebrides and the Moray Firth.

In table 3 the mean numbers of species recorded per site for all invertebrate groups are listed for each geographical region. The figures show a trend of increasing species richness from the Outer Hebrides in the west through the North Coast, Moray Firth to the East Coast.

The same trend is shown by some of the invertebrate groups when considered separately (table 3), for example the Lepidoptera and the Araneae. On the other hand there is no trend in the numbers of species of Carabidae nor with the other families of Coleoptera (Hydrophilidae to Scolytidae) and the Mollusca (land snails) show an inverse relationship, no doubt as a response to the calcareous shell sand of the Outer Hebrides sites. The figures for the Diplopoda and Isopoda are too small for conclusions to be drawn. Maps 2-6 show the numbers of species recorded per site expressed as components of six size groups. Examination by eye confirms the data in table 3 with more species of Lepidoptera and Araneae on the East Coast sites, more Mollusca species in the Outer Hebrides and North Coast while the two groups of Coleoptera show no clear patterns.

If the mean numbers of specimens taken per site for each region are compared (table 4) only the Lepidoptera and Mollusca clearly show the same trend. It is particularly obvious with the latter group which was much more abundant on the Outer Hebrides dune sites. The two groups of Coleoptera are again variable and no trend is detectable in numbers of Araneae because a few of the species on some western sites were very

numerous and so balanced the richer fauna on the East Coast.

Although the figures in tables 3 and 4 suggest considerable differences between the faunas of the east and west coasts the trend lies in a northeast - northwest direction, the richest East Coast sites lying about 128 km further south than the southernmost Outer Hebrides site. The north-south component in this trend can be shown by calculating correlation coefficients for number of species per site against latitude (table 5). The value of R for the Mollusca was very low but for all other groups the correlation coefficients were negative and significant at the 0.01 level. The same data were plotted on a scatter diagram (fig. 19) of total species per site against latitude. Excepting the North Coast sites, most of which are at 58°60'N, the other three regions show a fall in the number of species with increasing latitude although the overlap is considerable. Reference should also be made to the distribution maps (2 to 6 incl.) which illustrate species totals per site.

The climatic features of Scotland follow, to some extent, the regional differences in the fauna (Anon, 1978). The July isotherm means fall off along a line from southeast to northwest with a temperature difference of about 2°C between the most widely separated sites. The January isotherm mean shows a similar difference of 1.5 to 2°C but in this case the higher temperature is recorded in the northwest. The annual rainfall distribution is markedly east-west but the differences along the coasts, whether east, north or west, are minimised compared with the differences between mountains and lowlands. In general, the Moray Firth group and the more southern East Coast sites have less than 750 mm/year while in the west the rainfall is in the range 1000-1500 mm/year. There is a sharp east-west trend in the number of rain-days over the area studied with most of the East Coast and Moray Firth either a little below or a little above the 140 days/year line while in the west coast the majority of the sites are in the 200-220 rain-days zone. The climatic data may be summarised in very general terms as grading from a cool and moist northwest to a warmer and drier southeast.

This is undoubtedly an important factor in determining the distribution of species but other environmental features appear to be equally significant. These will be discussed in detail in the following sections which describe the occurrence and distribution of species in the different invertebrate groups. In general there was greater habitat diversity on the East Coast sites which included scrub and woodland, than in the west. This difference increased the number of Lepidoptera species, for example, taken in the light

FIGURE 20 MACROLEPIDOPTERA CAUGHT IN THE ROTHAMSTED TRAP ON BENBECULA DURING 1976.

Graph = Windspeed at Midnight G.M.T.

Columns = No. of specimens (shaded area = no. of species.)

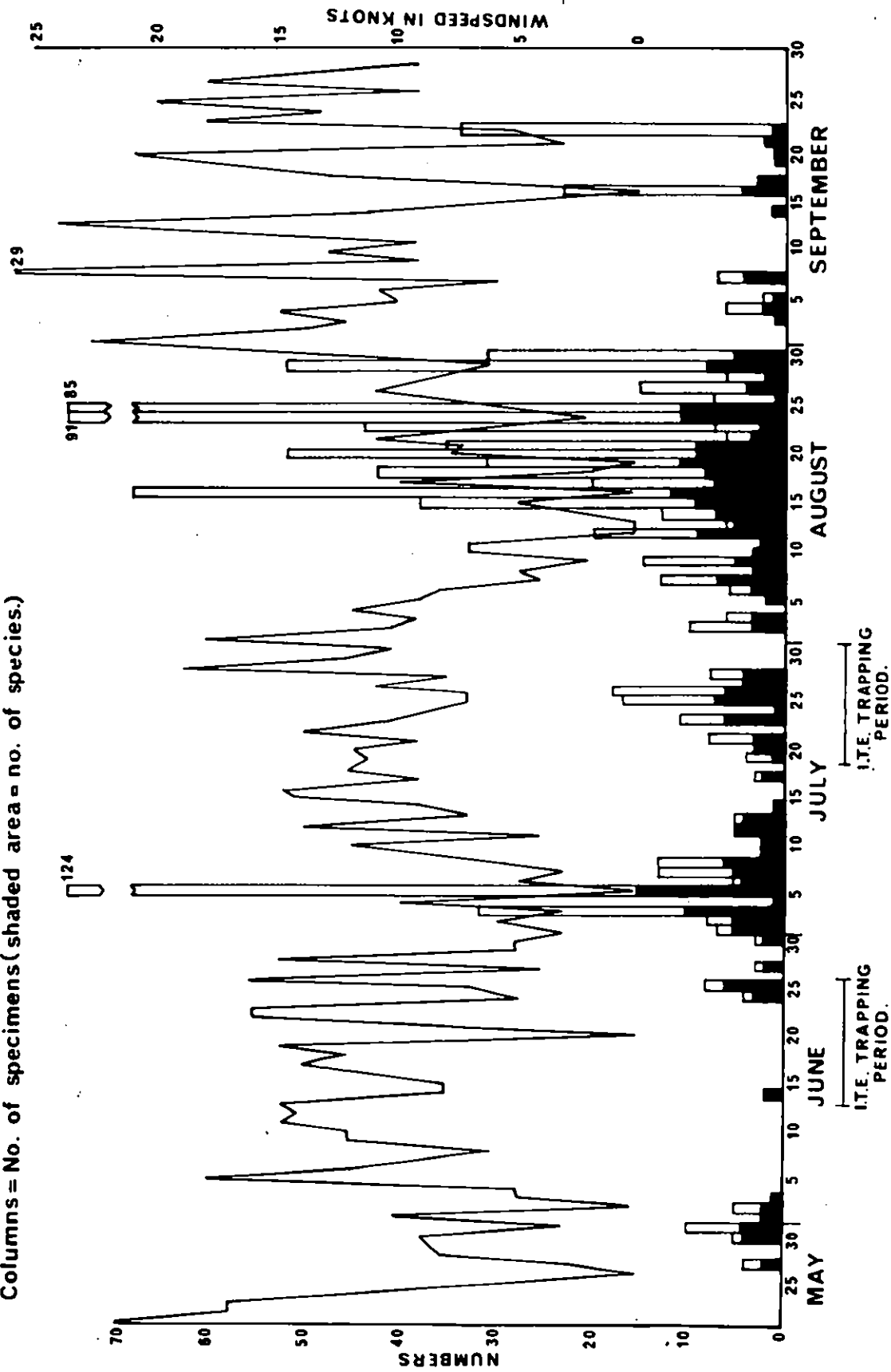
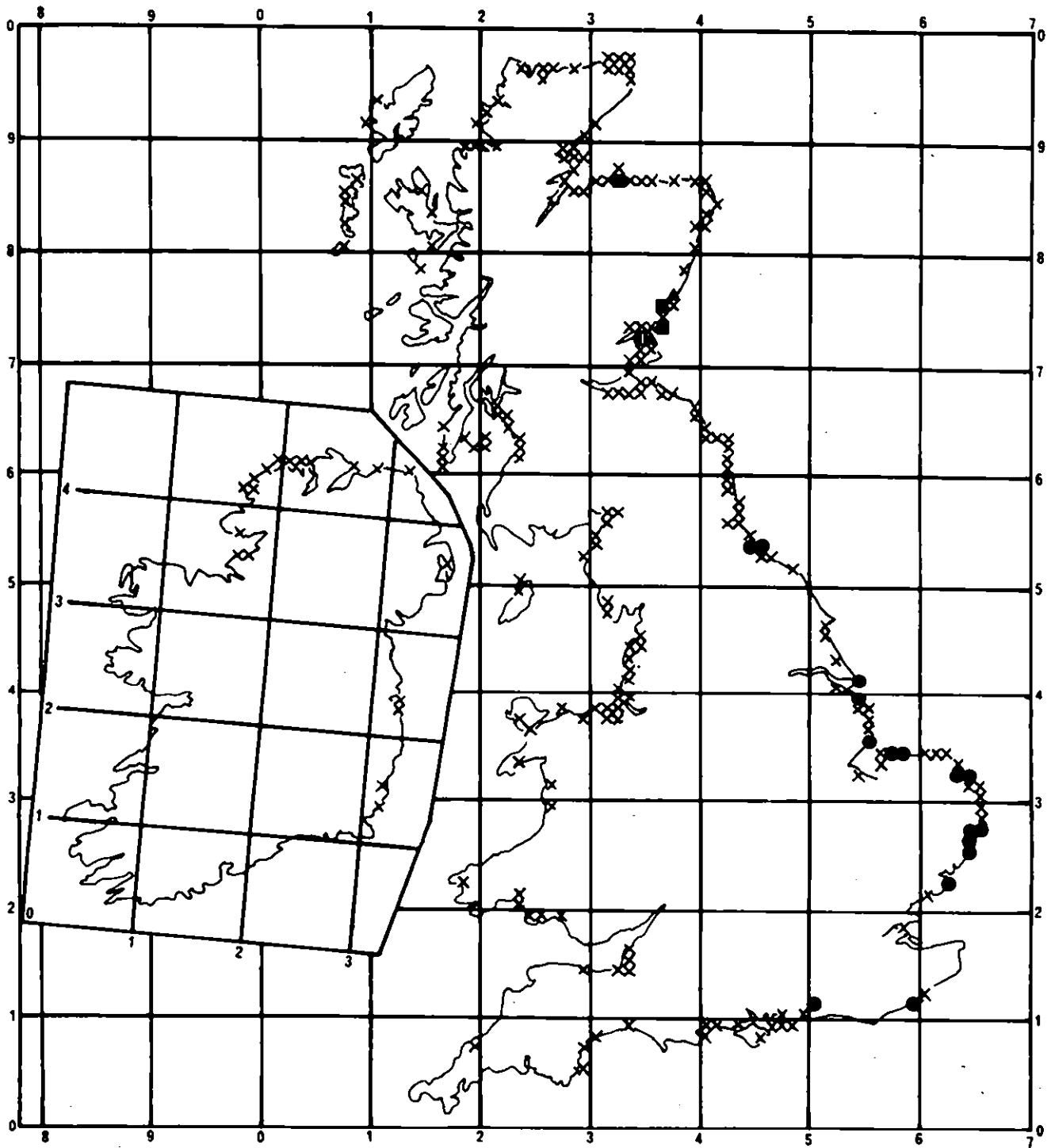


Table 6 Numbers of 10 common species of Lepidoptera taken in the four
Regions to show differences between 1976 and 1977.

No. light traps ()	1976 Hebrides (18)		1976 North Coast (16)		1977 Moray Firth (11)		1977 East Coast (13)	
	June	July	June	July	June	July	June	July
<i>Hada nana</i>	8	-	86	-	70	8	83	-
<i>Rusina ferruginea</i>	-	-	45	-	99	5	153	-
<i>Agrotis exclamationis</i>	-	-	15	-	19	63	126	9
<i>Oligia fasciuncula</i>	-	-	3	-	2	81	25	8
<i>Camptogramma bilineata</i>	-	-	5	1	-	41	9	46
<i>Autographa pulchrina</i>	-	7	2	11	-	-	6	14
<i>Diachrysia chrysitis</i>	-	7	1	16	-	1	1	20
<i>Mesapamea secalis</i>	-	1068	-	102	-	22	-	325
<i>Euxoa tritici</i>	-	80	-	717	-	-	-	2294
<i>Euxoa cursoria</i>	-	-	-	147	-	-	-	15

Map7 Distribution in the British Isles of Photedes elymi and
its foodplant Elymus arenarius



PHOTEDES ELYMI

ELYMUS ARENARIUS

- Records from survey
- ▲ Records from survey confirming other records
- Other records

x Records from Perring and Walters(1976)

traps. Similarly the wider range of ground vegetation types on the East Coast dunes increased the structural variety of the habitats available to the Araneae and so influenced species richness. For example the distribution maps (36-46) show that several species extended into Scotland mainly along the east coast. The land snails are particularly favoured by the calcareous machair dunes of the Outer Hebrides and northwest Scottish mainland but the higher rainfall and greater number of rain days in that region may also be a contributory factor to the much higher numbers recorded. However it is not possible to distinguish between the influence of climate and habitat although it is a reasonable assumption that both have a significant effect on numbers and species of invertebrate animals.

9-13 DETAILED ACCOUNTS OF EACH INVERTEBRATE GROUP

Sections 6, 7 and 8 were primarily concerned with analyses which illustrated the relationships between Sites and between Regions as shown by the most important invertebrate groups. In this Section each group is considered in more detail with particular reference to those species for which there is available information on behaviour, habitat preferences, food plants and ecology in relation to their occurrence on Scottish sand dunes.

9. LEPIDOPTERA

Totals of 19,055 specimens and 157 species of Macrolepidoptera were taken in the light traps at 57 out of the 58 dune sites. (Hosta was abandoned as unsuitable. See Site Report 32, Vol.II). The light traps operated for 14 to 18 nights, depending on local circumstances, during the latter parts of June and July (fig.2). However, in the Outer Hebrides the Rothamsted trap on Benbecula showed that the catches of moths were higher during the latter part of the summer, that is in July and August 1976. Records from the same trap showed that periods of low catches, coincided with the weeks when the Survey traps were in operation. This included the June sample when the Benbecula trap recorded no catch on 10 out of the 13 nights covered by the I.T.E. Survey. The highest numbers of species and individuals were recorded in August by the Benbecula trap, apart from one night in early July. When catch totals are related to meteorological data, windspeed can be shown to exert an important influence on insect activity in the Outer Hebrides where all sites (except Tolsta) were on the exposed west coast (fig. 20). Temperature and rainfall during the months prior to emergence also play a significant role in determining population size of many insects (Williams 1951, 1961). Local weather conditions during the Survey are summarised in Section 5.

The relative abundance and phenology of species can be expected to vary from year to year and there is some evidence of this in the Moray Firth catches which were taken in 1977, (table 6). The July trapping period in 1977 also commenced five days earlier than in 1976 allowing both the June and July periods to coincide with the new moon period.

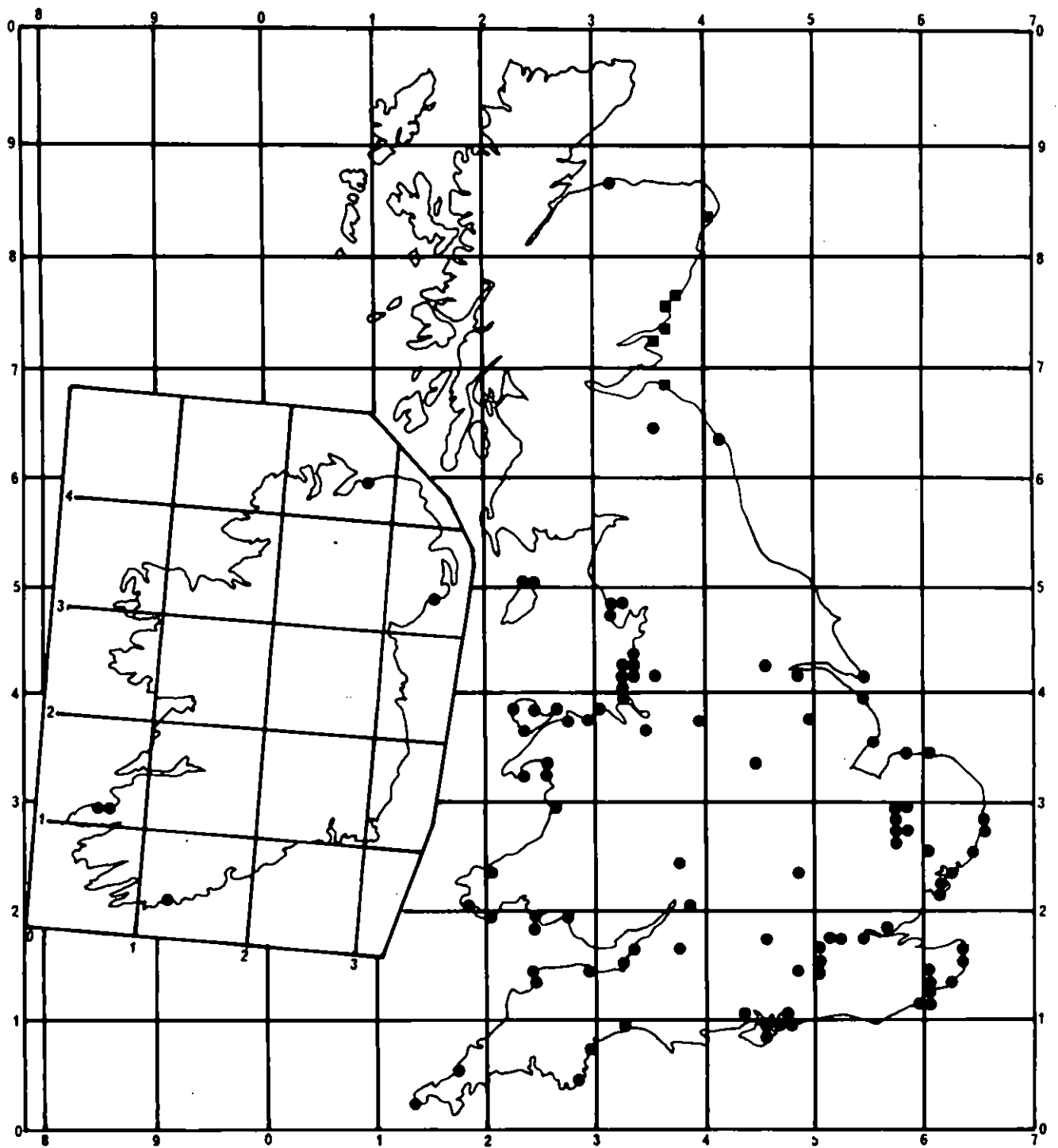
The figures in table 6 show that Hada nana occurred in the July samples only from the Moray Firth sites, whilst Agrostis exclamationis and Oligia fasciuncula were either confined to the June samples or were most numerous during that month on the North Coast and East Coast sites respectively, but most abundant in the July samples from the Moray Firth sites. Euxoa tritici occurred widely in three regions but was apparently absent from the Moray Firth although earlier records are known. The adult emerges in July and August, but may have been late in 1977 and so missed.

The highest species total, was recorded at Lunan Bay with 60 species and over 1000 specimens. Only three of these species were not trapped elsewhere but Tentsmuir which scored 54 species included nine which were not taken on any other site. E.C. Pelham-Clinton (pers. com.) collected Macrolepidoptera at Tentsmuir on several occasions from May to October 1970 and recorded 129 species. 43 of the 54 species collected in the ITE trap on this site were included in his list. Strathbeg produced the lowest catch of the East Coast or Moray Firth sites with only 15 species and 29 specimens. Only two specimens of two species were taken during the first trapping period although the trap functioned correctly. Borge (Outer Hebrides) produced the largest catch for the combined Regions, Outer Hebrides and North Coast, Mesapamea secalis making up 64% of the total with 446 specimens.

Most of the species recorded are associated with open areas, especially grassland, and a few are specific to sand dunes. Others are species of heath or scrub, a few of mountains and moorland while a large number occur in many different habitats. In addition many woodland species were taken especially where deciduous or coniferous woodland was present in the vicinity of the site.

9.1 Sand dune species

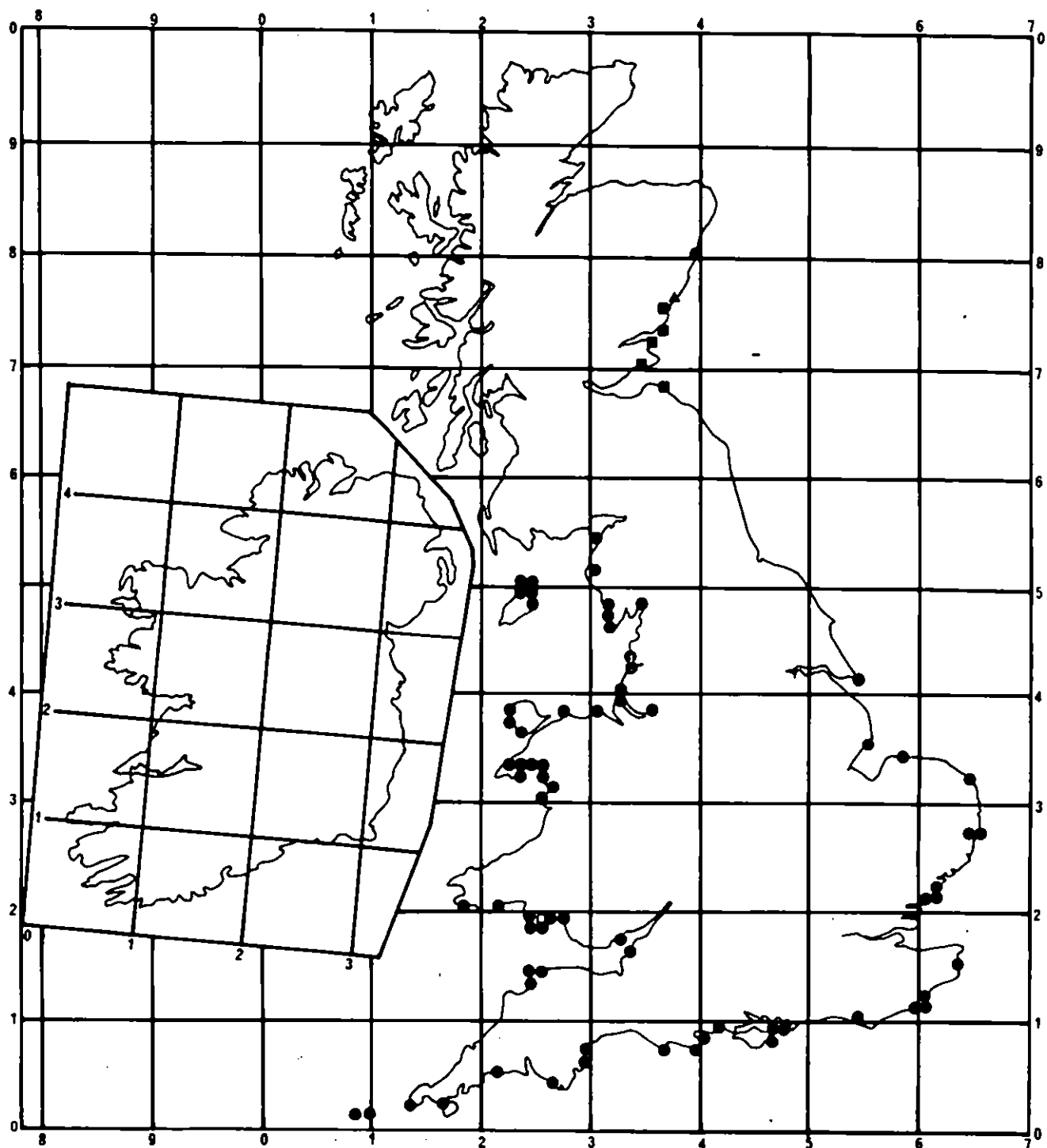
Several sand dune species were taken together with others which are more frequent on or near the coast than elsewhere. Photodes elymi (map 7) has a scattered distribution in Britain confined almost exclusively to the east coast. It feeds only on Elymus arenarius (Lyme grass) a local plant of sand dunes (map 7). Two specimens were taken at Lossiemouth in July, which is at the northern limit of its known range in Britain. It has been



SIDERIDIS ALBICOLON

- Records from survey
- Other records

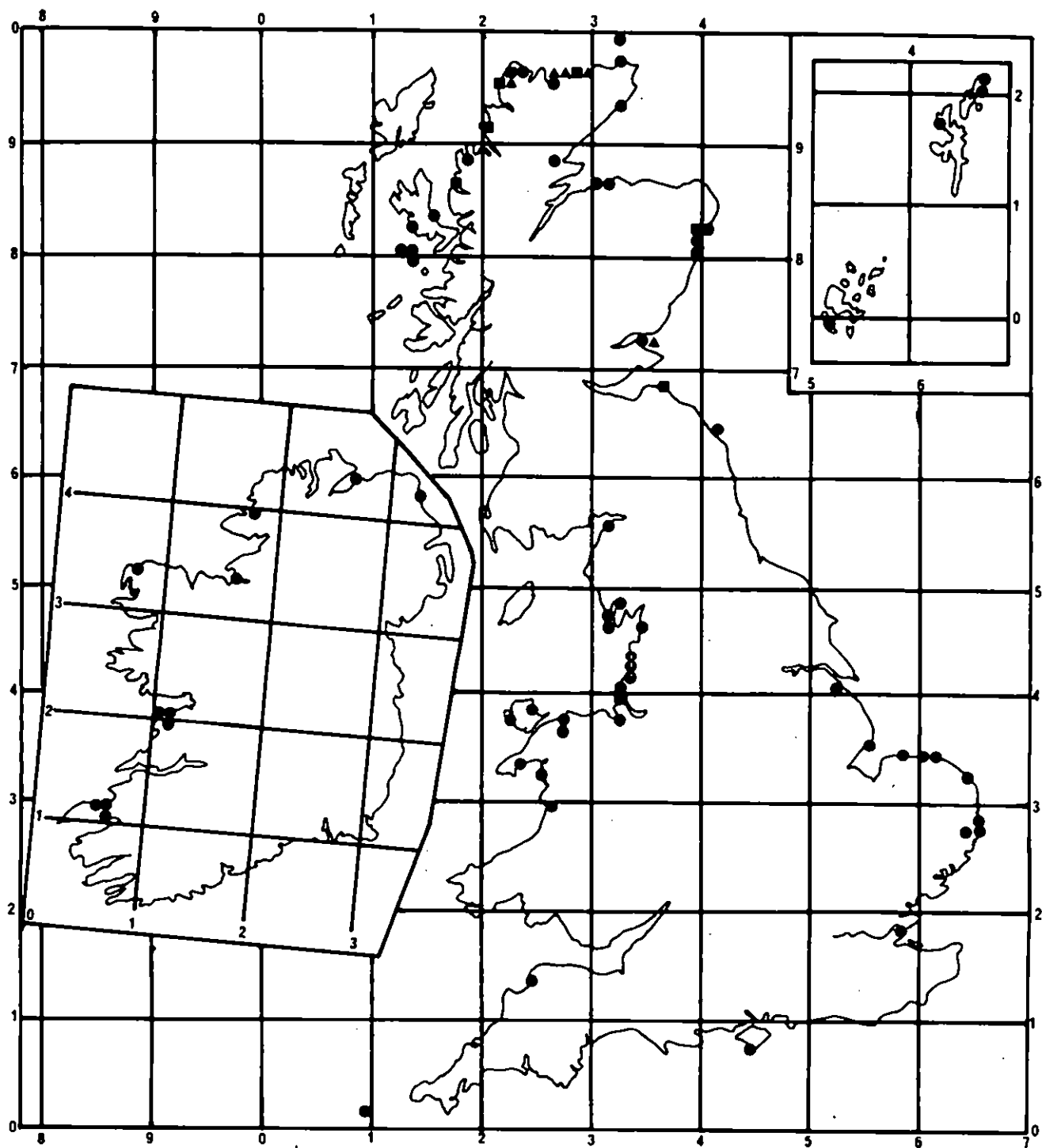
Map 8



AGROTIS RIPAE

- Records from survey
- ▲ Records from survey confirming other records
- Other records

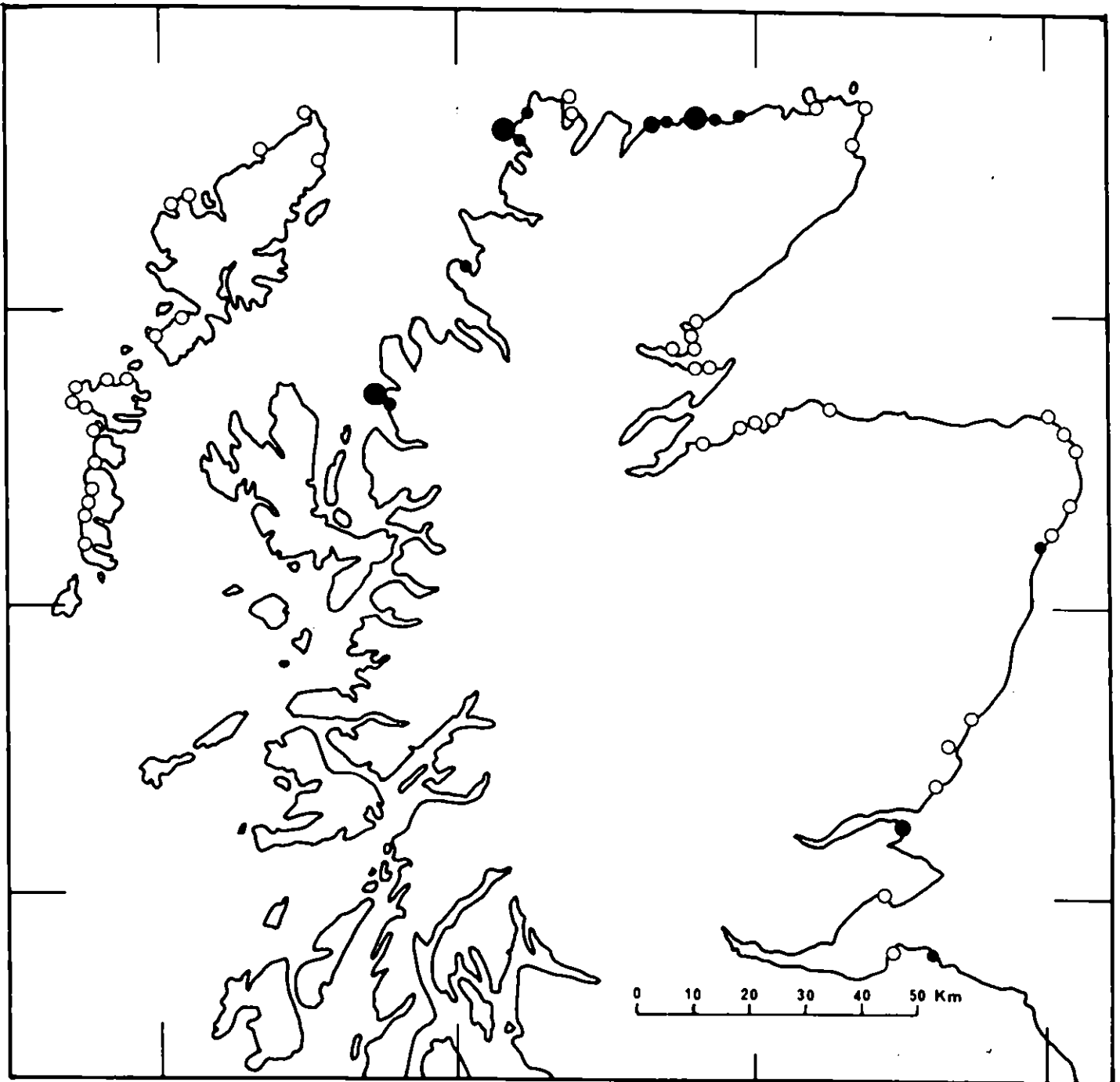
Map 9



EUXOA CURSORIA

- Records from survey
- ▲ Records from survey confirming other records
- Other records

Map 10

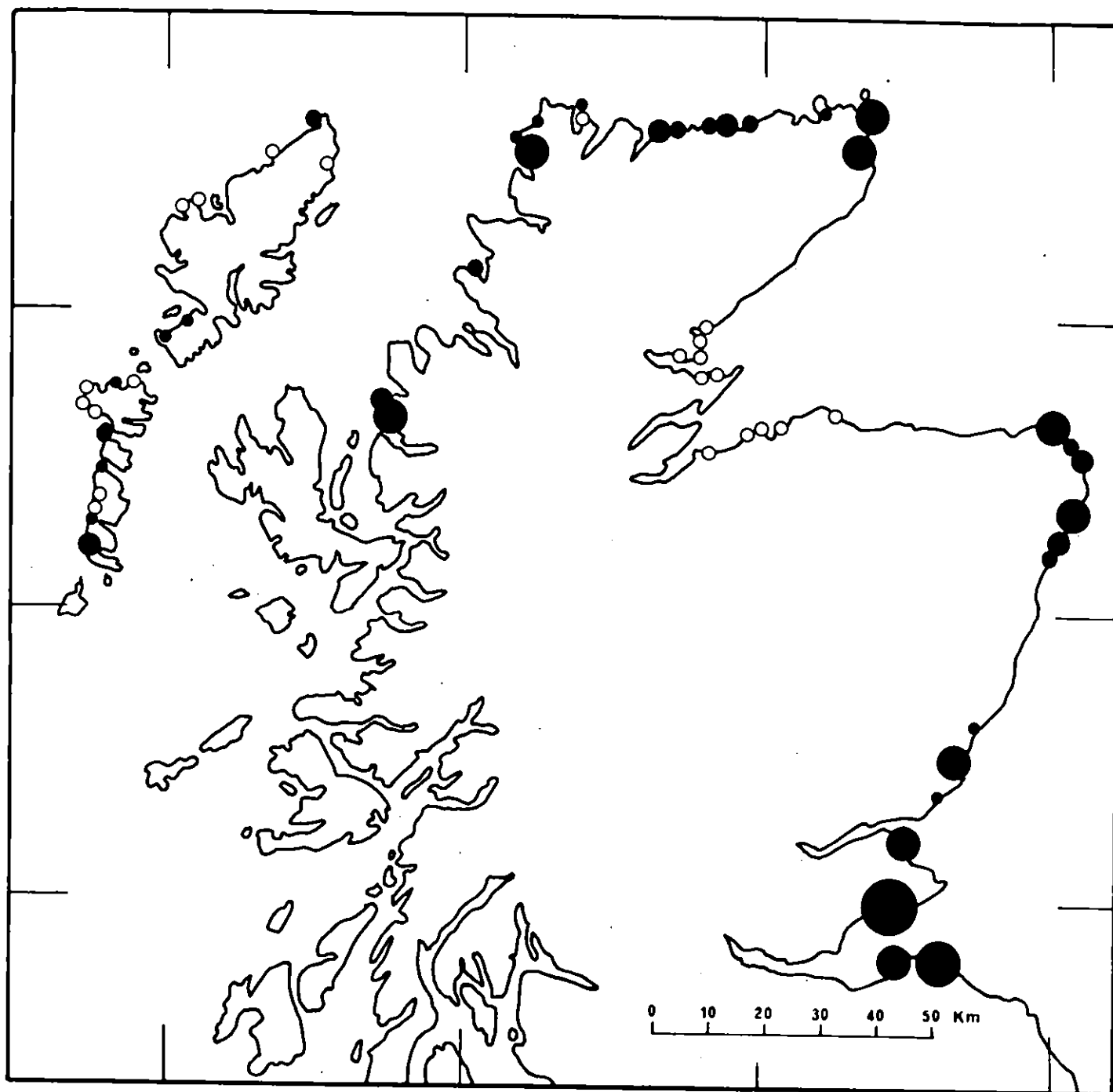


EUXOA CURSORIA

Map 11

Specimens recorded per site

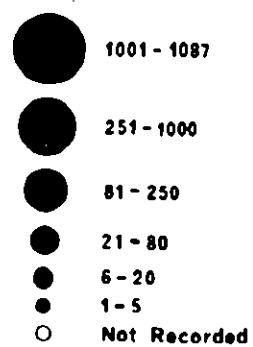
- 21 - 45
- 6 - 20
- 1 - 5
- Not Recorded

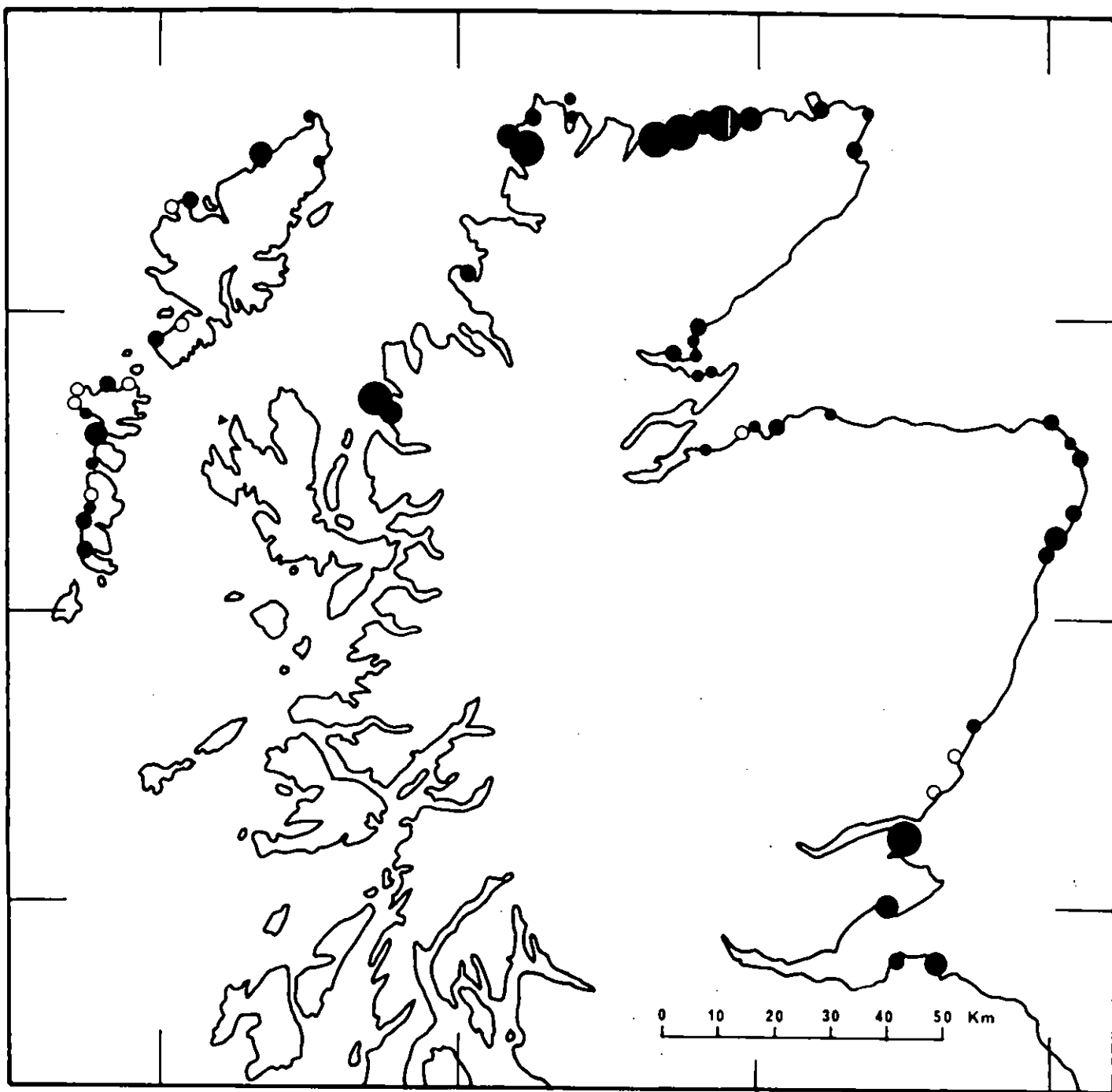


EUXOA TRITICI

Map 12

Specimens recorded per site

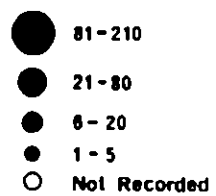


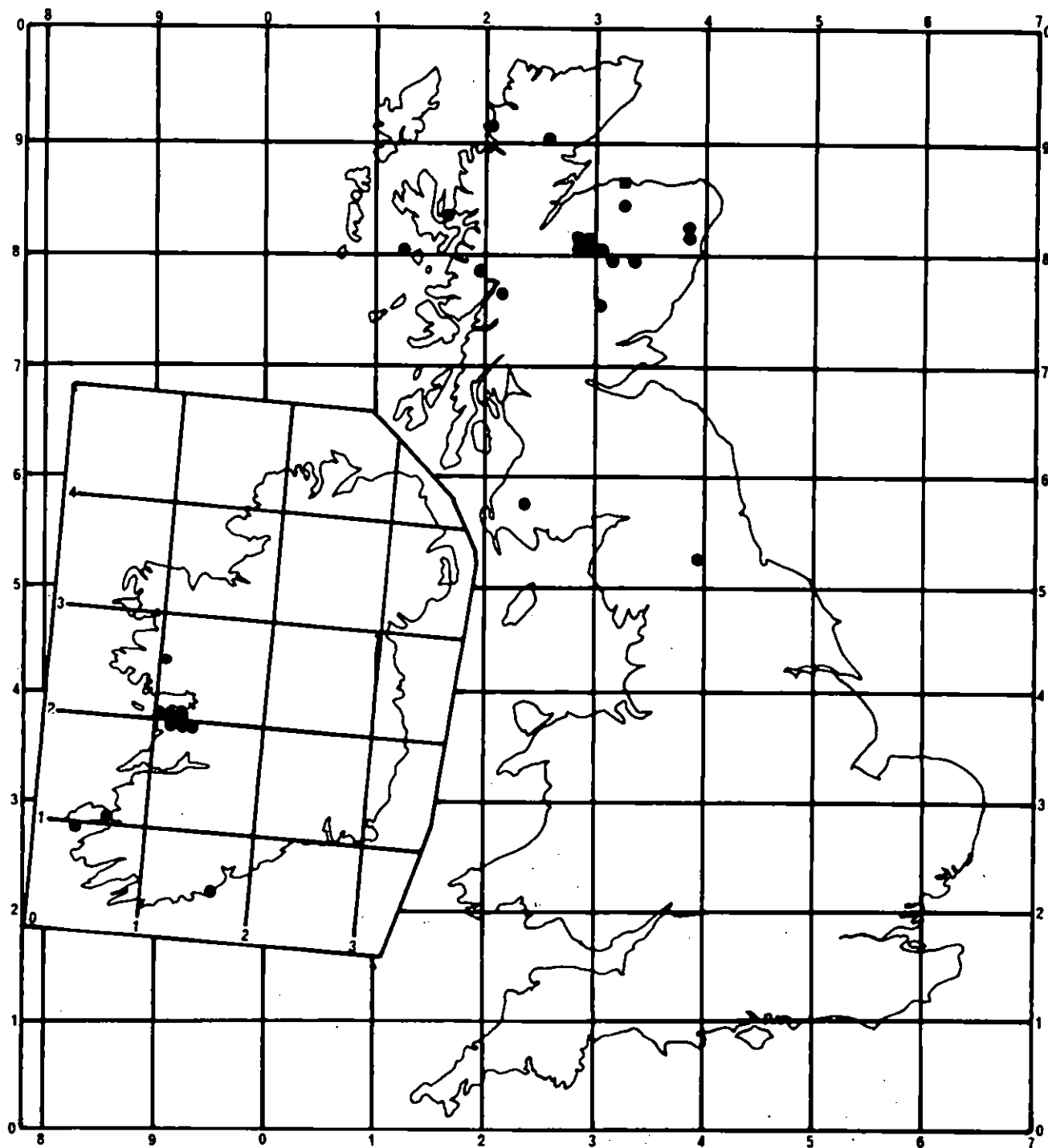


AGROTIS VESTIGIALIS

Map 13

Specimens recorded per site





ACRONICTA EUPHORBIAE

- Record from survey
- Other records

Map 14

recorded at Findhorn in recent years by Harman (1971) and Brown (1976). During the Survey it was also taken at four sites south of Lossiemouth on the East Coast confirming previous records for two 10 km squares and providing new records for two others. On the continent the species occurs on the west coast of Norway to 60°N and around the Baltic reaching 66°N. Lossiemouth is at 57°N. Sideridis albicolon (map 8), another species preferring sandy areas, produced new records for six 10 km squares, which apart from an old record for the Moray Firth (10 km square 38/16), are the most northern known records for Britain. These give some support to South's (1961) statement that "In Scotland it occurs on suitable parts of the east coast to Aberdeen and on the west coast to Clyde". The larvae feed on several maritime plants including Atriplex laciniata, Calystegia soldanella and Plantago maritima (K. Noble pers. com.). According to South (1961) it feeds on Plantago spp. and Taraxicum officinale and various other species not necessarily found near the sea, which may explain why the species has been recorded at a number of inland localities such as the Bagshot sands and the Breckland heaths of East Anglia.

Agrotis ripae (map 9) is a species of sandy coasts and feeds on maritime plants, notably Cakile maritima, Salsola kali and Eryngium maritimum. South (1961) considered it rare in Scotland and recent records include only two 10 km squares, both on the east coast. It was discovered by Dr M.W. Harper at St. Cyrus NNR (10 km square 37/76) in 1974 and by R.M. Palmer at Balmedie Bay (10 km square 38/91) in 1975. Palmer and Young (1977) record these as new records for Kincardineshire and Aberdeenshire (Vice-counties 91 and 92) respectively. The survey provided new records for five 10 km squares and confirmed the record for St. Cyrus NNR.

Euxoa cursoria, (maps 10 and 11), was taken at eleven of the North Coast sites (147 specimens) but elsewhere only at three East Coast sites (15 specimens). It has a scattered but widespread distribution in the British Isles where it occurs mostly on extensive sand dune formations northwards from Suffolk and Cheshire (South 1961, B. Goater, pers. comm.). The Survey results suggest that this species may be more widespread on the north coast of Scotland than earlier records indicate. Rosie (1976) records it as widely distributed along and near the coast of Caithness (Vice-county 109) and it has been recorded from the Moray Firth especially at Findhorn. The adult flight period is from late July to September but due to the lateness of the season in 1977 and the trapping period being five days earlier it may not have emerged when the light traps were operating.

Euxoa tritici was present in all regions except the Moray Firth (map 12 and table 6), probably for the same reason as the previous species. It was particularly common on the North and East Coasts, and although frequent on sand dunes it is not restricted to them. This species produced by far the largest individual total for any species at a particular site with 1087 specimens taken at Tynninghame.

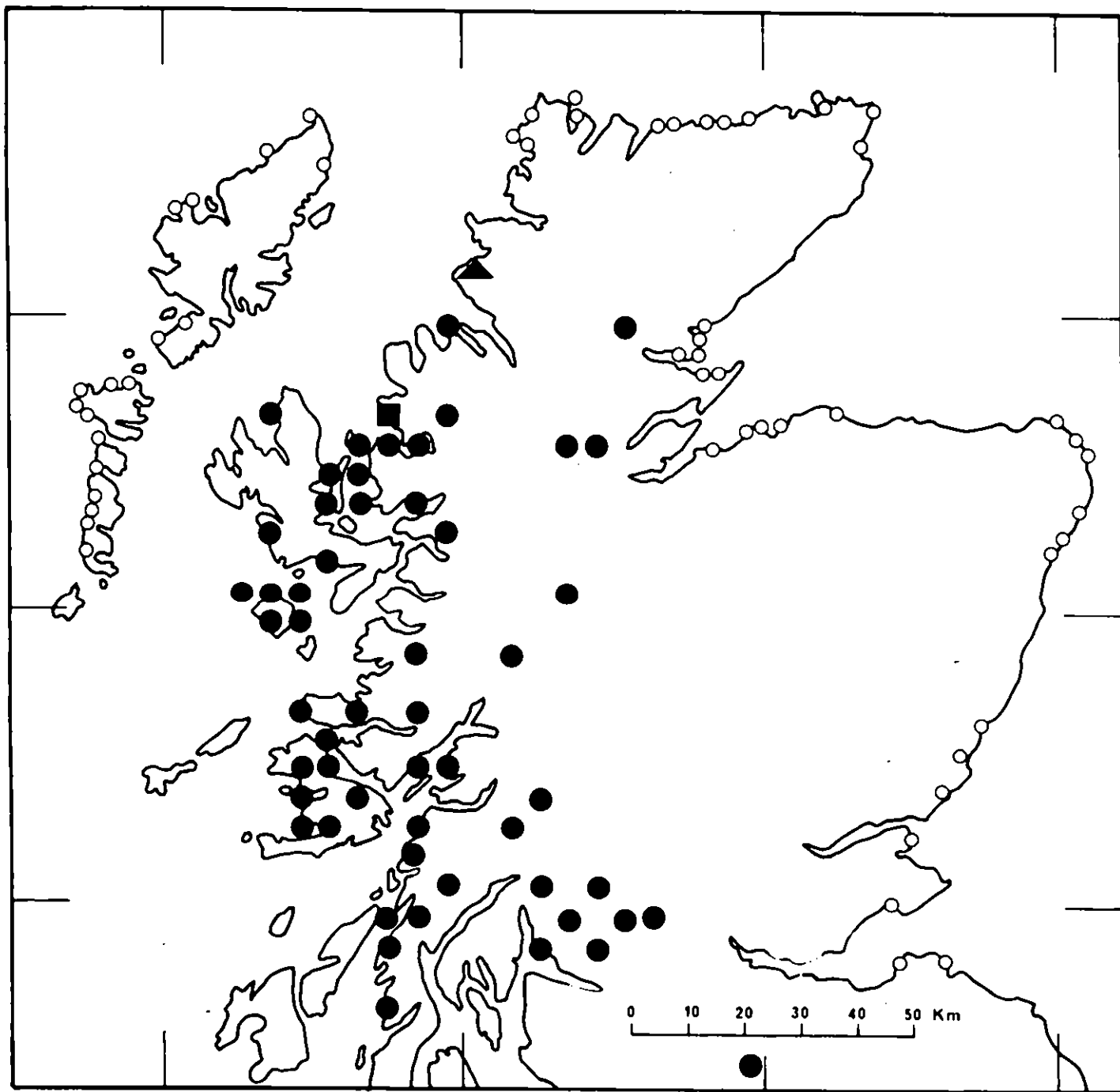
Agrostis vestigialis, was trapped in all regions and frequently common especially on the North Coast, (map 13). It is known to occur on most of the British Isles coastline as well as sandy areas inland in Norfolk, Suffolk and Surrey.

Several other species were taken which, although not confined to coasts, are often associated with them. These were Epirrhoe galiata, Aplocera plagiata and Stilbia anomala. Epirrhoe galiata is chiefly found in chalk and limestone districts especially on the coast. It was trapped only at Ferry Links and Morrich More (1 and 2) all in the Moray Firth. Aplocera plagiata is widely distributed throughout the British Isles but its stated food plant, Hypericum perforatum is not known to occur in north Scotland (Perring and Walters 1976). Presumably it feeds either on another Hypericum species or on an unknown foodplant. Stilbia anomala has a mostly western distribution in the British Isles, except in Scotland where it also occurs on the east coast. According to South (1961) it is a local species favouring heaths and rocky places by the sea. It was taken only at Redpoint (north), Strathy and Sinclairs Bay, all on the North Coast.

9.2 Northern or Scottish Species

The light trap catches included a number of northern species, of which two are only known from Scotland in Britain. Acronicta euphorbiae occurred as a single specimen at Lossiemouth in June and was the only moth in the sample. The species was first recorded in Britain in 1846 in Perthshire, but has since occurred widely in Scotland (map 14). Its larvae feed on Myrmica gale, Calluna vulgaris, Betula spp. and Salix spp.. Gnophos obfuscatus appears to be widely distributed in Scotland including the Western Isles. It frequents heaths, moors and mountains and the larvae feed on Calluna vulgaris and Genista anglica. It was taken at seven of the Moray Firth sites and at two North Coast sites.

Several other species with a northern distribution were recorded. For example Entephria caesiata, which occurs on mountains and moorlands and feeds on Calluna vulgaris, Erica spp. and Vaccinium spp. was taken only at Forvie (17 specimens); Perizoma blandiata which feeds on Euphrasia spp. occurred at five Outer Hebrides sites but only at Coul Links on the

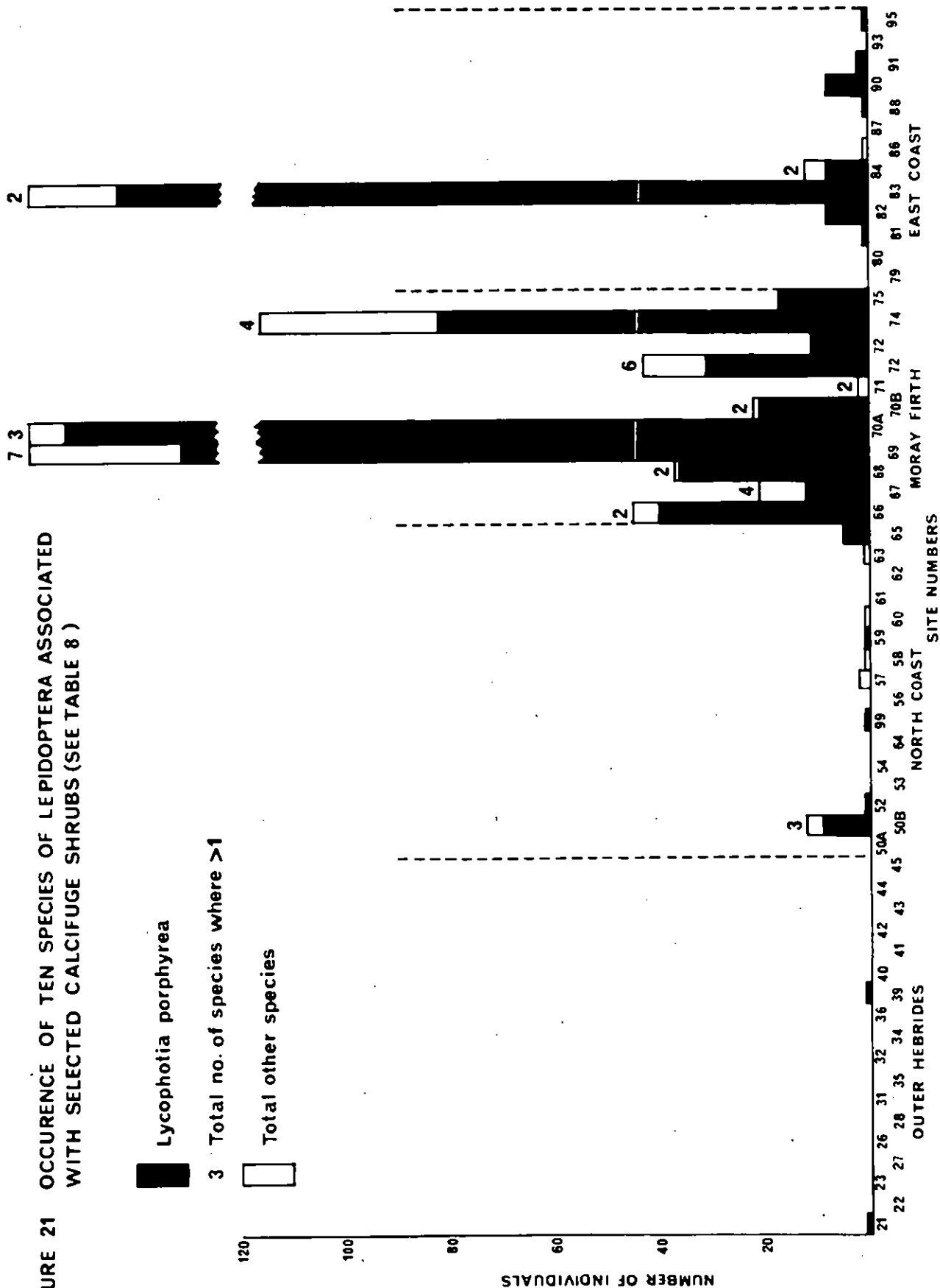


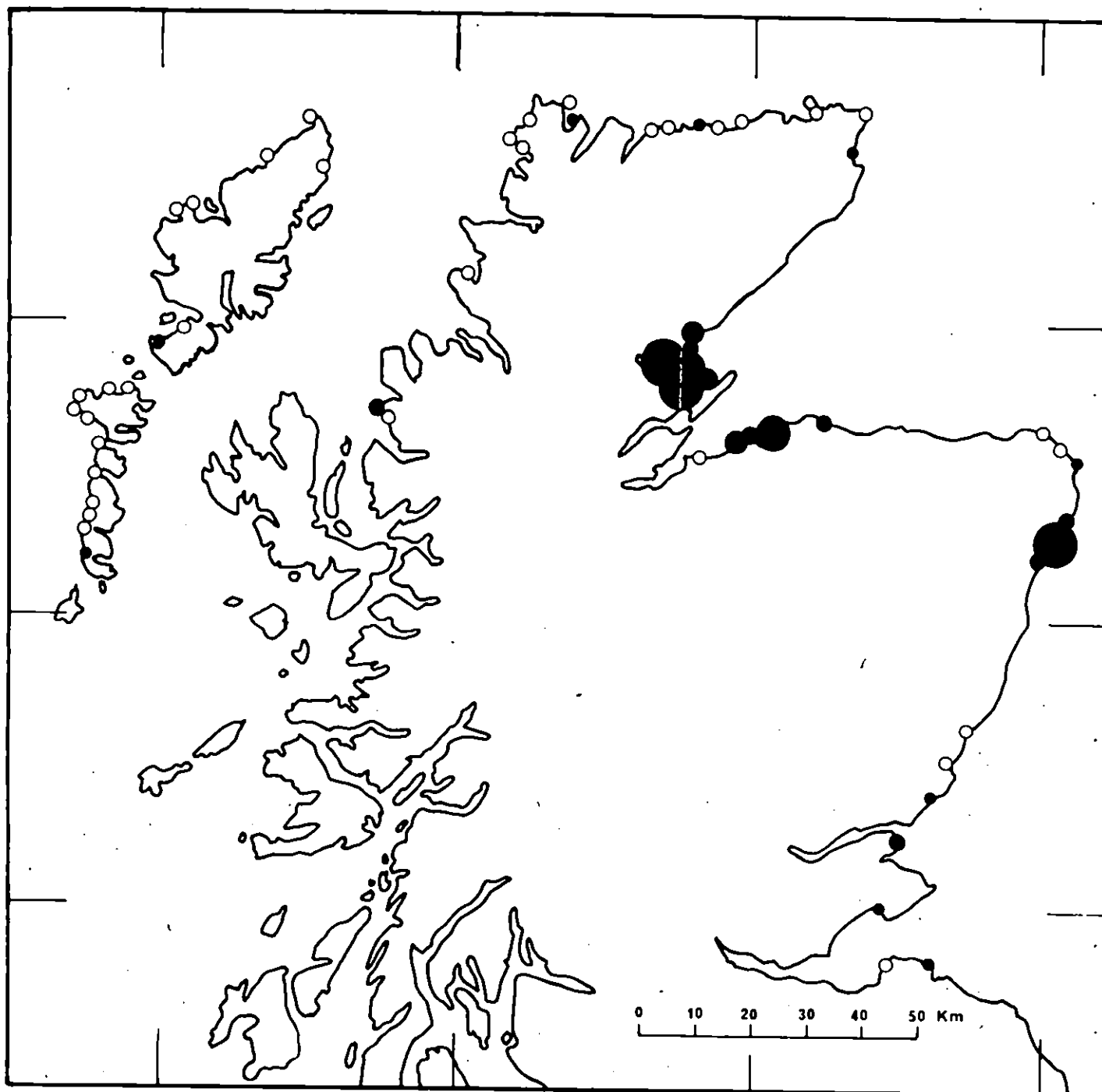
PHILUDORIA POTATORIA

- Recorded from sites 50 A & B
- ▲ Old record from 10km square containing site 52
- Other Scottish records
- Sites sampled during survey

Map 15

FIGURE 21 OCCURENCE OF TEN SPECIES OF LEPIDOPTERA ASSOCIATED WITH SELECTED CALCIFUGE SHRUBS (SEE TABLE 8)





LYCOPHOTIA PORPHYREA

Map 16

Specimens recorded per site

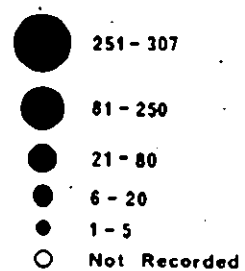


Table 7 List of calcifuge shrubs and associated Lepidoptera referred to in figure 21.

a. Calcifuge shrubs

<u>Genista anglica</u>	This list refers to the possible known range of food plants of the species of Lepidoptera selected and does not mean that these plants were observed growing at any of the sites.
<u>Ulex europaeus</u>	
<u>Sarothamnus scoparius</u>	
<u>Calluna vulgaris</u>	
<u>Erica</u> spp.	
<u>Vaccinium myrtillus</u>	<u>Ulex</u> and <u>Calluna</u> were recorded at some sites and <u>Sarothamnus</u> at Culbin Bar.

b. Associated Lepidoptera (excluding Lycophotia porphyrea) with host plants, site and number of specimens.

<u>Scotopteryx luridata</u> - <u>Ulex europaeus</u> , <u>Sarothamnus scoparius</u>	Coul Links(4), Dornoch(1), Clashmore(2), Morrich More A(4), Whiteness(1), Culbin Bar A(2), Findhorn(12), Don to Ythan(4)
<u>Entephria caesiata</u> - <u>Calluna vulgaris</u> , <u>Erica</u> spp., <u>Vaccinium myrtillus</u>	Forvie(17)
<u>Eupithecia nanata</u> - <u>Calluna vulgaris</u>	Redpoint B(2), Melvich(1), Freswick(1), Coul Links(1), Clashmore(9), Morrich More A(3), Culbin Bar A(1)
<u>Chesias rufata</u> - <u>Sarothamnus scoparius</u>	Culbin Bar A(4)
<u>Gnophos obfuscatus</u> - <u>Genista anglica</u> , <u>Calluna vulgaris</u>	Redpoint B(1), Bettyhill(2), Ferry Links(5), Coul Links(4), Clashmore(10), Morrich More B(1), Whiteness(1), Culbin Bar A(4), Findhorn(2)
<u>Dyscia fagaria</u> - <u>Calluna vulgaris</u> , <u>Erica</u> spp.	Farr Bay(1), Clashmore(6), Findhorn(1)
<u>Perconia strigillaria</u> - <u>Ulex europaeus</u> , <u>Sarothamnus scoparius</u> , <u>Calluna vulgaris</u> , <u>Erica</u> spp.	Culbin Bar A(1)
<u>Anarta myrtilli</u> - <u>Calluna vulgaris</u> , <u>Erica</u> spp.	Clashmore(1)
<u>Syngrapha interrogationis</u> - <u>Calluna vulgaris</u> , <u>Vaccinium myrtillus</u>	Clashmore(1)

Table 8 Occurrence of conifer-feeding Lepidoptera species with site and number of specimens collected in three regions. (No records from Outer Hebrides).

	North Coast	Moray Firth	East Coast
<u>Thera obeliscata</u>	Bettyhill(1)	Ferry Links(3) Coul Links(2) Clahsmore(2) Morrich More A(1) Culbin Bar A(2) Culbin Bar B(6) Findhorn(2) Lossiemouth(22)	Coul Links (2) Tyninghame(1)
<u>Semiothisa liturata</u>		Ferry Links(1) Clashmore(1) Morrich More B(1) Lossiemouth(2)	
<u>Bupalus piniaria</u>		Dornoch(2) Clashmore(5) Morrich More A(2) Morrich More B(1) Findhorn(3) Lossiemouth(16)	
<u>Hylaea fasciaria</u>		Clashmore(1)	St. Fergus(1) Tentsmuir(11)

mainland; Thera cognata whose sole foodplant is Juniperus communis occurred at only Bettyhill and Morrich More (1 and 2); Dasychira fascelina was taken at 6 sites in the Moray Firth area and a single specimen of Syngrapha interrogationis which feeds on Calluna vulgaris and Vaccinium spp. was taken at Clashmore.

9.3 Species with a restricted distribution.

Most of the species collected were more common on the East Coast particularly the more southern sites, becoming absent or scarce in the west. Good examples are Scotopteryx chenopodiata, Colostygia pectinataria, Lycophotia porphyrea, Mythimna impura, Rusina ferruginea and Thalpophila matura. Others were more or less uniformly distributed and some showed a westerly trend. Philudoria potatoria (map 15) was taken only at Redpoint (north and south), the most westerly of the mainland sites. In England the moth is widely distributed and often not uncommon on grassy places, but in Scotland it seems to be restricted to the western side especially near the coast and on some of the islands.

Caradrina clavipalpis was taken on four sites in the Outer Hebrides and three on the North Coast, the most eastern being Strathy. It is a migrant species and has been widely recorded throughout the British Isles. Perizoma blandiata was most common in the Hebrides where 23 specimens were recorded from five sites. Elsewhere only a single specimen was trapped, at Coul Links in the Moray Firth, thus providing some evidence of a westerly distribution. Arctia caja, although not recorded by the Survey on the northwest coast of Scotland nor from Harris and Lewis in the Outer Hebrides has previously been taken at a number of localities on the northwest mainland.

Some species are limited in range by the distribution of their foodplant(s). For example Thera cognata and Eupithecia pusillata feed on Juniperus communis, which is rather local in the British Isles, usually occurring on poorer soils where competition from other plants is limited (L.K.Ward pers. comm.).

In Scotland Mythimna comma is almost restricted to the eastern side and does not appear to have been recorded north of the Moray Firth. It was taken at a number of Moray Firth and East Coast sites.

Several species recorded are scarce in the north and some are at the northern limit of their known range in Britain. According to South (1961) Hecatera bicolorata is a southern species and is scarce elsewhere. Recent records confirm this and it was taken only at Lunan Bay. The occurrence

of Oligia versicolor at Findhorn in the Moray Firth is the most northern record in Britain, the nearest other locality being over 100 km to the south. Thalpophila matura, a grass feeder, does not appear to have been previously taken north of the Moray Firth but the Survey recorded it at several sites on the North Coast, Redpoint (north and south), Bettyhill, Strathy and Melvich. It was particularly common at the last two.

Other species which are apparently scarce in the north include Tyria jacobaeae, Deilephila porcellus, Axylia putris (taken only at Lunan Bay and Tentsmuir), Agrotis clavis, Hoplodrina alsines/blanda, Caradrina morpheus and Pyrrhia umbra.

9.4 The influence of calcifuge shrubs on the moth fauna (Moray Firth Sites)

The number of species whose foodplants are calcifuge shrubs was greater, and more specimens were taken at the Moray Firth sites than elsewhere (fig. 21). Several other species may also have been feeding on calcifuge shrubs but as detailed information of the flora of each site is not yet available these are omitted from fig. 21. Daschira fascelina, for example, was taken in small numbers on six Moray Firth sites (Coul Links, Clashmore, Morrich More I, Culbin Bar 1 and 2 and Findhorn) but nowhere else. It is known to feed on several woody species, including Ulex europaeus, Sarothamnus scoparius and Calluna vulgaris but also on Salix spp., Crataegus spp. and Betula spp.

With the exception of Whiteness, Lycophotia porphyrea (map 16), occurred at all the Moray Firth sites and was present in greater numbers than elsewhere except Forvie on the East Coast. The larvae feed on Calluna vulgaris and Erica spp..

Empetrum nigrum is not included in the list of calcifuge shrubs in table 7 as the only species taken which feeds upon it, Eulithis populata, also feeds on Salix spp..

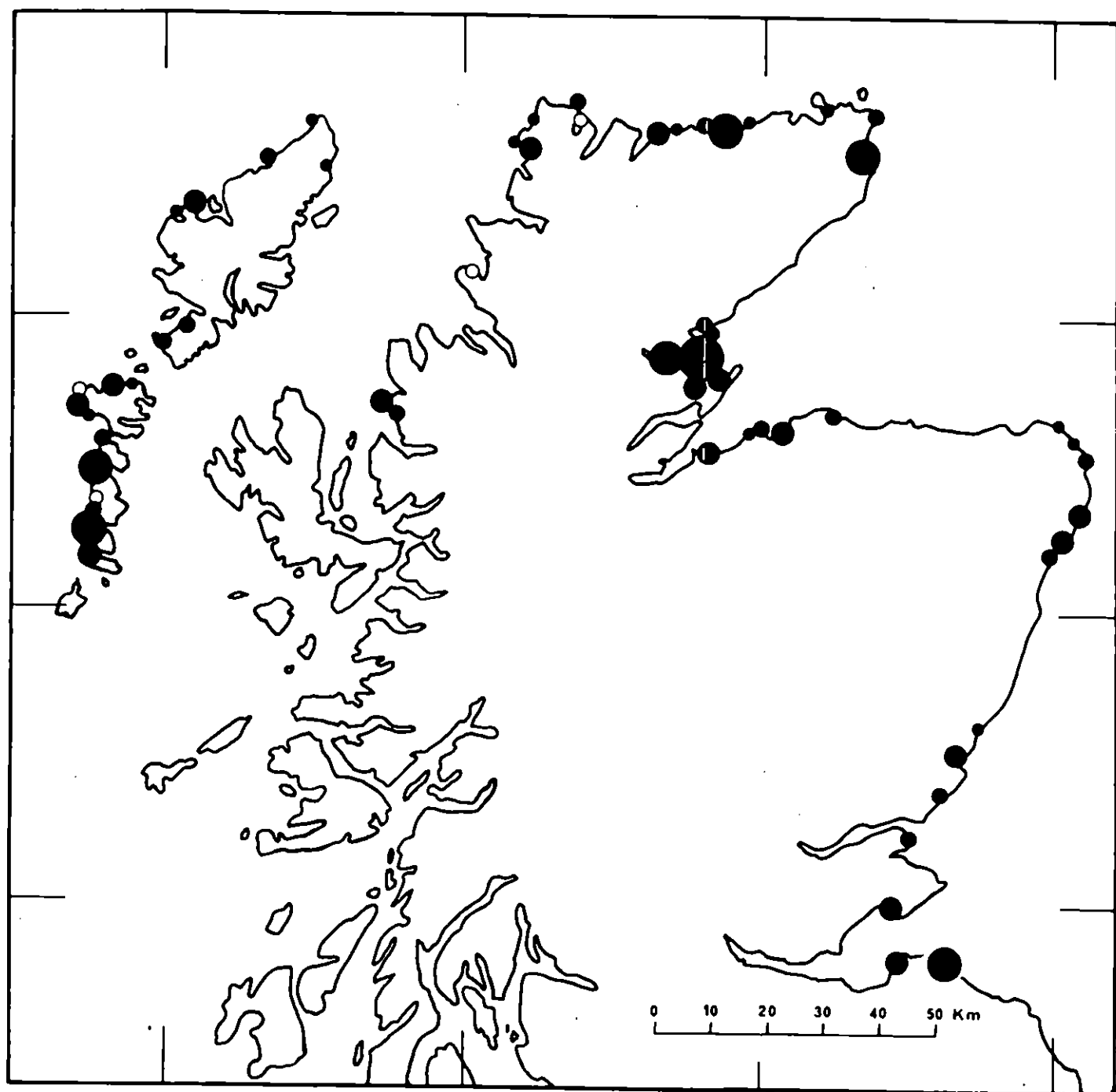
9.5 Species which feed on Pinus sylvestris and other conifers

Plantations of coniferous trees were recorded close to nearly all the Moray Firth sites. At Ferry Links, Morrich More 1 and 2, Culbin Bar 2, Findhorn and Lossiemouth the trees had been planted on, or adjacent to, the dunes. This feature appears to have been reflected in the catches (table 8). Four conifer-feeding species were collected at Clashmore although no softwoods were seen on the site or in the vicinity, the nearest being large plantations on surrounding hillsides. Conifer-feeding moths were entirely absent from the catches on the Outer Hebrides. A few specimens occurred on the North Coast but larger numbers were recorded at the Moray

Table 9

Other species of Lepidoptera taken which feed on woody plants.

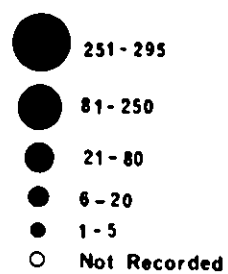
Macrothylacia rubi	Peribatodes rhomboidaria
Eulithis testata	Alcis repandata
E. populata	Cabera pusaria
Chloroclysta citrata	Campaea margaritata
C. truncata	Laothoe populi
Cidaria fulvata	Phalera bucephala
Plemyria rubiginata	Cerura vinula
Thera cognata	Pheosia gnoma
Hydriomena furcata	Ptilodon capucina
H. impluviata	Dasychira fascelina
Eupithecia vulgata	Graphiphora augur
E. pusillata	Diarsia mendica
Gymnoscelis rufifasciata	Xestia triangulum
Abraxas grossulariata	X. baja
Lomaspilus marginata	Ceramica pisi
Opisthograptis luteolata	Apatele euphorbiae
Crocallis elinguaris	Amphipyra tragopoginis
Biston betularia	Colocasia coryli

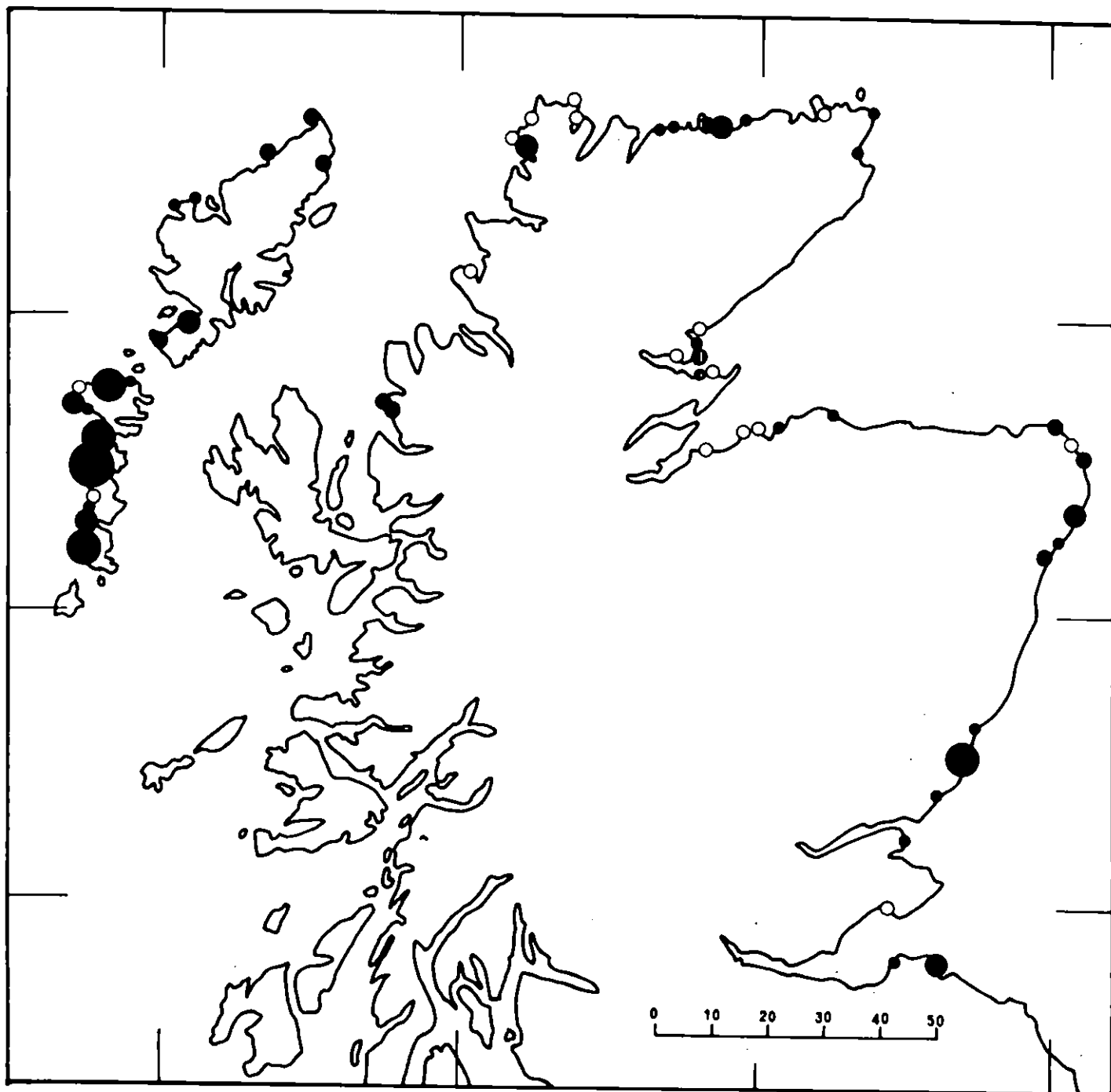


APAMEA MONOGLYPHA

Map 17

Specimens recorded per site

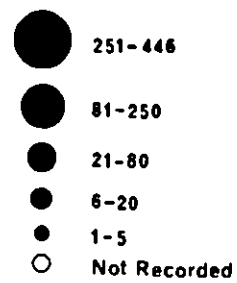


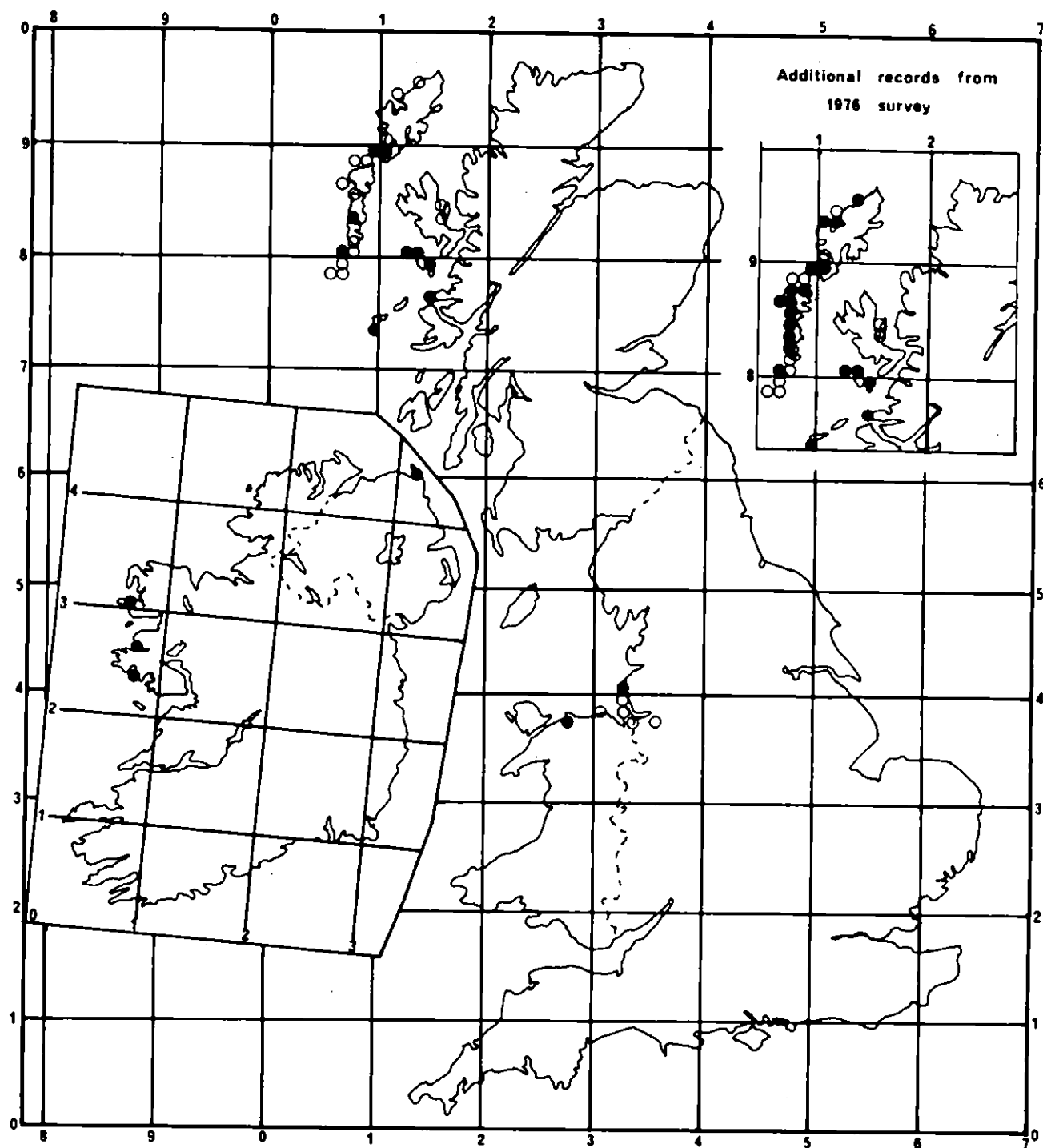


MESAPAMEA SECALIS

Map 18

Specimens recorded per site





LYCIA ZONARIA

○ → 1960
● → 1961

Map 19

10 kilometre square records

Firth and East Coast sites.

Extensive deciduous and coniferous woodland bordered and extended onto Tentsmuir on the East Coast and about twenty species which feed on woody plants were trapped there. Seven were taken at no other site, these being Hydriomena impluviata (which feeds solely on Alnus glutinosa) Plemyria rubiginata, Lomaspilus marginata, Crocallis elinguaris, Biston Betularia, Phalera bucephala and Colocasia coryli. Most of these are common woodland species. Ecliptopera silaceata, a woodland species also recorded at this site, feeds on non-woody plants such as Epilobium hirsutum and Circaea lutetiana.

Eilema lurideola was trapped at only four sites. 503 specimens were taken at Dornoch but only small numbers at Morrich More 2, St. Cyrus and Montrose Links and Lunan Bay. It feeds on lichens and algae growing on trees and bushes but there was no evidence that these were present at Dornoch. Cleorodes lichenaria, which has the same foodplants, was taken singly at Coul Links and Morrich More 2, both in the Moray Firth.

9.6 Woodland species

Apart from those species already mentioned a further thirty six were trapped which are known to feed on other woody plants. Many of these are woodland "generalists" whilst others are more characteristic of hedgerows and scrub (table 9).

9.7 Widely distributed species

The most widely distributed and abundant species were those associated with grassland habitats. Apamea monoglypha, (map 17), whose larvae feed on grasses is widespread in Britain. It was taken at more sites than any other species. A dark, sometimes blackish, form (f. infuscata) occurred in all regions and was especially common in the Outer Hebrides. Mesapamea secalis was also widely distributed and particularly numerous in the Outer Hebrides, (map 18). At Borge in July, many were seen resting during the day with Agrotis vestigialis on flowers of Senecio jacobaea. The larvae feed on grasses. Other species which were trapped extensively included Agrotis vestigialis, Noctua pronuba and Cerapteryx graminis. Hada nana also occurred widely, but was restricted to the June samples.

9.8 Diurnal species

A few day-flying moths were taken. Zygaena filipendulae occurred at a number of the Moray Firth and East Coast sites and its foodplant, Lotus corniculatus, was found in many places often growing in the vicinity of

the traps. All British species of Zygaenidae are mainly diurnal. A single specimen of Ematurga atomaria was trapped at Forvie. It was seen commonly in June at Culbin Bar 1 flying during the day but none was taken in the trap. Semiothisa clathrata occurred only at Dornoch and Anarta myrtilli at Clashmore.

9.9 The occurrence of Eupithecia species.

Ten species of what are commonly known as pug moths were taken during the survey (nine species of Eupithecia and Gynoscelis rufifasciata). Nine of these occurred on Moray Firth sites with only Lossiemouth failing to record any. Six species occurred in the other three regions. Eupithecia pusillata, which feeds on Juniperus communis was trapped at Bettyhill and was the only species not taken in the Moray Firth. Eupithecia tripunctaria was taken only at Findhorn. According to J. Reid (pers. comm.) it is unusual to record this insect so far north but South (1961) records it in Scotland as far as Aberdeenshire. It feeds on Angelica sylvestris and Heracleum sphondylium.

The quality of the material collected did not permit the separation of the species pair which has been recorded as Eupithecia absinthiata/goossensiata. Specimens were trapped at six sites in the Moray Firth and one on the East Coast. It is perhaps more appropriate to refer them to E. goossensiata which feeds on Calluna vulgaris and Erica spp. because these plants were more common on the sites concerned than were the main foodplants of E. absinthiata (Senecio jacobaea, Solidago virugaurea, Aster spp., Achillea millefolium and Eupatorium cannabinum).

Three other species were taken only in the Moray Firth samples.

Eupithecia icterata which feeds on Achillea millefolium (Ferry Links)
Eupithecia vulgata a polyphagous species, was taken at five sites and
Eupithecia distinctaria (Ferry Links and Morrich More 2) which feeds only on Thymus drucei.

Eupithecia centaureata occurred at a number of sites but not on the North Coast nor on Harris and Lewis suggesting that the Survey recorded it at the northern limit of its range. It is widely distributed in the British Isles and feeds on a variety of host plants.

9.10 Comments on other species

On the Outer Hebrides, larvae of Lycia zonaria (map 19) were observed in both June and July feeding mainly on Lotus corniculatus. They were found in abundance on the west coast at sites from Daliburgh to Robach on the Uists (including Borge on Benbecula). On Harris and Lewis larvae were less

Table 10 Butterflies (and the moth Lycia zonaria) recorded in the Outer Hebrides (OH), North Coast (NC), Moray Firth (MF) and East Coast (EC), 1975-1977. Refer to table 1 for site names. Dr D.S. Ranwell supplied many records including those for sites 2-20, 25, 33, 35 and 55 some of which were not covered by the Invertebrate Survey. The names of these sites are listed below.

? = Species seen but confirmation needed.

Lycia zonaria was recorded as larvae in the Outer Hebrides during June 1976.

Species	OH	2	3	4	5	7	8	9	12	13	14	15	16	17	18	19	20	21	22	23	27	25	26	28	31	35	32	33	34	36	37	39	40	41	42	43	45	
Pieris brassicae							+																															
P. napi			+				+	+									+		+		+																	
Polyommatus icarus				+				+	+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vanessa atalanta																																						+
Aglais urticae		+				+	+	+		+							+	+	+		+						+											
Argynnis aglaja						+	+	+									+																					
Hipparchia semele		+						+				+		+																								
Maniola jurtina		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Coenonympha pamphilus												+																										
Aphantopus hyperantus	+																																					
Lycia zonaria																		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	

Key to Dr D.S. Ranwell's sites.

2	Macrihanish Dunes	10	Calgary Dunes	18	Vatersay
3	Laggan Bay	11	Sanna	19	West Barra
4	Kilchoman Dunes	12	West Tirie	20	North Barra
5	Saligo Bay	13	Balleuvullin	25	Loch Bee
6	Gruinart	14	Hynish Bay	33	Vallay
7	Oronsay	15	Crossapol and Gunna	37	Berneray
8	Garvard	16	Totamore Dunes	55	Durness
9	Kiloran Bay	17	Gallanach		

Table 11 Coleoptera species recorded for the first time from the Outer
Hebrides

Species marked with an asterisk were from pitfall traps; all
others by hand collecting.

CARABIDAE

Trechus fulvus Dej.
Bembidion guttula F.
**Synchus nivalis* (Pz.)
**Amara communis* Pz.
**A. eurynota* (Pz.)
Bradycellus ruficollis Steph.

HYDROPHILIDAE

Chaetarthria seminulum (Hbst.)

PTILIIDAE

Acrotrichis fascicularis (Hbst.)
A. intermedia (Gillm.)

LEIODIDAE

**Choleva agilis* (Ill.)
**C. glauca* Brit.
**Catops chrysomeloides* (Pz.)

SILPHIDAE

**Thanatophilus sinuatus* (F.)

STAPHYLINIDAE

**Micropeplus staphylinoides* (Marsh.)
**Omalium exiguum* Gyll.
Carpelimus elongatulus (Er.)
Anotylus complanatus (Er.)
**Othius laeviusculus* Steph.
**Xantholinus laevigatus* Jacob
Gabrius trossulus (Nord.)
**Staphylinus melanarius* Heer
**Quedius fuliginosus* (Gr.)
Q. fumatus (Steph.)
Lordithon thoracicus (F.)
Tachyporus atriceps Steph.
T. nitidulus (F.)
Tachinus elongatus Gyll.
Myllaena minuta (Gr.)
Gyrophæna joyi Wend.
Bolitochara obliqua Er.
Autalia puncticollis Shp.

STAPHYLINIDAE (cont.)

Autalia rivularis (Gr.)
Atheta divisa (Maerk.)
**A. gagatina* (Baudi)
**A. exigua* (Er.)
A. graminicola (Gr.)
**A. triangulum* (Kr.)
A. puncticollis Benick
Aleochara bilineata Gyll.

SCIRTIDAE

Cyphon coarctatus Pk.

NITIDULIDAE

Meligethes viridescens (F.)

CRYPTOPHAGIDAE

**Cryptophagus intermedius* Bruce
**C. setulosus* Sturm
Atomaria apicalis Er.
A. fuscicollis Man.
**A. lewisi* Reitt.
A. ruficornis (Marsh.)

COCCINELLIDAE

**Nephus redtenbacheri* (Muls.)

LATHRIDIIDAE

**Lathridius authracinus* Man.
**Corticaria crenulata* (Gyll.)

CHRYSEMELIDAE

**Longitarsus succineus* Foud.

CURCULIONIDAE

**Strophosomus sus* Steph.
**Sitona lineatus* (L.)
**Hypera punctata* (F.)
**Ceuthorhynchidius troglodytes* (F.)

abundant, diminishing in numbers northwards. None was found north of Barvas at Eoropie nor at Tolsta on the east coast of Lewis. These records support South's (1961) comment that it "was reported by Heslop Harrison as being abundant from Barvas (Lewis) to the Isle of Pabbay (Barra Isles)." Larvae also occurred in pitfall trap samples on many sites on the Outer Hebrides but none on the North Coast. In the British Isles its records are restricted to five isolated coastal areas, North Wales and Merseyside, west Eire, (Galway and Mayo), a single locality in Antrim in Northern Ireland, on Ardnamurchan (West Invernesshire, now part of the Highland Region) (Dr M.G. Morris, pers. comm.) and the Western Isles. The Survey added and confirmed a number of records for 10 km squares. South (1961) states that this species feeds on low growing plants such as Salix spp., Taraxicum officinale, Rumex spp., Plantago spp., Trifolium spp., and Achillea millefolium. The adult male is on the wing in March and April. The female is brachypterous and flightless.

Parasemia plantaginis was observed at Lossiemouth in the Moray Firth, where adults were plentiful in June flying readily when disturbed. It is largely diurnal and widely recorded in Scotland.

Scotopteryx chenopodiata was trapped at many sites but was not taken in the Outer Hebrides nor on the more westerly North Coast sites. It was particularly abundant at Fraserburgh where 300 specimens made up nearly half of the total catch. The recorded foodplants are Trifolium repens, Vicia spp. and grasses

Noctua janthina and Mamestra brassicae are widely distributed species which were taken only at Oldshore More, Lunan Bay and Tynninghame.

The record of Lacanobia oleracea, a common species, from Borge constitutes the only known occurrence from the Outer Hebrides except for St. Kilda.

Luperina testacea has been widely but infrequently recorded from Scotland as far as the north coast. However during the Survey it was taken only at a number of Outer Hebrides and East Coast sites. The adult is generally on the wing in August and September and was probably too late to be caught in the Moray Firth traps.

9.11 Butterflies

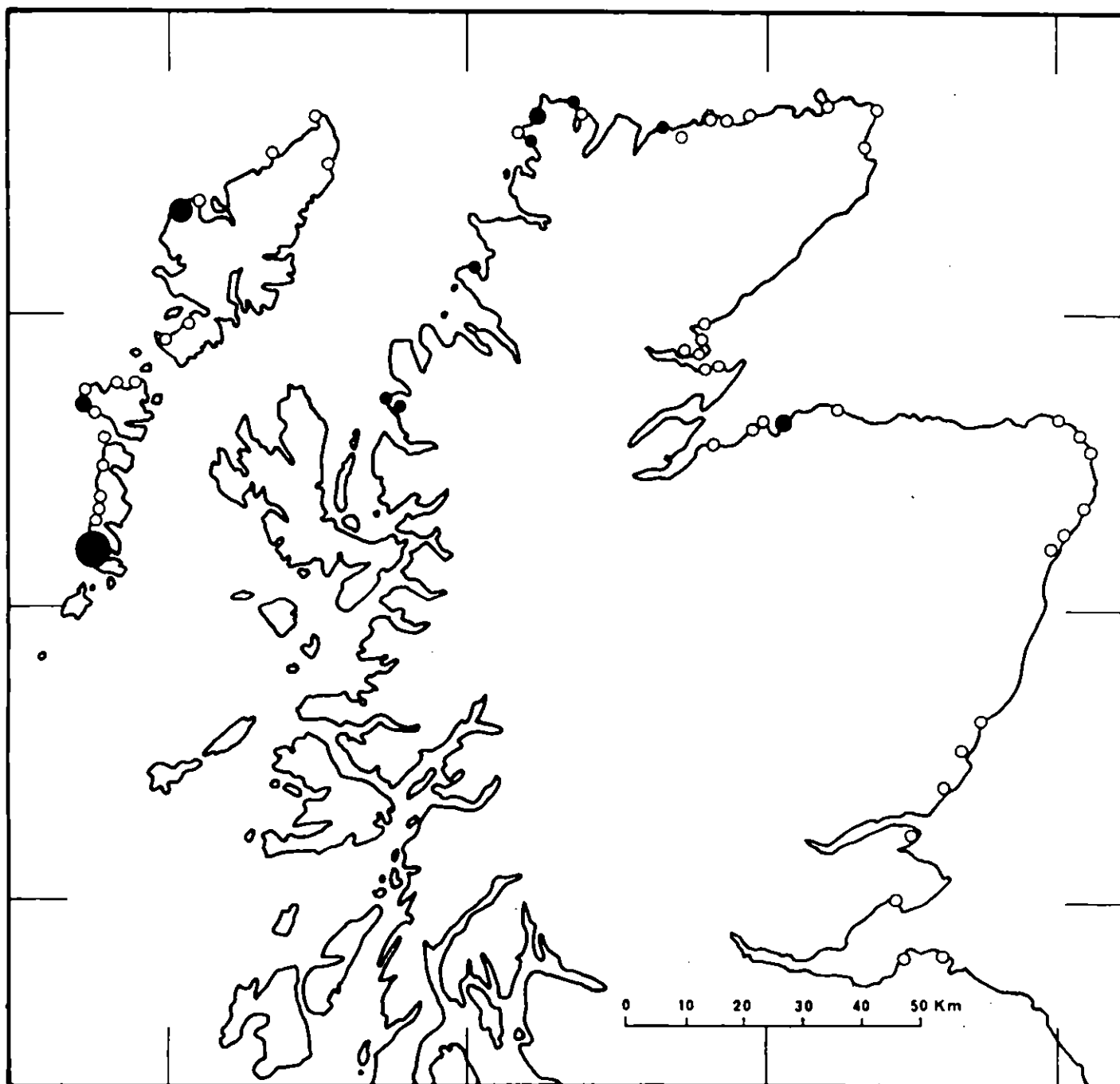
The opportunity was taken to note the butterflies seen during the Survey (table 10). Species observed by Dr D.S. Ranwell between 1975 and 1977 when visiting sites in connection with Project 340 are also included.

10. COLEOPTERA

The coastal Coleoptera of Scotland are poorly known, and even more poorly documented. Most entomologists seek out the rare or local northern species associated with the mountains or Caledonian pine forests. Walsh (1925 & 1926), in his papers on the "Coast Coleoptera of the British Isles" appears to have had little or no experience of the Scottish coasts and only mentions other workers' records from the Solway district. A few sites such as Aberlady Bay and Gullane, and more recently Tentsmuir Point have received closer attention from coleopterists resident in Scotland. Some records are available for one or two other east coast sites and the Findhorn (Forres of old collectors e.g. D. Sharp) and Culbin Sands areas attracted some attention before the latter site was extensively afforested. Other sites bordering the Moray and Dornoch Firths have been largely ignored and until very recently the north coast has remained virtually unrecorded, as have the few sites on the north-west coast of Sutherland and Wester Ross.

As a result of the symposium on "The Natural Environment of the Outer Hebrides" held in Edinburgh in September 1977, the known insect fauna of these islands has been thoroughly reviewed and a list of approximately 560 species of Coleoptera has been made. It is interesting to note that, of this total, 55 species listed in table 11 and by Welch, (in press, B) are recorded for the first time during this survey. Only 27 of them were collected in pitfall traps and two of these were caught outside the main sampling periods. The Coleoptera of the Outer Hebrides are thus reasonably well understood although there is an almost total lack of previous information regarding the fauna of the nearest comparable sites on the mainland of Scotland. As a result, no matter how common or widespread the recorded species may be elsewhere in Britain, this survey will have greatly enhanced our knowledge and better understanding of the distribution of these species.

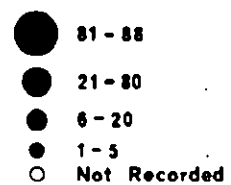
During the five week trapping period 343 species of Coleoptera from 26 families were recorded, of which the most numerous were Staphylinidae (137 spp.), Carabidae (55), Curculionidae (26), Leiodidae (20), Chrysomelidae (13) and Cryptophagidae (11). When the pitfall traps were emptied at the end of the third trapping period, a party of botanists was still surveying sites on Harris and Lewis for Project 340. Through their cooperation the traps at the 7 sites from Northton to Tolsta were re-set on 30/31.7.76 and collected between 19 and 23.8.76. These samples contained no species of Coleoptera which were not recorded elsewhere during this survey although in every case species were taken which had not occurred in the earlier samples. These are listed under "Additional species" in the appropriate Site Dossier.

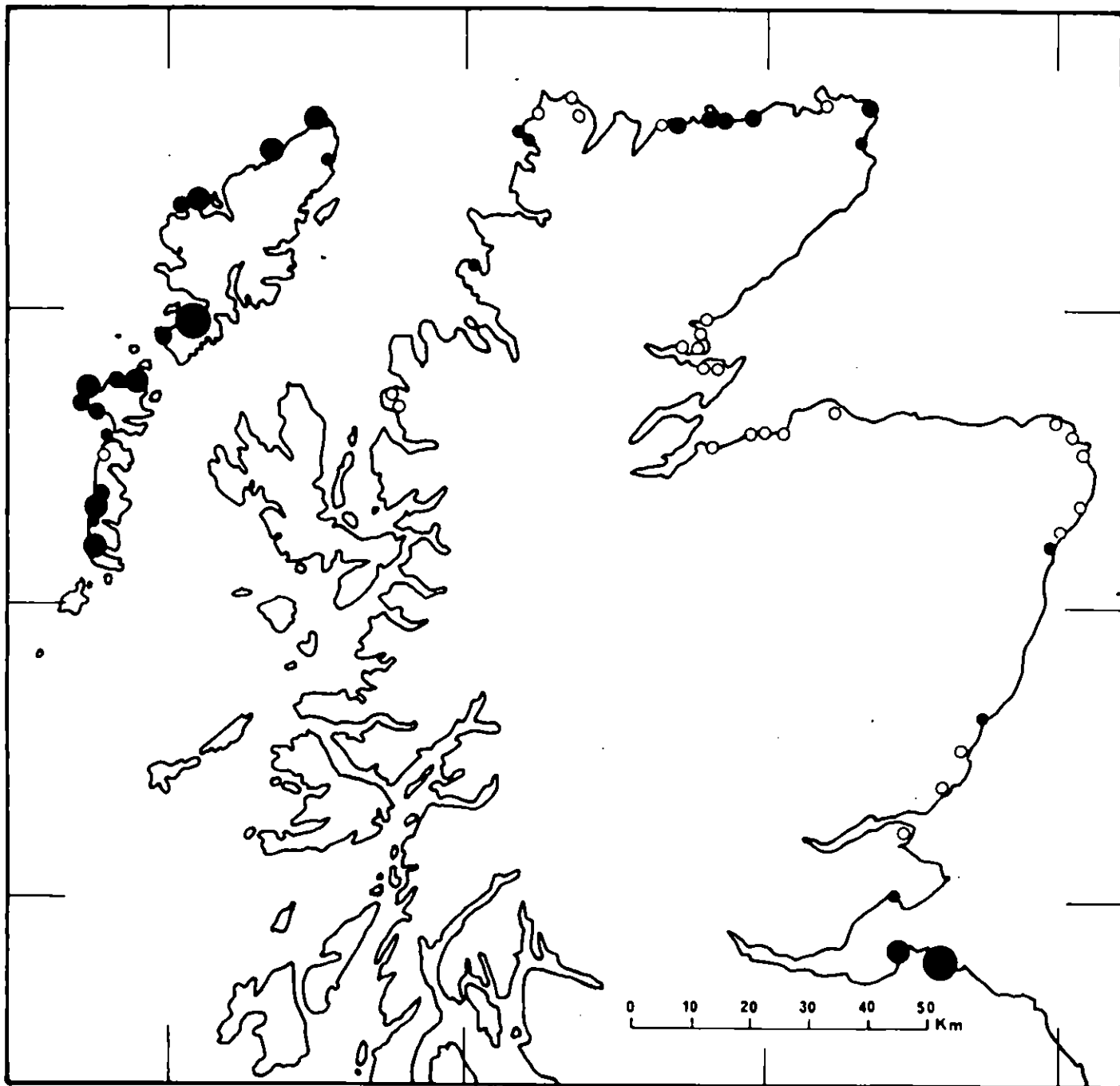


GEOTRUPES VERNALIS

Map 20

Specimens recorded per site

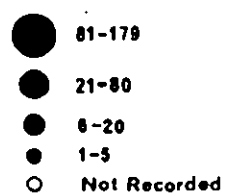


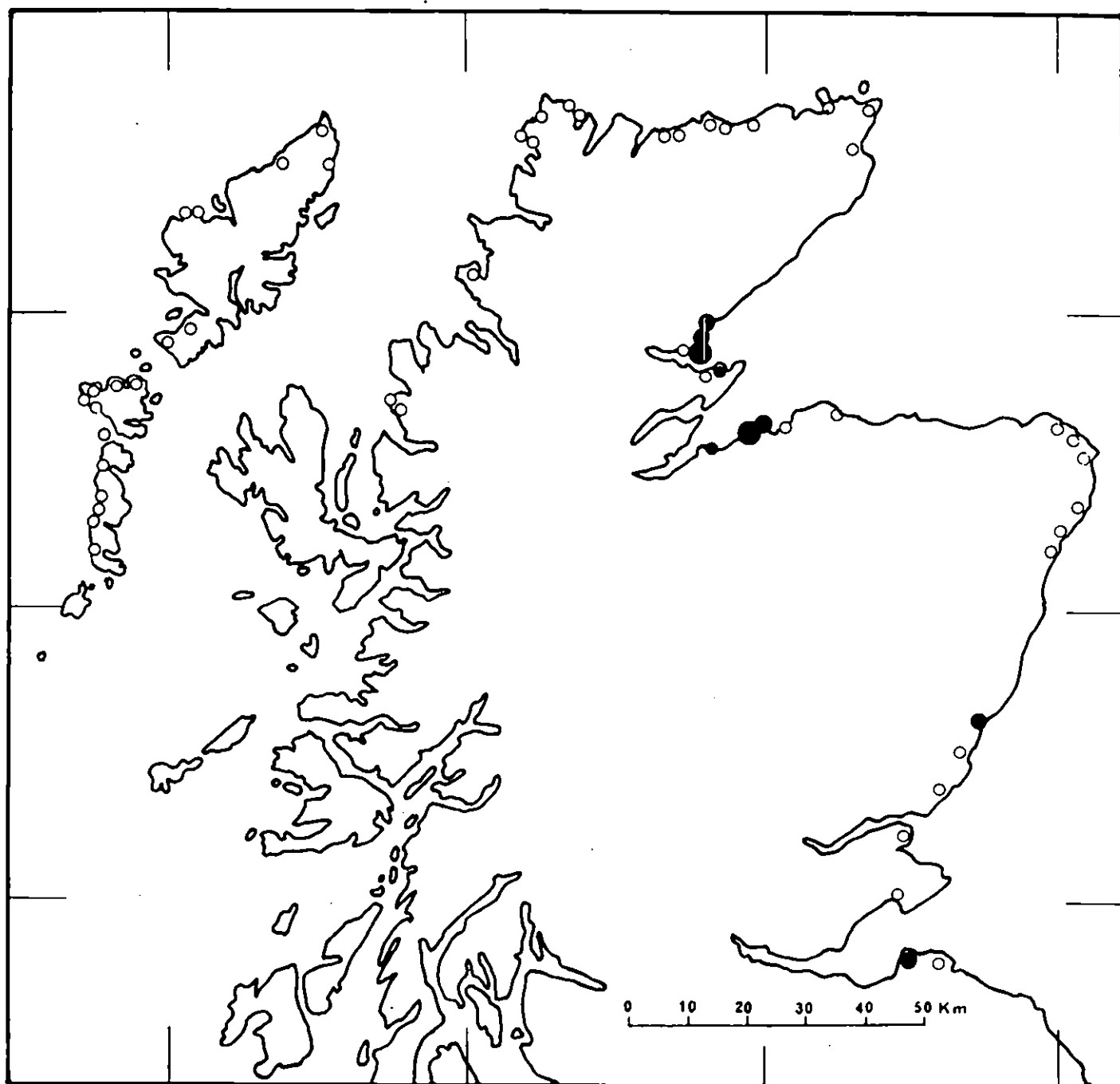


LONGITARSUS JACOBAEAE

Map 21

Specimens recorded per site





SEPEDOPHILUS NIGRIPENNIS

Map 22

Specimens recorded per site

- 21 - 79
- 6 - 20
- 1 - 5
- Not Recorded

With only 8 pitfall traps per site, large and sometimes varied areas of a site remained unsampled. In the Outer Hebrides, Luskentyre is the only one among those visited where there is a well developed mobile dune system. Rather than sample this part of the site, which was subject to intense public pressure, it was decided to place the traps at Seilebost. This peninsula is within the delimited site boundary and not only more closely resembled the topography and vegetation of the other Outer Hebrides sites sampled, but was also believed to be a good site for Lepidoptera (E.C. Pelham-Clinton pers. comm.). Short periods of hand-collecting (30-45 minutes) from strand-line seaweed, (see Welch, in press, A) along the base of the seaward-facing shallow dune cliff and searching under drift-wood and other debris on the beach and in the dunes/machair, scored thirteen coastal or arenophilous species, with an average of about seven additional ones per site.

10.1 Carrion and coprophagous species

The Coleoptera collected in pitfall traps tend to be the more active predatory species of the families Carabidae and Staphylinidae whilst phytophagous species feeding on the aerial shoots of various plants tend to be under-recorded. Comment has been made elsewhere concerning the relative abundance of shrews and other small mammals trapped in the different regions (fig. 3). Apart from filling up the traps and enabling later captures to escape, their decomposing bodies also attracted necrophagous beetles. A good correlation is obtained between Nicrophorus investigator, N. vespilloides, Thanatophilus rugosus and Saprinus aeneus, with those sites and sampling periods during which most small mammals were also caught. The only exception was at Cruden Bay where a single N. investigator was collected in the third sampling period in one of the six traps which did not contain a shrew. In the second period when all the traps contained small mammals no N. investigator were caught although N. vespilloides was taken in the largest numbers of the survey. During the first sampling only one trap did not contain small mammals but no carrion beetles were collected during this period. No such correlation can be found with the occurrence of N. humator and T. sinuatus.

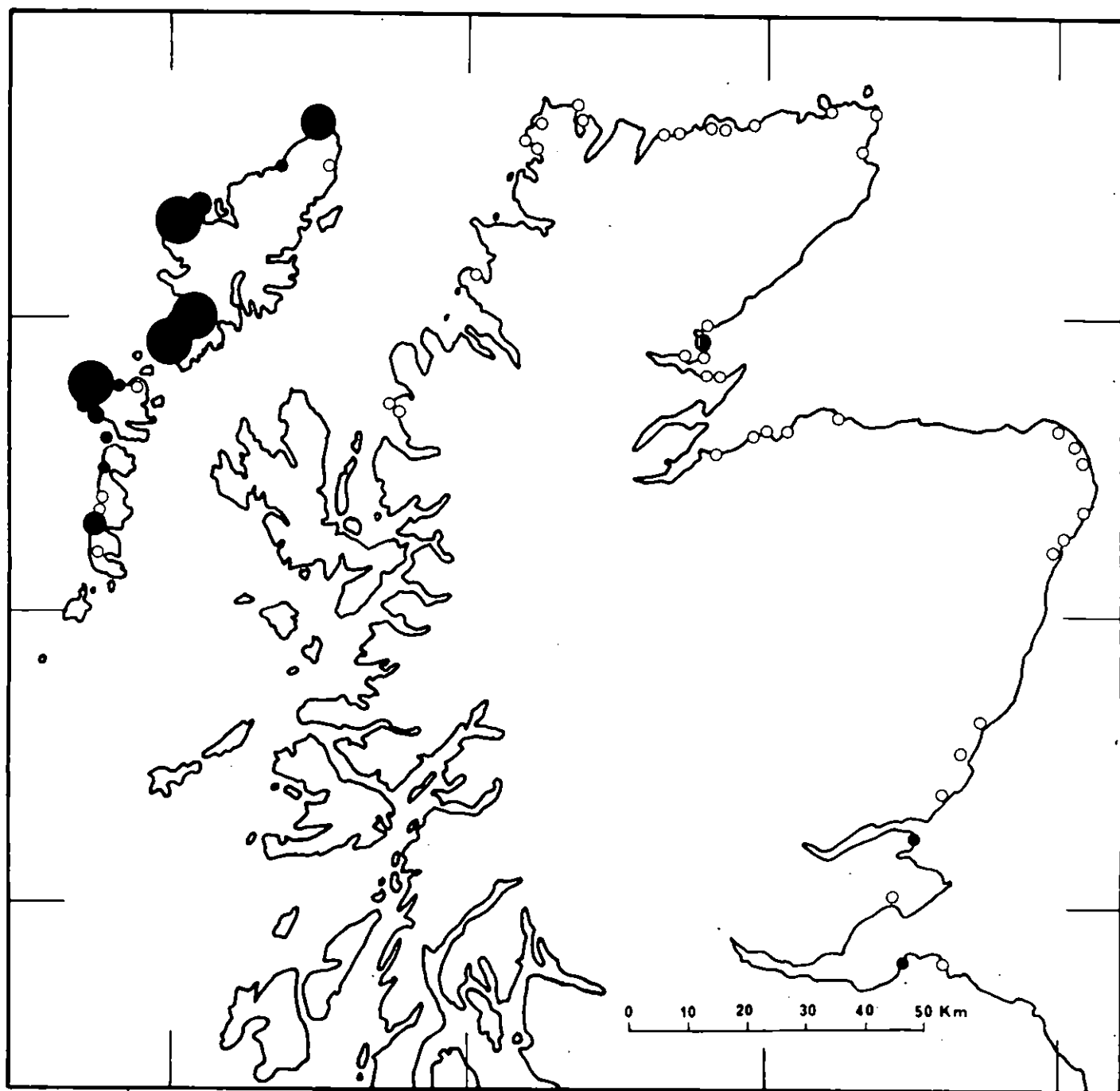
When considering the coprophagous Coleoptera, but ignoring those species which may occur in other habitats such as decaying vegetable matter, members of the genera Aphodius and Geotrupes (map 20) appear to be virtually restricted to sites on the Outer Hebrides and north-west mainland. This, in turn, may be a reflection of the greater use made of the machair for grazing stock when compared with the less palatable vegetation of the

"marram transition zone" and dune heath more typical of the East Coast and Moray Firth sites. Thus the presence or absence of carrion and dung beetles may in some way express the influence exerted upon the vegetation by larger or smaller numbers of herbivores, rather than show a correlation with any physiographic or vegetational site factors.

A further example of the interaction between the mammals and Coleoptera is shown by rabbits. Species such as Laemostenus terricola (Ormistate, Luskentyre and Valtos), Aleochara cuniculorum (Balranald) and less specifically, Oxypoda spectabilis, (Reay, Dunnet and St. Fergus) occur in rabbit burrows. Thus, even if no note had been made of rabbits on these sites, these species would indicate their presence and relative abundance. Rabbit activity also creates areas of bare ground i.e. scrapes and burrows which would favour species such as Amara bifrons which occur in sparsely vegetated sandy areas.

10.2 The fauna of the Moray Firth Sites

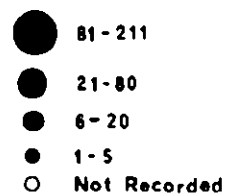
It is difficult to make valid comparisons between this Region and the other three because of the seasonal differences described in Section 3.3. This can best be illustrated by Longitarsus jacobaeae which feeds on Senecio jacobaea. During 1976, with the exception of Howbeg, this chrysomelid first appeared as teneral adults in the second period samples, becoming most numerous in the samples for the final week. It was also trapped in large numbers in Harris and Lewis where the traps were left operating well into August for an additional three weeks. The fact that no L. jacobaeae were collected at the Moray Firth sites, despite the presence of the foodplant, is regarded as reflecting this critical difference in sampling dates and certainly does not indicate the absence from, or even the relative rarity of this species, at these sites (see map 21). The distribution of Sepedophilus nigripennis (map 22) cannot be so easily explained. Hammond (1973) records this species from Forres (at or near Findhorn), St. Kilda and Edinburgh but states that, although it may be scarce in the North, it is probably generally distributed throughout Britain. Fairly intensive collecting on the Outer Hebrides, the Shetlands and Rhum has failed to record it, and its presence in moderate numbers at St. Cyrus and Montrose Links and Gullane points to its relative abundance at several of the Moray Firth sites as being indicative of its distribution in Scotland (see map 41 of the spider Gnaphosa leporina, which was also more numerous at the Moray Firth sites).

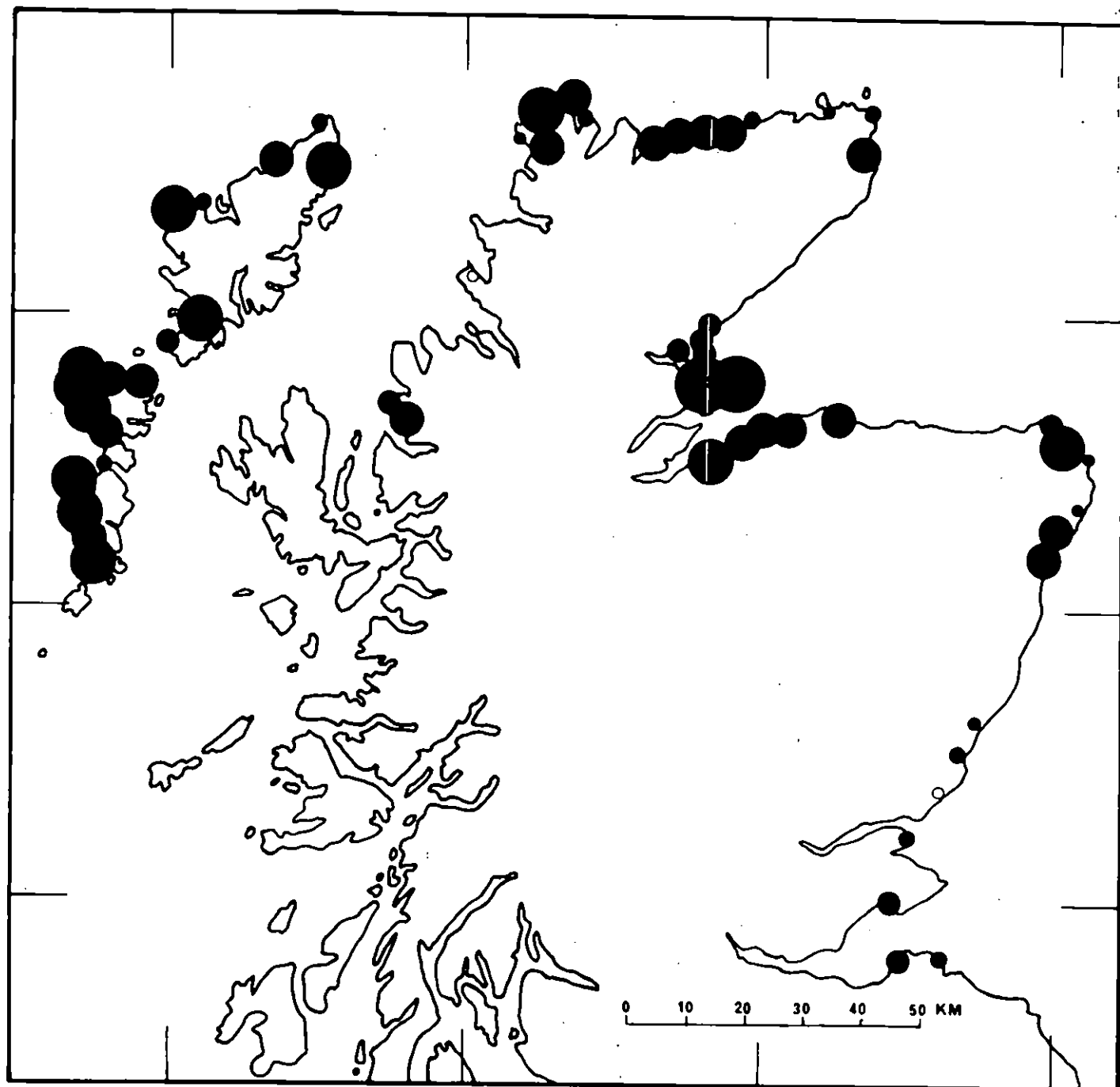


DYSCHIRIUS GLOBOSUS

Map 23

Specimens recorded per site

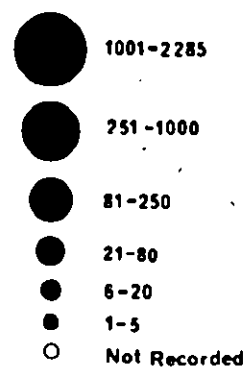




CALATHUS FUSCIPES

Map 24

Specimens recorded per site



10.3 Habitat preferences in the Carabidae and some other families

The ecology of some carabid species has been studied in detail, whilst for most others their broad habitat requirements are fairly well known. Thiele (1977) discusses thermophily and xerophily and provides lists of species typical of sandy heaths, dry sandy grass areas and of the psammophilic species of yellow dunes. Of those known to occur in Scotland, nearly 70% of the species in his lists were recorded during this survey. The most recent information available on British Carabidae is provided by Lindroth (1974) in the form of brief habitat and distribution notes. The following 16 species trapped during this survey are categorised by him as xerophilic, coastal or occurring in dry sandy places:-

<i>Dyschirius politus</i>	<i>Amara bifrons</i>
<i>Broscus cephalotes</i>	<i>A. tibialis</i>
<i>Asaphidion pallipes</i>	<i>Harpalus rubripes</i>
<i>Bembidion pallidipenne</i>	<i>H. tardus</i>
<i>Calathus erratus</i>	<i>Bradycellus harpalinus</i>
<i>C. mollis</i>	<i>Dromius linearis</i>
<i>Synuchus nivalis</i>	<i>D. notatus</i>
<i>Amara aenea</i>	<i>Metabletus foveatus</i>

A further 11 species are regarded by Lindroth as characteristic of open dry country:-

<i>Carabus problematicus</i>	<i>Calathus melanocephalus</i>
<i>Nebria salina</i>	<i>Amara communis</i>
<i>Notiophilus aquaticus</i>	<i>A. eurynota</i>
<i>N. germinyi</i>	<i>A. familiaris</i>
<i>N. substriatus</i>	<i>Dromius melanocephalus</i>
<i>Calathus fuscipes</i>	

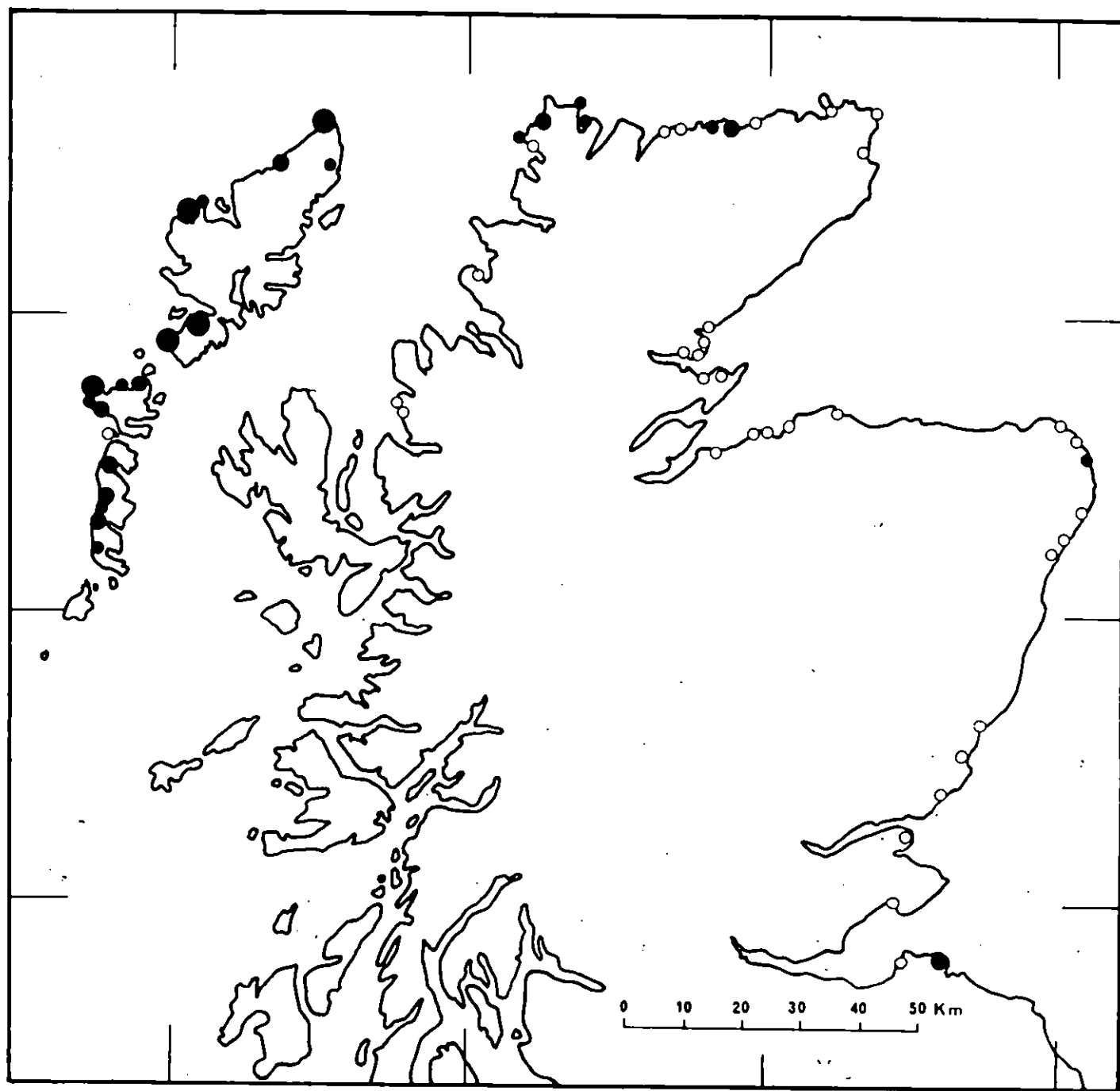
These two groups account for half the total number of species of Carabidae trapped. Others, such as *Nebria brevicollis* and *Pterostichus madidus*, were regarded by Walsh (1925) as "generally distributed species ... found on the sea coast just as in almost all other types of locality". Inexplicably the usually ubiquitous *P. madidus* was trapped only at Bettyhill whilst *Nebria brevicollis* was not common on the Outer Hebrides with only one or two specimens recorded from two North Coast and five East Coast sites. However, on the intervening sites *N. salina* apparently replaces the former species and only at Tentsmuir were both species trapped. Walsh also included *Bembidion tetracolum*, *Amischa analis* and *Atheta atramentaria* in this group. The first of these was not collected during this survey and the last is widespread in dung. *Amischa analis* is largely replaced by *A. cavifrons* in Scotland and although present in about half the East

Coast and Moray Firth sites there is only one isolated more northerly record, at Reay. It was not taken on the Outer Hebrides although it has since been recorded from South Uist by Waterston et al. (in press).

Brosicus cephalotes is one of several species which live under material in the drift-line. Both adults and larvae typically occur under seaweed and drift-wood on sandy beaches, and although the adults are sometimes found on the dunes they are far less common there. Only five specimens of this species were trapped at two Outer Hebrides sites whilst hand collecting on the beach showed it to be present at eight additional sites (Welch, in press, A, table 2). For the most part Brosicus cephalotes occurred singly or in very small numbers in the samples from scattered sites. However, at three sites on the East Coast (Arbroath, Tentsmuir and St. Cyrus and Montrose Links) it was remarkably numerous, although why this should be so is not understood. Other species included in this group and associated with drift-line seaweed were taken singly:- Ptenidium punctatum (Dumbarnie and Tynninghame) and Aleochara obscurella (Borve and St. Fergus). Although not included by Walsh, Anotylus maritimus, recorded as a single specimen at Valtos, should be added to this group. This species was found in drift-line seaweed at 16 of the 18 Outer Hebrides sites sampled.

Dyschirius politus was taken at only four sites, and of these it was only numerous at Valtos (37 specimens). D. globosus, however, is a very eurytopic species and was recorded from 13 of the 18 Outer Hebrides often in fairly large numbers. Elsewhere it was trapped at Dornoch (13), Tentsmuir (5) and Gullane (1) (see map 23). Bembidion pallidipenne was taken singly at Stilligarry (south) and Eorpie whilst the rarer Asaphidion pallipes is represented by one specimen from Achnahaird.

Although Calathus erratus and C. mollis are typical coastal species they were the least abundant members of the genus trapped. C. erratus occurred in samples at only six of the East Coast sites, 9 of the 11 Moray Firth sites (being most numerous at Lossiemouth and Tentsmuir and three scattered North Coast sites (Dunnet, Achnahaird and Redpoint). It is not known from the Outer Hebrides. C. mollis is more generally distributed, although less well represented at Moray Firth sites, and was at its most numerous at Sheigra and Melvich. C. fuscipes and C. melanocephalus have essentially similar distributions being recorded for all but two and four sites respectively. The former was trapped in large numbers at Morrich More 1 and 2, otherwise it was most common on the Outer Hebrides, especially at Hosta and Howbeg (map 24). C. melanocephalus, although most numerous at Paible, was trapped in the next largest numbers at Morrich More 1. The numbers for these two

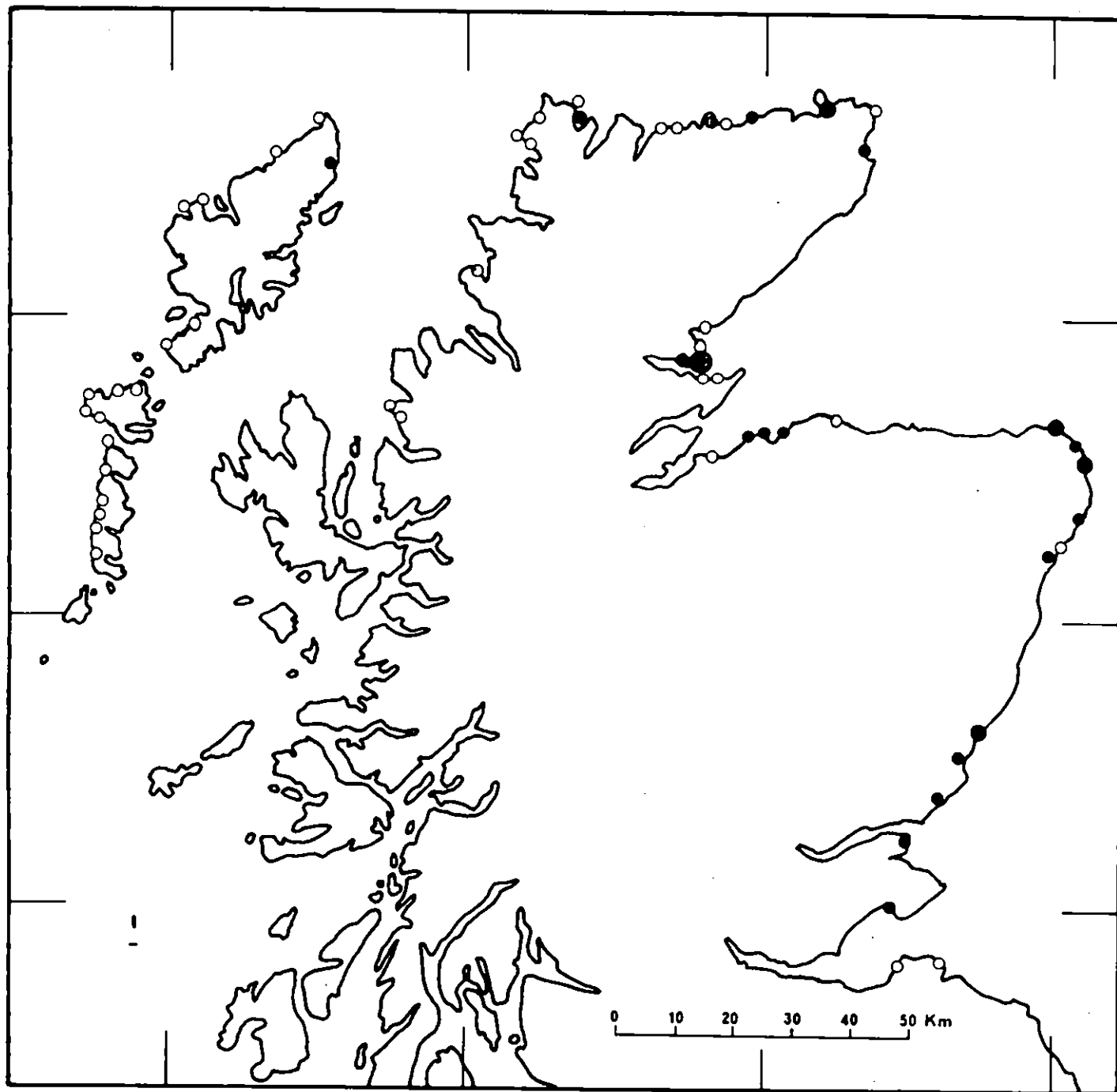


AMARA BIFRONS

Map 25

Specimens recorded per site

- 21-61
- 6-20
- 1-5
- Not Recorded

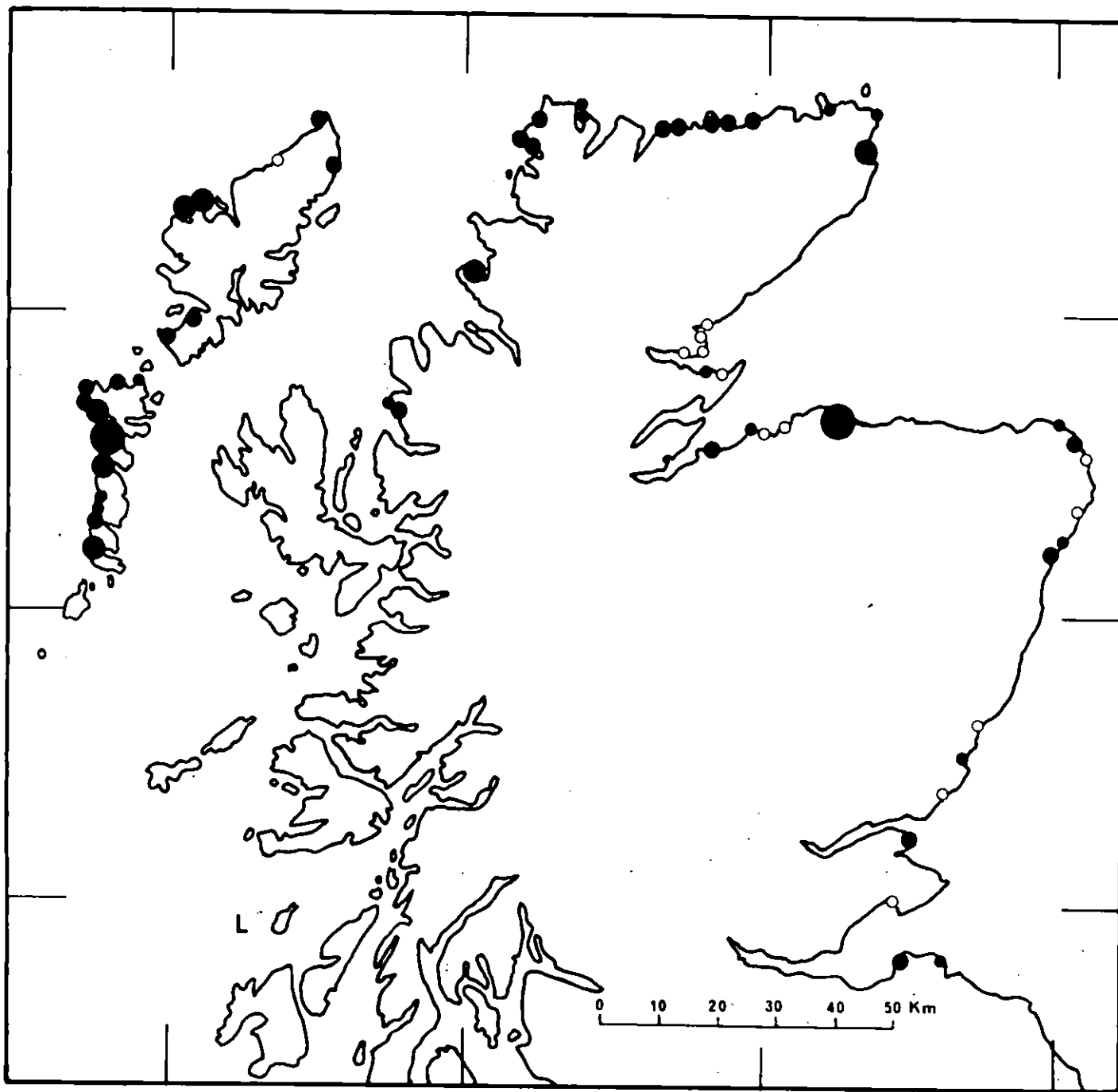


LEISTUS RUFESCENS

Map 26

Specimens recorded per site

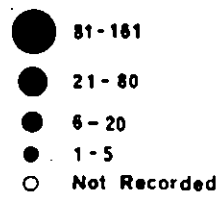
- 21 - 44
- 6 - 20
- 1 - 5
- Not Recorded

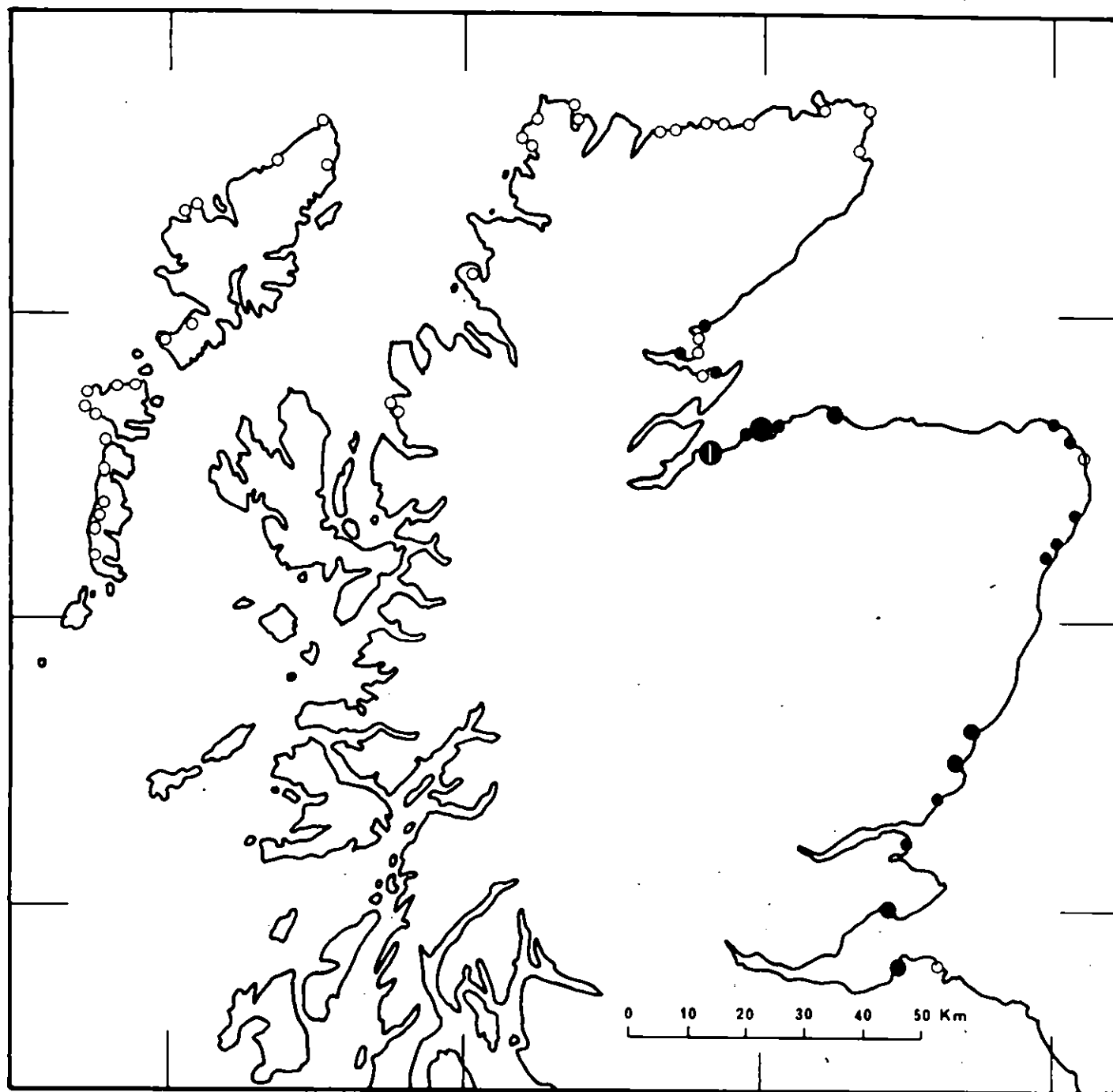


PHILOPEDON PLAGIATUS

Map 27

Specimens recorded per site





OTIORHYNCHUS OVATUS

Map 28

Specimens recorded per site

- 21-39
- 6-20
- 1-5
- Not Recorded

species from the two Morrich More sites make up over half the total number of Carabidae from all sites.

The xerophilous Amara bifrons was well established throughout the machair of the Outer Hebrides and broadly similar sites along the North Coast, being recorded elsewhere only at St. Fergus and Tynningame (map 25). A. familiaris has a similar distribution but was better represented on East Coast sites and two specimens were also recorded at Morrich More 2. Perhaps less explicable are the results for Loricera pilicornis, which is normally a more hygrophilous species. It had an Outer Hebrides - North Coast distribution with the exception of St. Cyrus and Montrose Links where the largest number of specimens was trapped. The data for A. tibialis and A. aenea may reflect the northern limits for their distribution in Britain. Moore (1957) does not record the former north of the Moray Firth and the latter only from west and south-west Scotland. During the Survey A. tibialis was absent from the North Coast sites and yet occurred in the northernmost sites on Lewis, whilst it was taken at only a single Moray Firth site (Whiteness) and five East Coast sites. A. aenea, on the other hand, was well represented in the Moray Firth and Uists although not recorded from Harris and Lewis nor on the extreme north coast of the mainland. It was however taken at Redpoint and Oldshore More on the north-west coast.

Of the two species of Harpalus listed by Lindroth, H. rubripes was recorded at only three adjacent sites on the Moray Firth (Whiteness, Culbin Bar 1 and 2) with 37 specimens taken on the mainland relict of Culbin Sands. H. tardus is considered uncommon in the north and the occurrence of only three specimens at Fraserburgh and Gullane would seem to confirm this. However Lindroth (1974) and Moore's (1957) assessment that Dromius linearis is only known from the west lowlands of Scotland, was obviously based on very limited knowledge. This species was not only trapped from the Firth of Forth to the Moray Firth but a single specimen was also collected at Farr Bay on the North Coast. Of the remaining xerophilic species D. notatus occurred singly at Dornoch, Culbin Bar, Tenstmuir and Dumbarnie. Metabletus foveatus was trapped at only two sites (Fraserburgh and Tentsmuir), Synuchus rivalis at only three scattered sites (Daliburgh, Melvich and Culbin Bar 1) and Bradycellus harpalinus singly at Findhorn, Lossiemouth and Tynningame.

Two further species of Carabidae are worthy of comment. Badister bipustulatus, a very eurytopic species, occurred in small numbers in several East Coast and Moray Firth sites with an isolated two specimens trapped at Faraid Head. Lindroth (1974) regards Leistus rufescens, as the most hygrophilous member of the genus. It was trapped at all but one of the

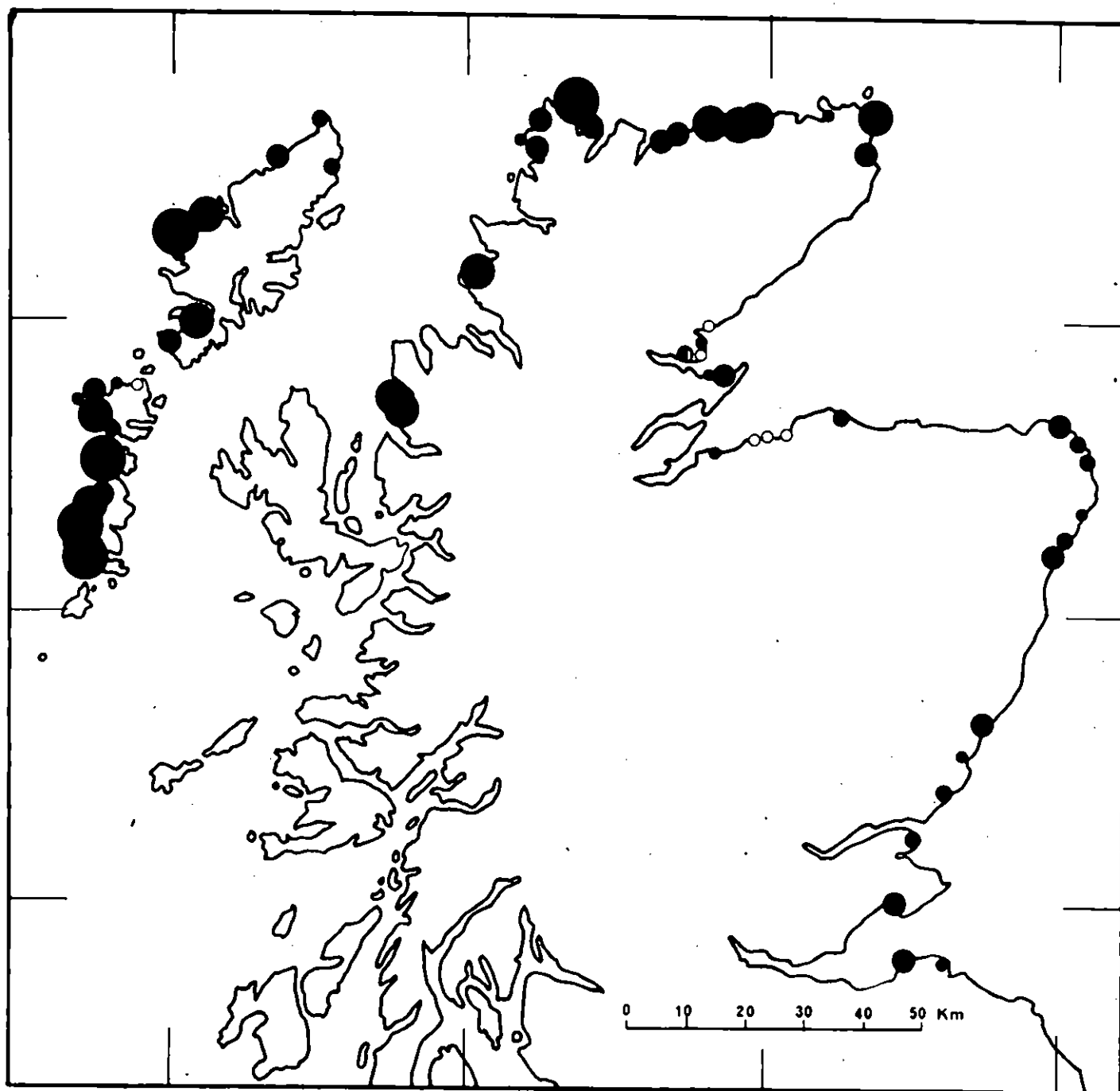
East Coast sites, with a maximum of 44 specimens at Dornoch. It was also collected at five North Coast sites and a single specimen was recorded at Tolsta on Lewis (map 26). It is interesting to note that this was the second most numerous species of Carabidae recorded by Cotton (1967) at Whiteford Burrows National Nature Reserve.

10.4 Other families of Coleoptera

The Curculionidae, Scarabaeidae and Tenebrionidae of coastal sand dunes are represented by fairly large, readily identifiable species. Among the Curculionidae Otiorhynchus atroapterus is considered almost synonymous with sand dunes and Philopodon plagiatus only slightly less so. The latter species was recorded from all the North Coast and Outer Hebrides sites with the exception of Barvas on Lewis, and although the largest numbers were trapped at Lossiemouth it was recorded from few of the other Moray Firth and East Coast sites (map 27). O. atroapterus shows an almost identical distribution with maximum numbers trapped at Lossiemouth but it was not recorded from the once extensive dune system at Culbin Bar. Although absent from pitfall trap samples from many of the more southerly Outer Hebrides sites hand collecting showed it to be present at all except Stilligarry (south) but it doubtless does occur there. O. ovatus, a species regarded by Walsh (1926) as one of a small group of northern coastal Coleoptera was restricted to samples from the East Coast and Moray Firth sites although Dr M.G. Morris (pers. comm.) has taken it recently at Dunnet on the North Coast. This species is not known from Shetland (M.E. Bacchus pers. comm.) or the Outer Hebrides (Waterston et al, in press) (map 28). Another large weevil associated with thistles on sandy sites which might be expected to occur more especially on some of the East Coast sites is Cleonus piger.

This species has been recorded in considerable numbers during May at Gullane by Hudson Beare (1921), and at Aberlady Bay in September by Crowson (1956) and during April and May by Cawthra (1958). Crowson (1970) found it at Tynninghame and Carter (1921) records it as "never common on thistles" at Monifieth (= site 89, Barry Links of Project 340). Morris (1971) summarises other early records of Cleonus piger from Scotland and records a single specimen from Tentsmuir "just outside the National Nature Reserve". No specimens were trapped or seen during this survey, but Cawthra observed that after laying their eggs "very few adults of this species remained by late May and none in June.

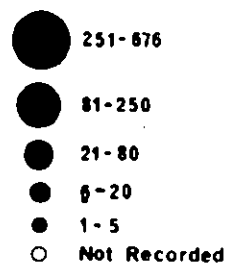
A less conspicuous species of sandy and predominantly coastal areas is Sitona griseus. Recorded by Fowler (1891) from Tay and Moray Firth areas it was trapped during this survey in moderate numbers at Tentsmuir with

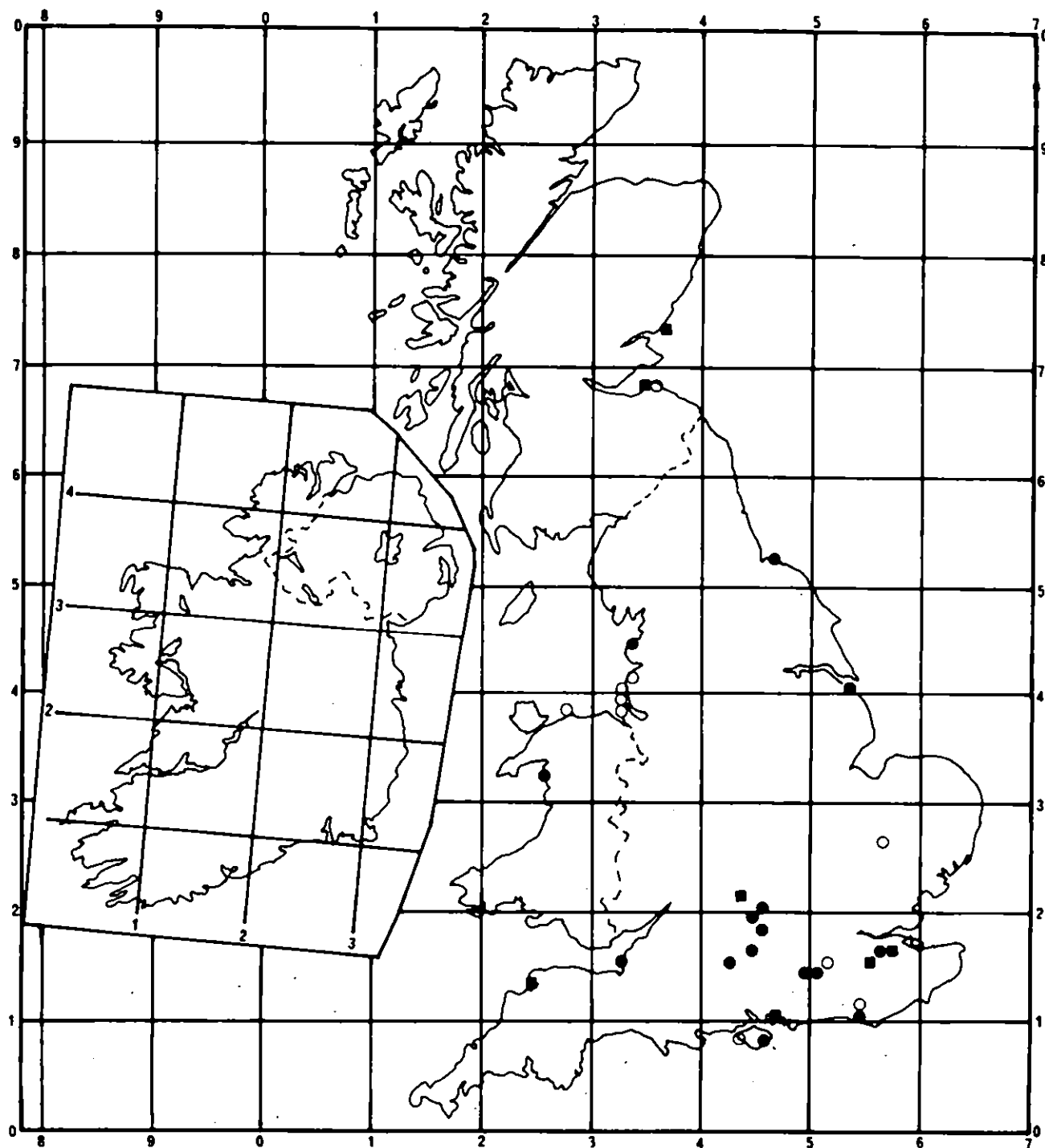


SERICA BRUNNEA

Map 29

Specimens recorded per site





**APHODIUS (HEPTAULACUS)
VILLOSUS**

Map 30
Distribution in the British Isles

- → 1900
- 1900-1939
- 1940 →

smaller catches at St. Cyrus and Montrose Links, Lossiemouth, Whiteness and Culbin Bar. Dr M.G. Morris (pers. comm.) has also recorded it at Coul Links Dornoch and Morrich More and these would appear to be its most northerly known localities. Another weevil Miarus campanulae was trapped at St. Cyrus where Crowson (1977) had recorded it "on Campanula glomerata L., remarkably abundant at possibly its northernmost British station". Perring and Walters (1976) show only one more northerly locality for this plant, near Stonehaven (O/S ref 37/88). If this was its only host plant Crowson's statement would be indisputable. However, Morris (1967) has shown this species to breed in C. rotundifolia, which he regards as by far the most usual host, and which is widespread in Scotland.

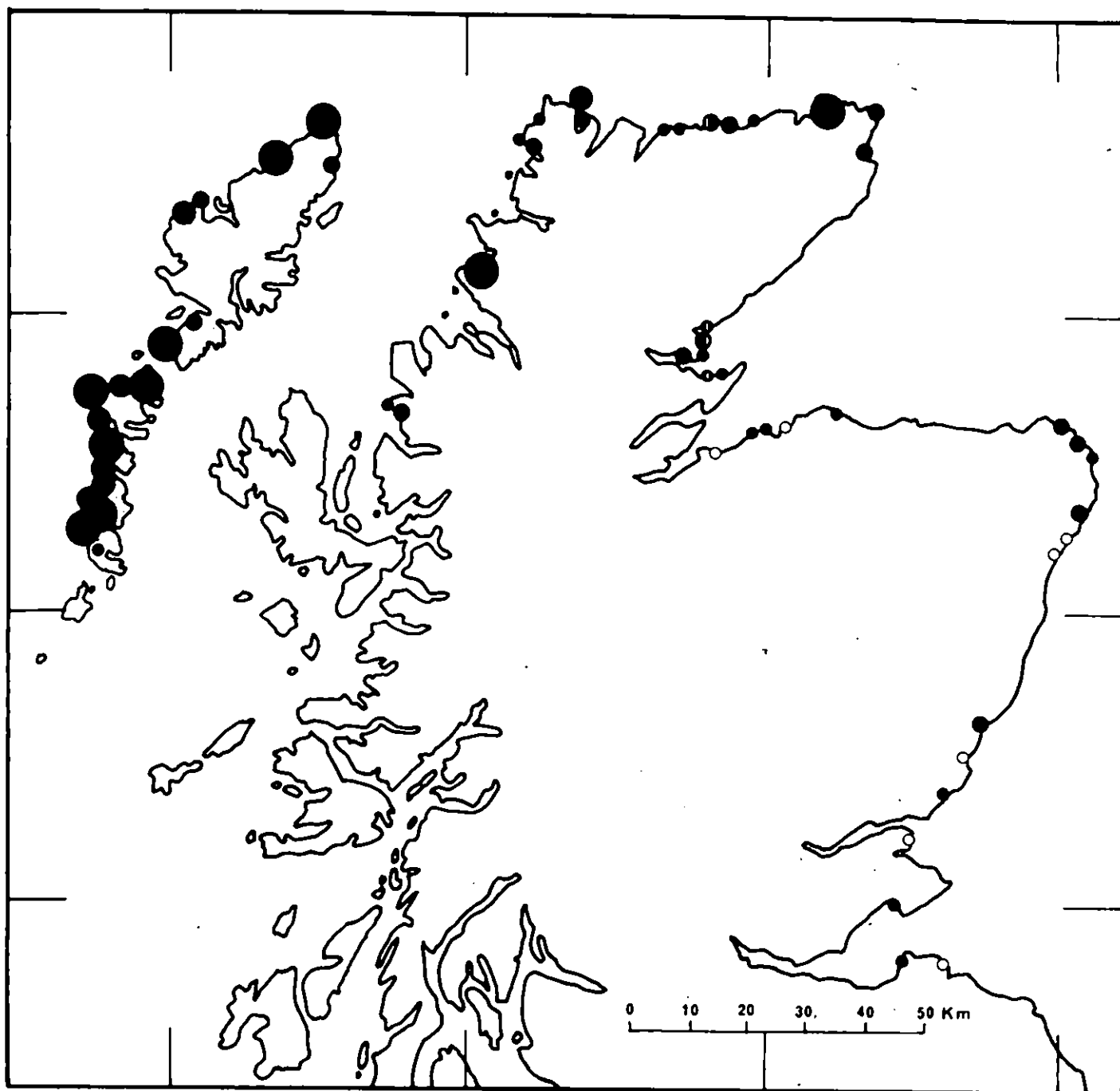
Aegialia arenaria, one of the most characteristic Scarabaeidae of coastal dunes, and generally regarded as widely distributed, was recorded by Murray (1853) as "occasional" on the "shores of the Firth of Forth". During this survey only one specimen was trapped at Redpoint (north) although it has been recorded at Tentsmuir and Forvie (Smith, 1967 and 1977). Carter (1921) recorded it "on sandhills near Monifieth" among a group of species he lists as "more or less plentiful". Side (1977) recorded it from Barry Links on the north banks of the Tay Estuary. This species has also recently been widely recorded on the Outer Hebrides (Waterston et al). A single specimen of the less common A. sabuleti was collected at Tentsmuir. Psammodius asper was recorded by Fowler (1890) as "extremely local in the Tay district". Euchlora dubia has been recorded from Gullane and Montrose by Murray, Monifieth by Carter (1921), and Smith (1967) has taken it at Tentsmuir. Neither of these species was trapped during this survey but Britton (1956) stated that adults of the latter species are active during May, well before the first sampling period. However, Side (1977) recorded it as late as 3 July at Tentsmuir. By far the most abundant scarabaeid (adults and larvae were trapped) was Serica brunnea (map 29), which was most numerous on the Outer Hebrides and North Coast and was only unrecorded at one North Uist and four Moray Firth sites. A.R. Waterston (pers. comm.) regards this as "one of the most characteristic machair insects".

The large dung beetle Geotrupes vernalis, with the exception of nine specimens at Findhorn was recorded from the ten more north-westerly sites, being most numerous in the Outer Hebrides at Daliburgh, Uig and Balranald. The most interesting scarabaeid record is of a single Aphodius villosus at Arbroath. Britton (1956) erroneously recorded it as "very rare, sand and chalk country in the south of England", apparently disregarding not only

many late nineteenth century records from the Southport district, and from North Berwick, East Lothian (Fowler and Donisthorpe, 1913) but also a more recent capture from Redcar. More recently Crowson (1956) collected one specimen under a dead rabbit on the dunes at Aberlady Bay. This latest record is only the seventh known from Britain during the last 40 years (map 30).

The third family characteristic of coastal dunes, at least in southern Britain, is the Tenebrionidae, whose distribution has been recently summarised by Brendell (1975). None of the five main dune species was recorded by Brendell from the Regions covered by this survey and none was found. Crypticus quisquilius is not known north of Flint and south-east Yorkshire. Phyllan gibbus and Phaleria cadaverina are known no further north than the coast of Ayrshire and Opatrum sabulosum reaches Cumberland, which Brendell also gives as the most northerly locality for Melanimon tibialis. However, Carter (1921) recorded this last species (as Microzoum tibiale) at Monifieth where he described it as "more or less plentiful", and more recently Smith (1967) has taken it on more than one occasion at Tentsmuir between 1963 and 1967. Lagria hirta, now included in the Tenebrionidae, although not a species of coastal or necessarily sandy areas, flies regularly to light. Its distribution in Scotland is unusual in being apparently restricted to the south-west and the Moray Firth (Fowler, 1891 and Buck, 1954). The results of this survey would appear to support this in that it was collected only at Culbin Bar 2, Findhorn and Lossiemouth and at the last site three larvae were also trapped.

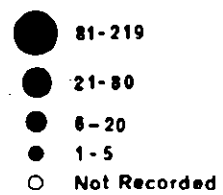
Two other very distinctive species most commonly found on coastal sand dunes are Orthocerus clavicornis and Notoxus monoceros. The former is known from very old records from Dalmeny near Edinburgh (Fowler 1889 and Murray 1853). Carter (1921) recorded "half a dozen" specimens at Monifieth in June 1910; Crowson (1956) collected it in September 1955 at Aberlady Bay and Luce Bay (= Torrs Warren, Site 1 of Project 340). It was recorded at Tentsmuir by Smith (1967), and more recently at St. Cyrus by Crowson (1977) who thought this to be "at or near its northern British limit". However, during this survey 13 specimens were collected at Lossiemouth, 6 at Culbin Bar 2 and one at Clashmore, thus greatly extending its known range in Scotland. Notoxus, although known from Cocksburnspath in Berwickshire, Gullane and near St. Andrews, was not collected during this survey and has not been recorded during more extensive studies at Tentsmuir. The coastal histerid, Baekmanniolus maritimus is known in Scotland by old records from the Firth of Forth area (Murray, 1853 and Fowler, 1909). Hudson Beare (1921)

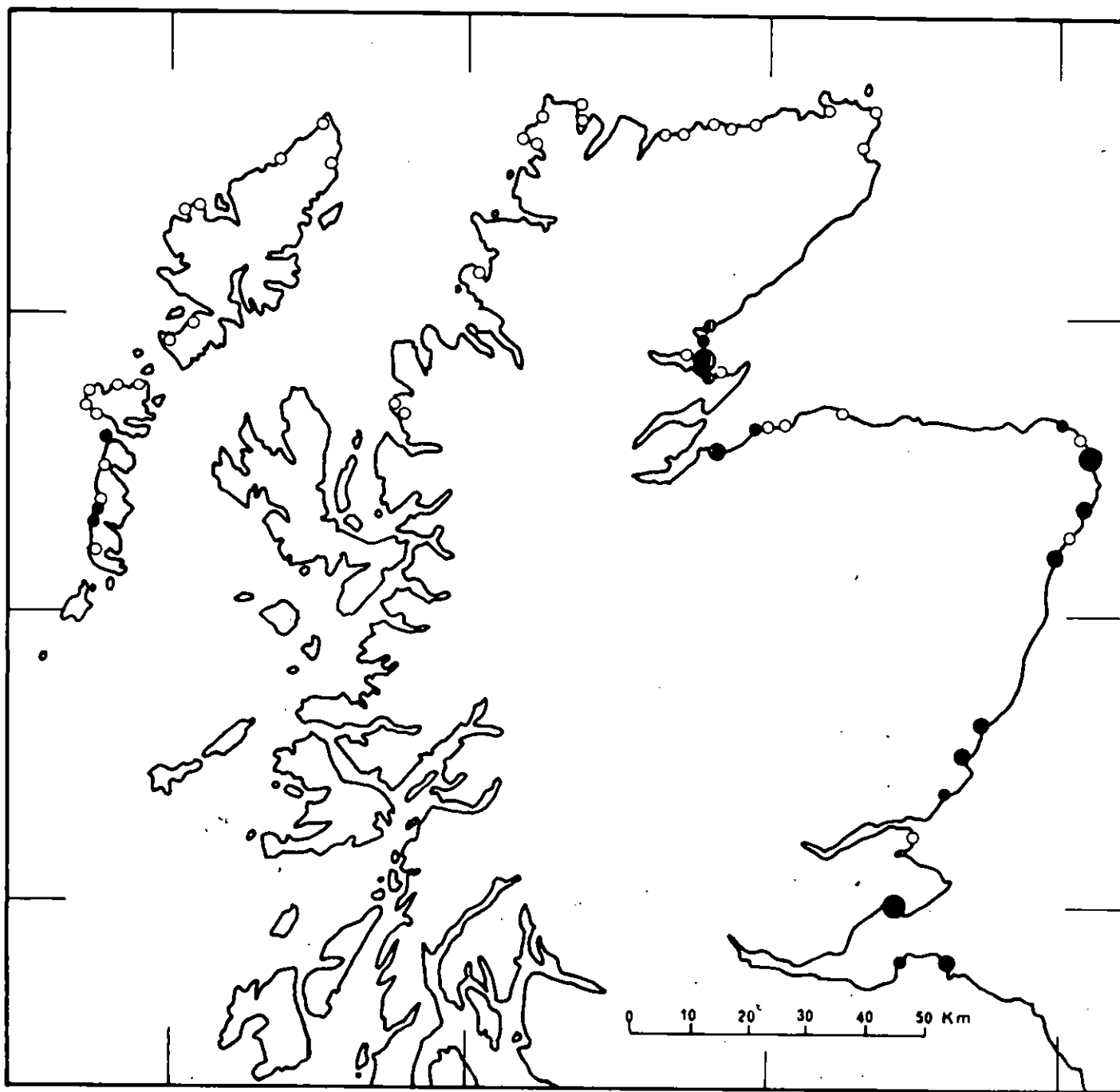


LEIODES DUBIA / OBESA

Map 31

Specimens recorded per site





CORTICARIA CRENULATA

Map 32

Specimens recorded per site

- 21 - 51
- 6 - 20
- 1 - 5
- Not Recorded

recorded it at Gullane (as Pachylopus maritimus) and Smith (1967) has found it further north at Tentsmuir. None was trapped during this survey.

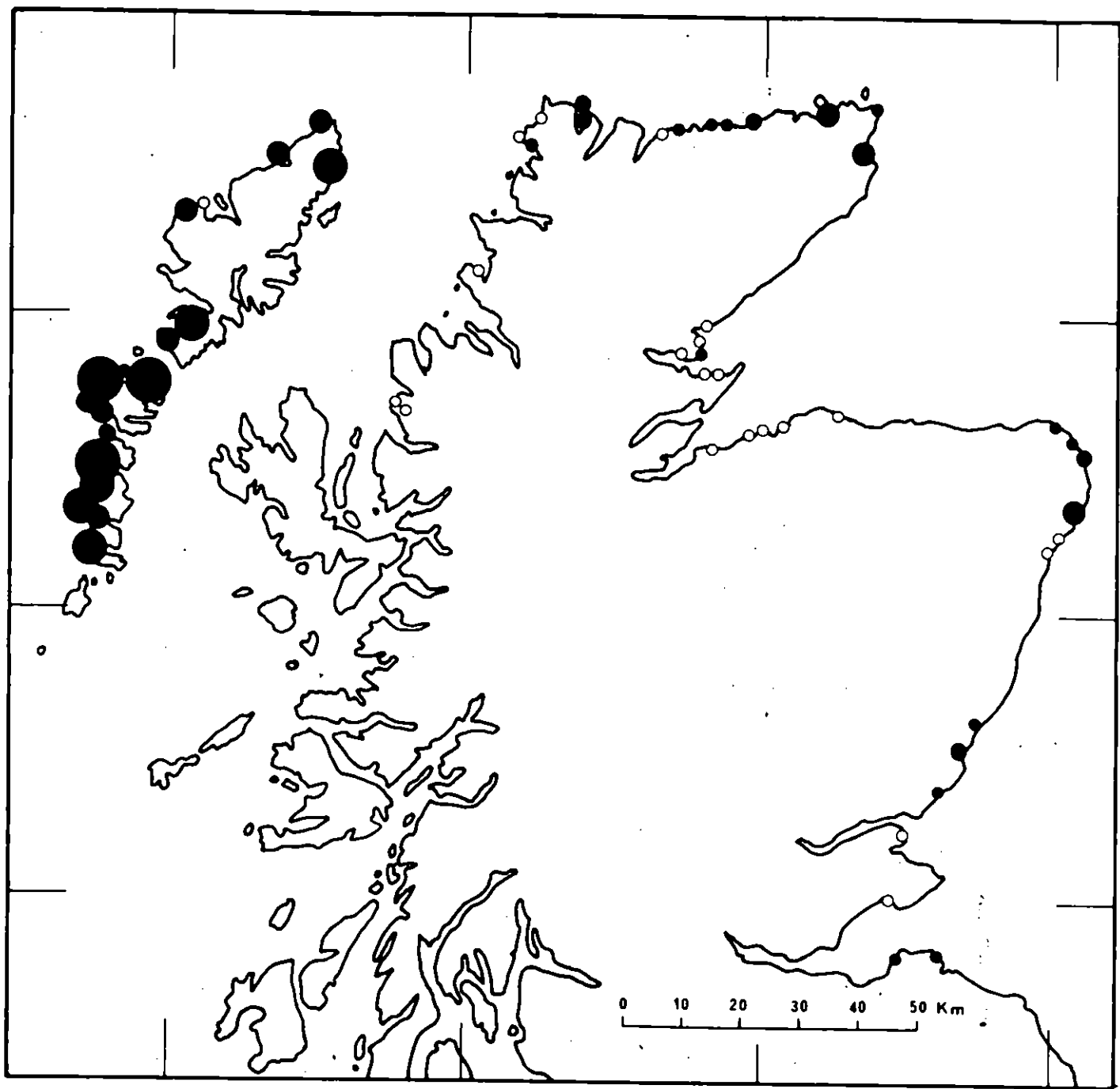
The genus Leiodes is difficult taxonomically due to the species exhibiting considerable size variation and differential development of the secondary sexual characters. As a result, although undoubted males of both L. dubia and L. obesa have been identified from the material collected it has been considered prudent to combine the records and in the Site Dossiers (Vol. II) all specimens are referred to as Leiodes dubia. Neither is regarded as a coastal species but both frequent areas with sandy soils. From the Survey samples they proved to be far more numerous on the machair of the Outer Hebrides and at mainland sites such as Achnahaird, but there was a marked decline in numbers on the Moray Firth and East Coast where they were unrecorded from seven sites (map 31). Byrrhus fasciatus, another arenophile rather than coastal species, was considerably less abundant than the previous species. It had a similar distribution pattern centred on the Outer Hebrides and North Coast. The largest numbers were taken at Sinclairs Bay and it was virtually absent from the Moray Firth (two at Culbin Bar 1 only) and occurred in small numbers at only five East Coast sites. Corticaria crenulata (map 32) is considered to be a species with a predominantly coastal distribution. It was trapped in two thirds of the East Coast and Moray Firth sites and was particularly numerous at Dornoch, St. Fergus and Dumbarnie. The records from the three Uist sites are the first for the Outer Hebrides.

Corticarina fuscula, a more generally distributed species associated with decaying vegetable matter, showed a very similar distribution pattern although it was also trapped at Freswick and Sinclairs Bay and is known from Shetland (M.E. Bacchus pers. comm.). Corticaria umbilicata, although not generally regarded as having any coastal affinities, was especially numerous at a number of the East Coast sites (e.g. Fraserburgh). It was also well represented in the Moray Firth and occurred at three North Coast sites. There are no records for the Outer Hebrides or Shetland. It would appear that in Scotland this species is not as rare as was earlier believed (Fowler 1889) and it is possible that its distribution is largely coastal. Crowson (1970) found it in "drift along the high tide line" at Tynninghame and included it in a list of twenty species of Coleoptera from St. Cyrus. "Most of which seem to be at or near their northern British limits" (Crowson 1977).

Species of Bledius burrow into sandy and muddy substrates. They are usually very local in their distribution and some are submerged at high

tide. Two were recorded during this survey. B. fuscipes, a species of sandy coasts and estuaries, recorded by Hudson Beare (1921) "in 'hundreds" at Gullane in May and known to occur at Tentsmuir (Smith, 1967), was recorded as a single specimen from Achnahaird. B. longulus, on the other hand, is a species of sandy areas, not necessarily coastal. The survey showed it to be common throughout the Outer Hebrides although apparently absent from the three most northerly sites on Lewis. On the mainland it was numerous at Redpoint (south) and Achnahaird but was recorded elsewhere only at Dunnet, Sinclairs Bay and Don to Ythan, although there is a record from Culbin Sands at the end of the last century. Bledius spp. are preyed on by several species of Dyschirius including D. politus but not D. globosus. The fact that a single D. politus was recorded at St. Cyrus and Montrose Links indicates that species of Bledius, possibly B. longulus, could be expected to occur there. Another staphylinid characteristic of sandy soils is Atheta exigua. Apart from three specimens at Lossiemouth and Dornoch in the Moray Firth group, it was restricted to samples from the Outer Hebrides where it was only unrecorded from four scattered sites. Another species which, from the results of this survey, would appear to have a very restricted distribution is Silpha tyrolensis. It was trapped in often considerable numbers, both as adult and larva, at nine Uist sites only. It was, however, recorded by hand collecting at Eoropie in the north of Lewis and at Hushinish, Harris and is generally regarded as widely distributed, local but not rare. Fowler (1889) mentioned the Tay and Dee regions as localities for this species and it is surprising that over three hundred specimens were taken at two Outer Hebrides sites, (Borve and Paible) and yet none was trapped anywhere on the mainland.

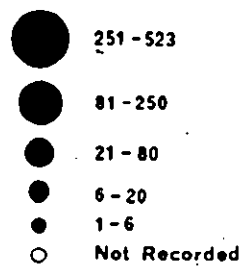
Psylliodes marcida is restricted to coastal areas due to the distribution of its foodplant, Cakile maritima. Although only a single specimen was trapped at Stilligarry (south) it is known to be widely distributed in Scotland. Crowson (1971) regarded the distribution of Chaetocnema hortensis to be "In Scotland, confined largely to the south and to coastal habitats". A single specimen was trapped at Fraserburgh. Its larvae bore into the basal stems of a variety of grasses. Other phytophagous species recorded by the Survey feed on plants with a much more general distribution. Thus although the abundance of Apion dichroum on the Outer Hebrides reflects the abundance of Trifolium repens in the rich machair turf, this species is common throughout most of the British Isles which makes its relative absence (5 specimens from 4 sites) at both Moray Firth and East Coast sites all the more surprising. Similarly the presence of Apion loti directly reflects the relative abundance of Lotus corniculatus on the sample sites. Longitarsus

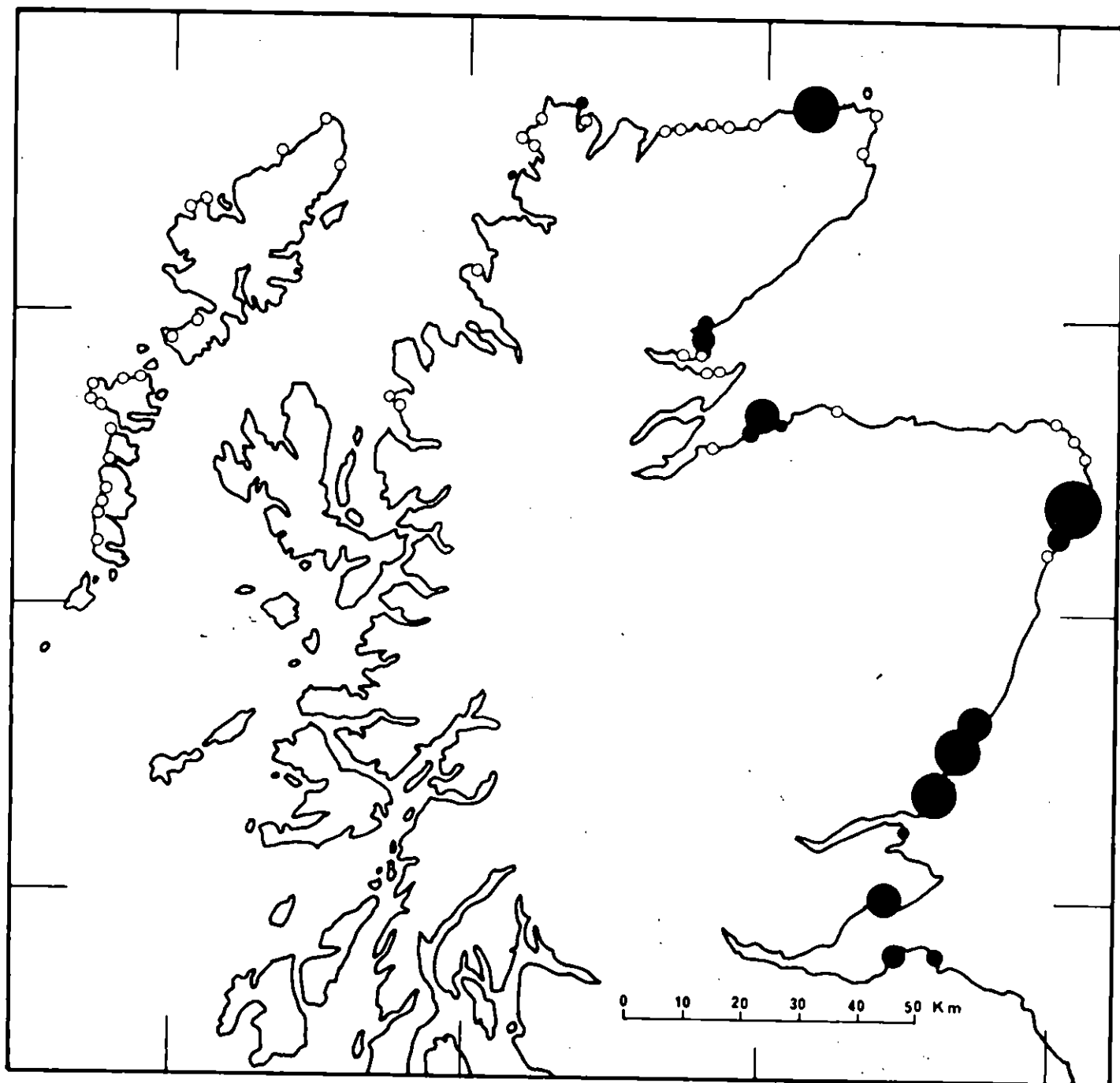


MEGASTERNUM OBSCURUM

Map 33

Specimens recorded per site

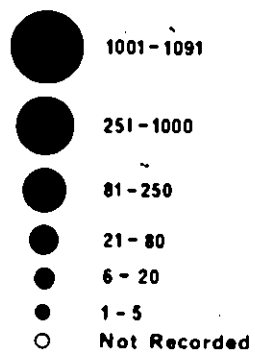




DRUSILLA CANALICULATA

Map 34

Specimens recorded per site



succineus, which Kevan (1967) recorded as polyphagous on various Compositae, was trapped at many East and North Coast sites, although found at only three Outer Hebrides and two Moray Firth sites. This is interesting in that it is contrary to Crowson's (1977) belief that St. Cyrus is "at or near the northern British limit" for this species.

A few other species of Coleoptera were recorded which have a tendency to be more numerous in coastal areas. Quedius semiaeneus, with the exception of single specimens trapped at Melvich, Strathbeg and Forvie was confined to Outer Hebrides sites, although only present in small numbers. Coccinella 11-punctata was once regarded as a coastal species but in recent decades appears to have spread inland and become more common. It was recorded in low numbers at nine scattered sites but was locally abundant at Tynninghame. Hypnoides riparius was described by Joy (1932) as "chiefly on the coast". It is however, much more widely distributed although in this survey it occurred at only three sites, Robach, (76 specimens), Dunnet (25) and Freswick (a single specimen). Of greater interest are the two male Quedius humeralis caught at Dornoch. This species was previously thought to have a southern, and largely coastal distribution with Spurn Head as one of its more northerly localities. Recently Mr P.M. Hammond (pers.comm.) discovered a specimen in the D. Sharp collection at the British Museum (Natural History) taken at Garelochhead, Dunbartonshire, in July 1865 and Smith (1967) recorded it as Q. obliteratus at Tentsmuir. The Dornoch specimens thus greatly increase the known British range of this species. The Quedius boops - group comprises a number of taxonomically closely related species of which Q. aridulus appears to be a typical dune species. However, the seventeen specimens at sites ranging from Ormiclate to Tolsta in the Outer Hebrides and from Reay in the North to Forvie on the East Coast all appear to be the true Q. boops. Othius laeviusculus is not uncommon in southern England in estuarine conditions, water meadows and flood refuse but Crowson (1961) regards it as "usually associated with maritime dunes and calcareous downland" and referred to records for Aberlady Bay, Duddington and Arran. Crowson (1977) later took it at St. Cyrus and Montrose Links which he regards as being "at or near its northern British limit." The most northerly specimens seen by P.M. Hammond (pers. comm.) are from the 10 km square in which this site is situated and from Iona. It is also known from Tentsmuir (Smith, 1967). Although only a single specimen was trapped at Bettyhill during the main survey, additional specimens were collected at Northton and Barvas in pitfall traps left operating for a further three weeks during August 1976 and a single specimen was taken at Strathy on 31 July 1972. These are not only the most northerly records for Britain but probably for Europe. Mycetoporus angularis was

recorded from a single specimen trapped at Achnahaird. This species is not common and is known from widely scattered localities including the Moray Firth and Shetland. Several of these records are from coastal sites. Two other Staphylinidae warrant comment from a distributional viewpoint.

Metopsia retusa has been rarely recorded in Scotland or northern England. Murray (1853) listed Aberdeenshire, Dalmeny Park and Berwickshire, Smith (1967) recorded it from Tentsmuir and there may be more recent inland records e.g. Rannoch. Single specimens were trapped at Arbroath, Culbin Bar 2, Morrich More 2 and Strathy the last being in the centre of the north coast. In the past there has been considerable confusion over the identity of Anthobium spp. The most northerly record for A. atrocephalum known to P.M. Hammon (pers. comm.) is an old D. Sharp specimen from Forres. Single specimens were collected during this survey, one at possibly the same locality, Findhorn and another at Coul Links slightly further north.

Megasternum obscurum (map 33) was consistently one of the most numerous species in samples from the Outer Hebrides sites. It was considerably less abundant at North and East Coast sites and only a single specimen was trapped at Dornoch out of all the Moray Firth sites. What appear to be melanistic forms of this species were collected at Stillgarry (south), Hosta and Uig although no published reference to such a form has yet been found. On what is known of the general biology of this species it is difficult to explain its abundance on the machair. Fowler (1887) stated that it is "common and widely distributed in decaying vegetable matter, rotting fungi, dung etc.", all of which indicate a preferred hydrophilous habitat. Possible explanations are that the dense machair turf contained sufficient litter to support these populations, or that there was a greater abundance of dung or even that the 200-220 Rain Days (Anon. 1978) each year provide a sufficiently humid environment. However, none of these appear very convincing. Similar hypotheses are required to explain why much greater numbers of such common, widely distributed species as Tachyporus chrysomelinus, Stenus nanus, Philonthus succicola, P. varius and Atomaria nitidula were trapped at the Outer Hebrides sites.

10.5 Myrmecophilous beetles

Drusilla canaliculata was regarded by Donisthorpe (1927) as a non-obligate myrmecophile associated with several different species (and genera) of ants. It is frequently found in considerable numbers in the immediate vicinity of ants' nests and may be a tolerated scavenger. During this survey it was recorded only at East Coast, Moray Firth and two North Coast sites (map 34). However, it is known to be widely distributed in Scotland and has been

Table 12 List of 72 species of Coleoptera recorded as single specimens.

Site numbers in brackets to left of species name. (Refer to table 1 for site names)

CARABIDAE

- (81) *Leistus fulvibarbis* Dej.
- (90) *Notiophilus germinyi* Fauv.
- (52) *Asaphidion pallipes* (Duft.)
- (95) *Bembidion guttula* (F.)
- (75) *Pterostichus adstrictus* Esch.
- (43) *Agonum albipes* (F.)
- (95) *A. dorsale* (Pont.)
- (41) *Amara eurynota* (Pz.)
- (86) *A. plebja* (Gyll.)
- (41) *Harpalus rufipes* (Deg.)
- (86) *Dromius melanocephalus* Dej.

HYDROPHILIDAE

- (91) *Helophorus arvernensis* Muls.
- (44) *H. flavipes* (F.)
- (91) *Cryptopleurum minutum* (F.)

LEIODIDAE

- (82) *Agathidium atrum* (Pk.)

SCYMAENIDAE

- (66) *Scydmorephes helvolus* (Schaum)

STAPHYLINIDAE

- (87) *Lesteva longoelytrata* Goetz.
- (75) *Omalium caesum* Gr.
- (22) *O. excavatum* Steph.
- (42) *O. rivulare* (Pk.)
- (52) *Bledius fuscipes* Rye
- (42) *Anotylus maritimus* Th.
- (26) *A. nitidulus* (Gr.)
- (63) *Stenus crassus* (Steph.)
- (79) *S. subaeneus* (Er.)
- (57) *Othius laeviusculus* Steph.
- (63) *Xantholinus fracticornis* (Muell.)
- (81) *Gabrieus osseticus* (Kol.)
- (91) *Staphylinus globulifer* Fourc.
- (91) *Quedius picipes* (Man.)
- (52) *Mycetopus angularis* Muls & Rey
- (84) *M. clavicornis* (Steph.)
- (69) *M. nigricollis* Steph.
- (99) *Tachinus elongatus* Gyll.
- (81) *T. proximus* Kr.
- (86) *Encephalus complicans* Steph.
- (61) *Boreaphila islandica* (Kr.)
- (70) *Atheta (Philhygra) melanocera* (Th.)
- (62) *A. (Microdota) glabricula* Th.
- (68) *A. (Mocyta) clientula* (Er.)
- (63) *A. (s.str.) graminicola* (Gr.)
- (88) *A. (s.str.) xanthopus* (Th.)
- (93) *A. (Lohse Grp 1) crassicornis* (F.)
- (61) *A. (Dimetrota) setigera* (Shp.)
- (62) *A. (Chaetida) longicornis* (Gr.)

STAPHYLINIDAE (Cont)

- (62) *Ocalea picata* (Steph.)
- (52) *Aleochara bilineata* Gyll.
- (35) *A. cuniculorum* (Kr.)

SCARABAEIDAE

- (96) *Aegialia arenaria* (F.)
- (90) *A. sabuleti* (Pz.)
- (35) *Aphodius depressus* (Kug.)
- (88) *A. villosus* Gyll.

ELATERIDAE

- (95) *Agrypnus murinus* (L.)
- (93) *Agriotes sputator* (L.)

CANTHARIDAE

- (64) *Malthodes pumilus* (Breb.)

CRYPTOPHAGIDAE

- (23) *Cryptophagus intermedius* Bruce
- (31) *C. scanicus* (L.)
- (22) *Atomaria lewisi* Reitt.
- (84) *A. ruficornis* (Marsh.)

COCCINELLIDAE

- (93) *Rhyzobius litura* (F.)

LATHRIDIIDAE

- (42) *Lathridius anthracinus* Man.

CHRYSOMELIDAE

- (69) *Phyllotreta undulata* (Kuts.)
- (79) *Chaetocnema hortensis* (Fourc.)
- (27) *Psylliodes marcida* (Ill.)
- (75) *Cassida rubiginosa* (Muell.)

APIONIDAE

- (27) *Apion (Erythrapion) cruentatum* Walt.
- (86) *A. (Eutrichapion) ononis* Kirby

CURCULIONIDAE

- (82) *Sitona hispidulus* (F.)
- (91) *Grypus equiseti* (F.)
- (21) *Ceuthorhynchidius troglodytes* (F.)
- (90) *Rhinoncus castor* (F.)

SCOLYTIDAE

- (95) *Hylastinus obscurus* (Marsh.)

Table 13 26 species of Coleoptera which were recorded from only a single site but in numbers greater than one.

Site number in brackets to left of species name. Number of specimens trapped at the site is given after the author's name for each species.

CARABIDAE

- (57) *Pterostichus madidus* (F.) 21
(22) *Laemostenus terricola* (Hbst.) 2

HISTERIDAE

- (95) *Saprinus aeneus* (F.) 3

LEIODIDAE

- (82) *Choleva agilis* (Ill.) 3

STAPHYLINIDAE

- (79) *Anthobium unicolor* (Marsh.) 2
(81) *Othius myrmecophilus* Kies. 2
(35) *Philonthus fimetarius* (Gr.) 3
(57) *Staphylinus olens* Muell. 3
(68) *Quedius humeralis* Steph. 2
(36) *Q. scintillans* (Gr.) 6
(79) *Cypha punctum* (Mots.) 2
(62) *Liogluta granigera* (Kies.) 15
(62) *Atheta* (Bessobia) *excellens* (Kr.) 2
(62) *A.* (*Microdota*) *liliputana* (Bris.) 23
(95) *A.* (*Acrotona*) *muscorum* (Bris.) 9
(82) *A.* (*s.str.*) *brunneipennis* (Th.) 5

SCARABAEIDAE

- (52) *Aphodius rufus* (Moll.) 2

LATHRIDIIDAE

- (95) *Aridius bifasciatus* (Reitt.) 13
(63) *Lathridius pseudominutus* (St.) 2

CHRYSOMELIDAE

- (86) *Phaedon tumidulus* (Germ.) 2
(83) *Phyllodecta vulgatissima* (L.) 4
(91) *Longitarsus curtus* (Allard) 4

CURCULIONIDAE

- (90) *Phyllobius pyri* (L.) 2
(62) *P. viridicollis* (F.) 7
(79) *Hypera plantaginis* (Deg.) 2
(86) *Miarus campanulae* (L.) 4

recorded from Tarbert, Harris. Falagria thoracica, was relatively numerous at Sandwood with only one other specimen being trapped at Bettyhill, where a single specimen was also collected on 28 July 1972. These records are considerably further north than any previously known Scottish localities.

10.6 Discussion

As has already been mentioned phytophagous species are generally under-recorded by the Survey and, apart from the few described above, details of host plants are given in the individual Site Dossiers. The limited amount of information available about the various habitat preferences of other species is also described there. As is usual in survey work several species were represented by single specimens. These were about 21% of all the species recorded (table 12). The few which are rare are mentioned either above or in the Site Dossiers. 26 species which were represented by 2 or more specimens occurred only at a single site (table 13), e.g. 23 specimens of Atheta liliputana were not only all collected at Dunnet but were all taken in the same pitfall trap (1A) during the second sampling period. The rarity of this species is such that little is known of its habitat requirements. It is thought that it may have some association with small mammals but none was caught in the same trap. However, as this pair of traps was in an area of fairly tall, dense vegetation there could have been a small mammal's nest nearby with which the species could conceivably have been associated. The most southerly East Coast site, Tynninghame, had 7 species unique to this survey, as had Dunnet, one of the most northerly (tables 12 & 13). Dumbarnie had 6 species, St. Cyrus, Fraserburgh and Achnahaird had 5, and Tentsmuir, Cruden Bay, St Fergus and Freswick had 4. Thus the largest aggregation of these "unique" species are from East Coast sites where 44 were recorded, equal to the total for the Hebrides and North Coast together. Only 9 such species were recorded from the 11 Moray Firth sites.

No sites were sampled south of Redpoint. Three such mainland sites were listed by the NCC for inclusion in ITE Project 340, namely Laggan Bay (Site 3), Macrihanish Dunes (Site 2) and Torrs Warren (Site 1). These three sites are very widely separated and the dissected nature of much of this coastline makes access time-consuming if not difficult. The largest gap remaining in our knowledge of the coastal Coleoptera of Scotland is the relationship between the fauna of the hebridean and north-west coasts with that of the Ayr coast and Torrs Warren, where a strong southern element is known to be present. Some information is beginning to accumulate for the Argyll coast although most recent invertebrate surveys in that region have concentrated on the woodland NNRs and SSSIs.

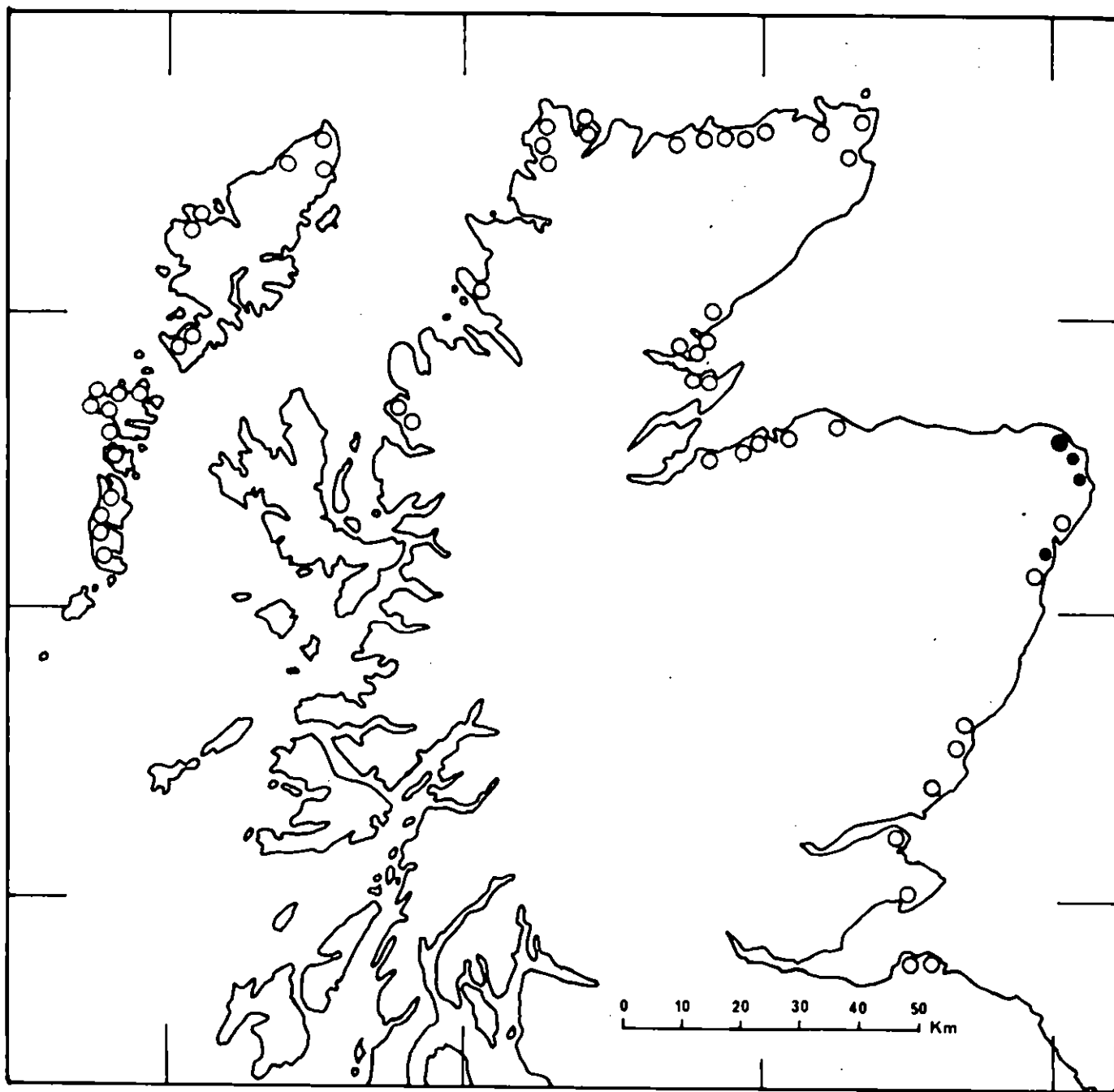
The sampling results seem to suggest that the Moray and Dornoch Firth area has a distinctive fauna but, as already explained, this should be treated with caution. There is some evidence of faunal discontinuities at Kinnaird's Head and at Dunnet Head. There is support for the expected similarity between the shell sand bay sites of the North Coast and the west coast sites of the Outer Hebrides, which in turn show similarities with the isolated sites on the north-west coast of mainland Scotland.

11. THE ARANEAE

The 58 sampling sites produced a relatively poor fauna of only 115 species. There are several reasons for this, and it would be difficult to assert that this is a true measure of the collective richness of the spider fauna on Scottish dune systems. Although most of the traps were set in relatively confined areas, so that only a small section of each site was sampled, they operated for 5-6 weeks at what was probably the most productive time of the year. The siting of the traps (explained in para 3.2) probably means that the results represent the fauna of the "marram transition zone" (fig. 1) rather than other dune biotopes. The most notable exceptions were in the Outer Hebrides where the traps were frequently sited in a short, grazed, dune meadow where marram grass was scarce or absent. In some instances this biotope was modified by rabbit burrowing and scratching, which produced areas of bare sand. Records were kept of the vegetation and proportion of bare ground surrounding the traps, and this has proved to be of considerable importance when interpreting the results of trapping.

11.1 Comments on the fauna of some well-studied dune systems

Previous work by the British Arachnological Society at the Tentsmuir dune system on the east coast (where a party of 8 collected by hand for 5 days) recorded over 140 species but this site is exceptional for its wide range of habitat types (Duffey 1968). In contrast the highest total recorded during the Survey was 40 species at Gullane. Both Tentsmuir and Gullane are situated in the southern part of the East Coast region which had the richest fauna (all invertebrate groups) of any part of the Scottish dune system. Sand dunes on the coast of Norfolk such as Scolt Head NNR and at Whiteford Burrows NNR on the Gower coast in south Wales, where comprehensive studies have been made, have produced totals comparable with that from Tentsmuir. All four sites mentioned above are large dune systems with much stabilised dune heath or grassland biotopes which generally have richer faunas than others nearer the sea. About 80% of the species in the long lists of spiders from these localities are characteristic of dry grassy places on porous soils in Britain and are not specific to coastal areas. In

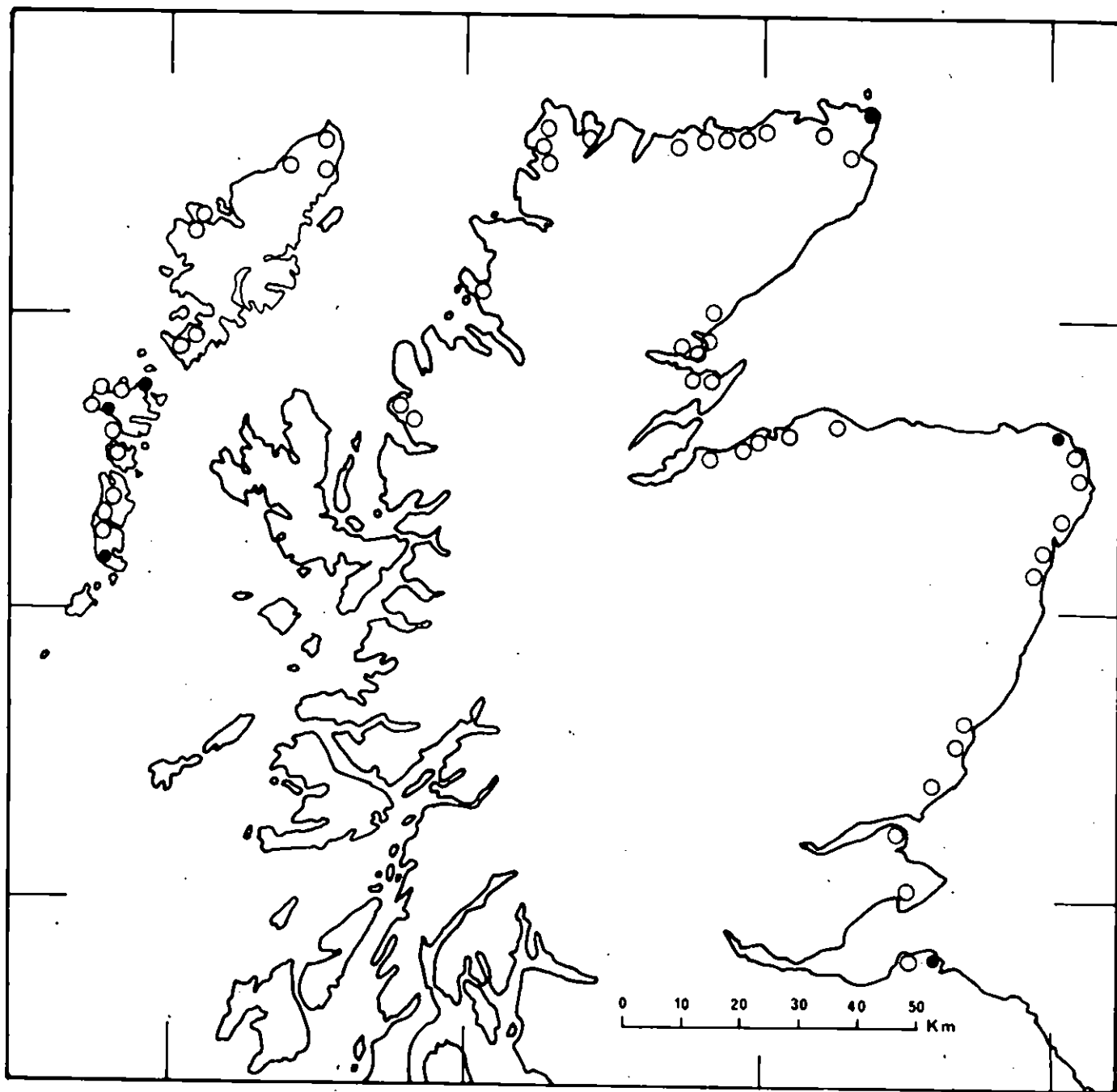


SILOMETOPUS INCURVATUS

Map 35

Specimens recorded per site

- 6-7
- 1-5
- Not Recorded

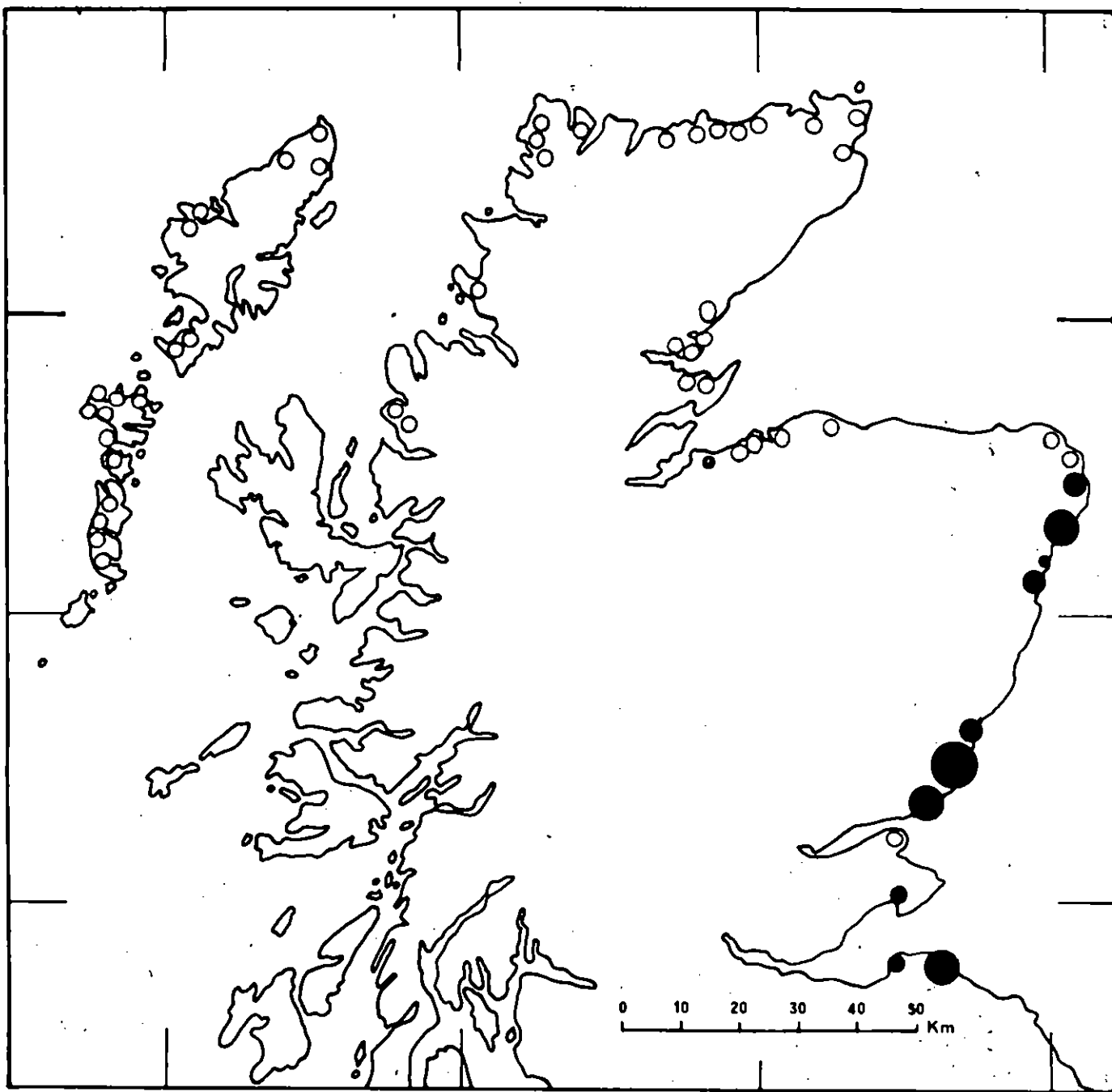


BATHYPHANTES GRACILIS

- 1-5
- Not Recorded

Map 36

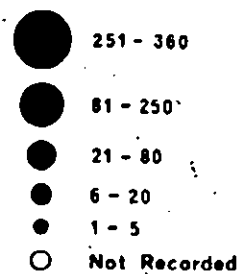
Specimens recorded per site

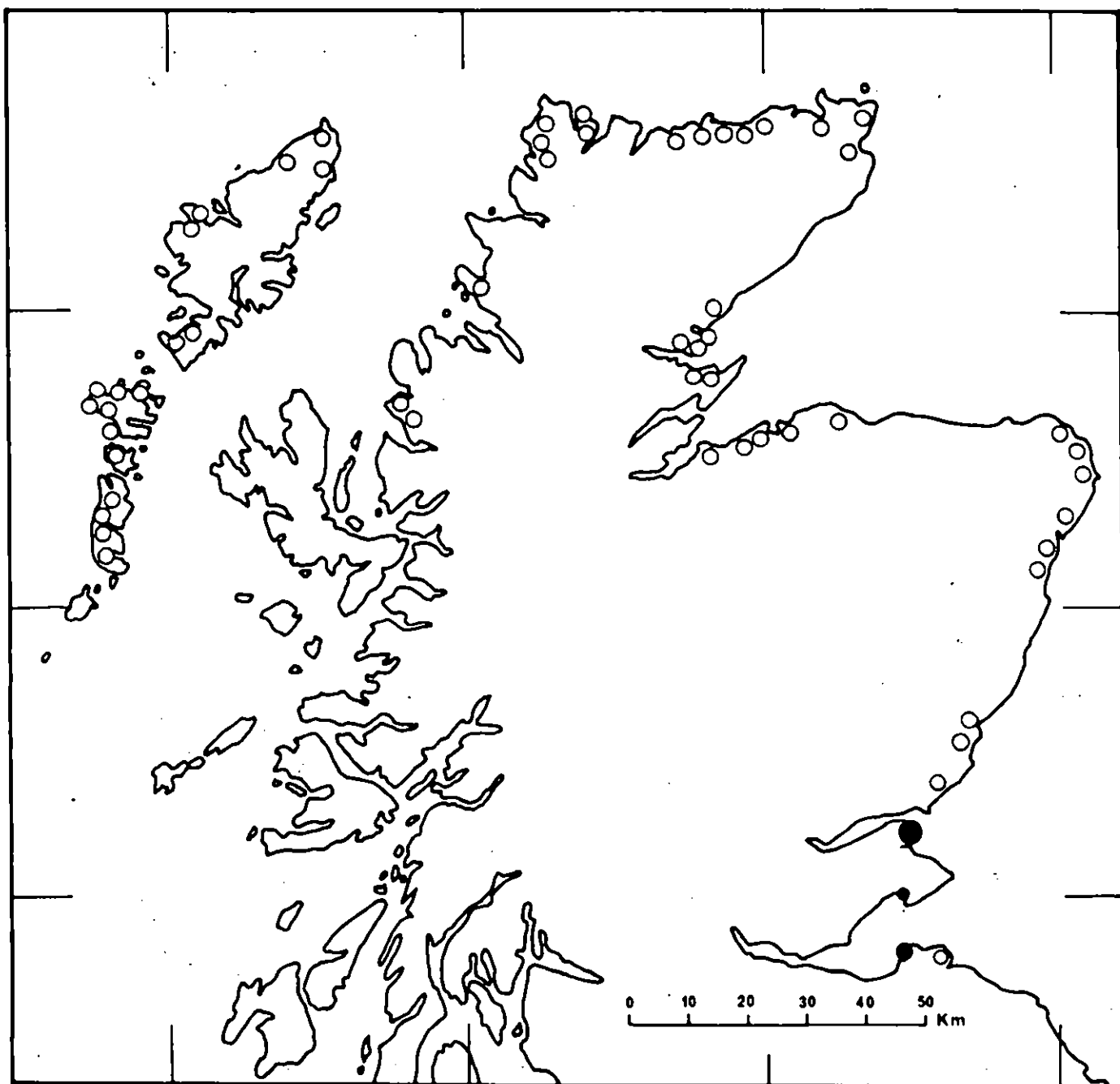


BATHYPHANTES PARVULUS

Map 37

Specimens recorded per site



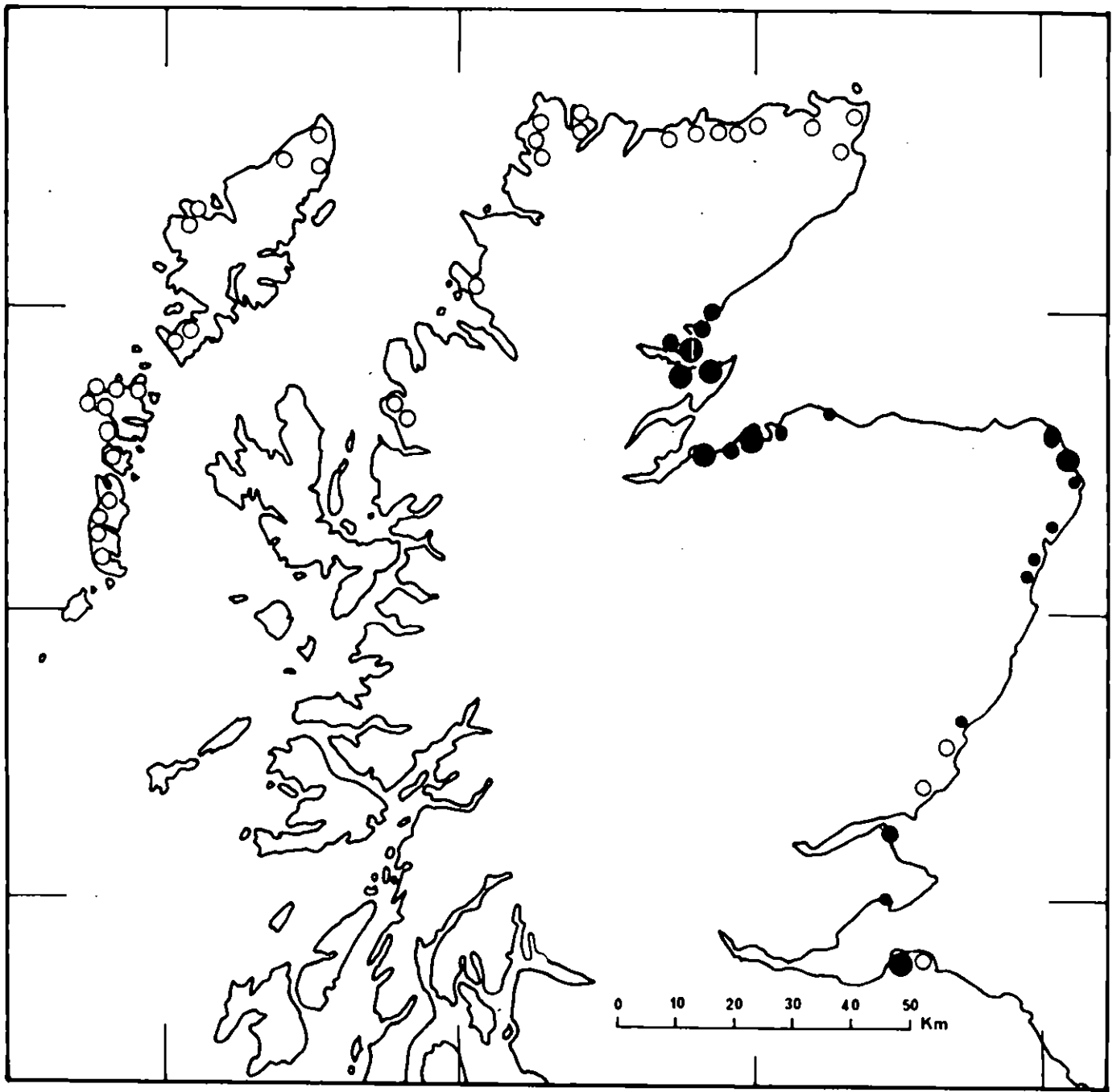


ZELOTES ELECTUS

Map 38

Specimens recorded per site

- 21 - 28
- 6 - 20
- 1 - 5
- Not Recorded

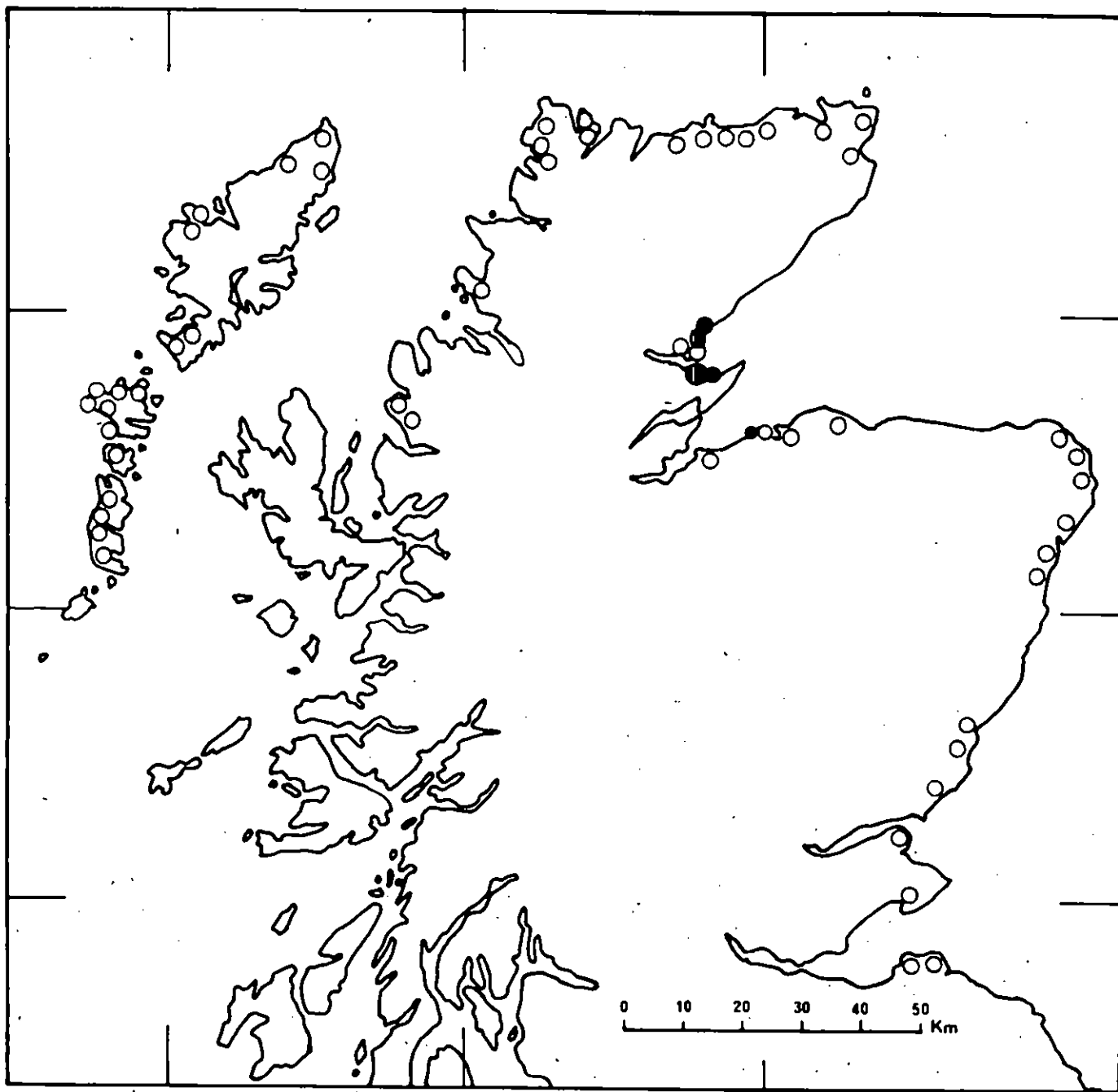


ZELOTES PUSILLUS

Map 39

Specimens recorded per site

- 21 - 45
- 6 - 20
- 1 - 5
- Not Recorded



GNAPHOSA LEPORINA

Map 40

Specimens recorded per site

- 21-28
- 6-20
- 1-5
- Not Recorded

contrast smaller and/or disturbed sites generally have a poorer fauna and a higher proportion of widely distributed species. Very few sites in Britain, coastal or inland, have scored more than 200 species of spider even when comparatively well-worked and the record is currently held by Chobham Common in Surrey, and area of dry and wet heathland, for which over 240 species are known (Murphy 1973, Murphy and Murphy, 1979). If it had been possible to trap over a wider range of dune habitats on the 58 Scottish sites, a larger number of species would have been recorded.

11.2 Some characteristics of the fauna.

It is well known that the number of species of most invertebrate groups declines with increasing latitude in Britain and despite its limitations the Survey has confirmed this. A few species indicate a northern component in the fauna but only Silometopus incurvatus appears to be confined to the north of England and Scotland, a small number of specimens being recorded at four sites on the north eastern corner of Aberdeenshire (map 35). In the British Isles the species is not known south of Yorkshire (Locket, Millidge and Merrett 1974).

The single male Erigone aletis, taken at Gullane on the East Coast, is a new record for Britain and Europe, (previously known only in N. America), but few other rarities were recorded during the survey. Pelecopsis mediocris is new to Scotland, and was taken at Oldshore More (the 6 females being distributed through all 3 trapping periods) and at Redpoint where one specimen was taken in June. Both of these sites are on the northwest mainland coast.

Lepthyphantes insignis was previously thought to be confined to the dry grassland in southern England south of the Wash, but the Survey recorded a single specimen at Dumbarnie on the East Coast. Troxochrus cirrifrons, if a valid species, is also new to Scotland, a single specimen having been taken in each Region except the Outer Hebrides.

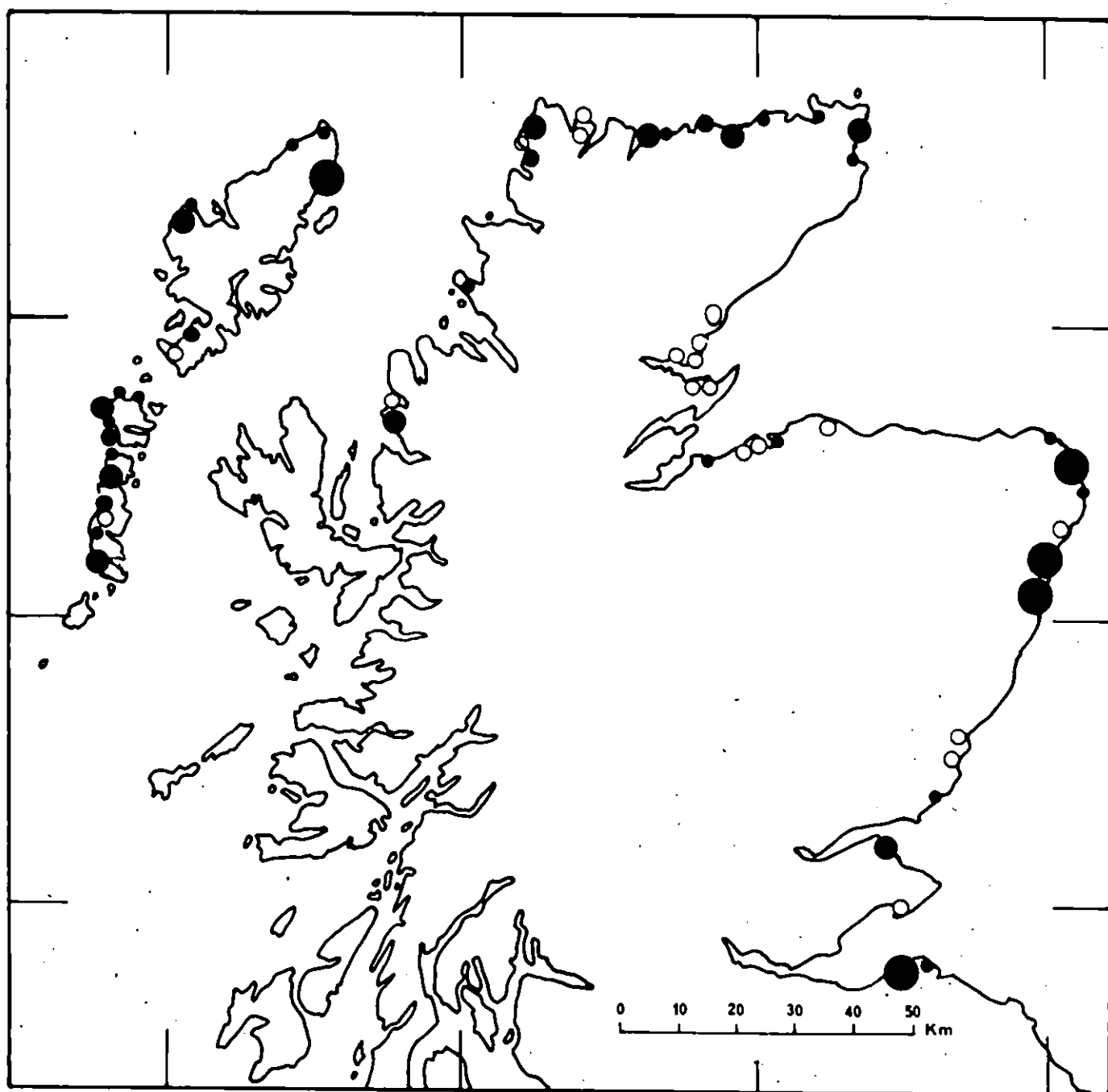
The four geographical groups of dune systems from the Outer Hebrides to the East Coast, show a clear trend of increasing mean number of species from north west to southeast with means of 12, 18, 20 and 24 species per site in the Outer Hebrides, North Coast, Moray Firth and East Coast respectively. There is no comparable trend in the numbers of individual specimens taken. These varied from a mean of 313 per site in the Outer Hebrides to 337 on the East Coast, but fell to 195 on the Moray Firth sites (tables 3 and 4).

11.3 New knowledge on the distribution and relative abundance of spiders in Britain.

Additional information on the distribution and relative abundance of well-known species was provided by the Survey. For example, Bathyphantes gracilis and Bathyphantes parvulus which spin small "hammock" webs in ground vegetation are widespread in Britain, but the former is much more common and almost

ubiquitous in grassy places. B. gracilis was taken in small numbers during the Survey and occurred on only a few sites on the East, and North Coasts and the Outer Hebrides (excluding Lewis and Harris) (map 36). On the other hand, Bathypantes parvulus (map 37) was restricted virtually to the East Coast south of the Moray Firth, but where it occurred it was sometimes taken in very large numbers, including as many as 360 individuals on one site. Its ecological preferences in this country are not well known but it has never previously been regarded as having any preference for dunes or coastal habitats. It is widely distributed in Britain but tends to be local and has not been recorded on the well-worked Welsh and English dune systems. Its abundance on some of the East Coast sites was quite unexpected and no obvious explanation can be offered.

Two other spiders, Zelotes electus and Z. pusillus, non-web-spinning ground hunters are also of interest. In England and Wales, Zelotes electus is a characteristic and widespread sand dune species while Z. pusillus is more often associated with inland sandy heaths. However, Z. electus also occurs on the sandy heathlands of the Suffolk and Norfolk Breckland, where it is regarded as one of the "maritime" elements together with Arctosa perita, the most widespread and characteristic of coastal dune spiders. In this survey it was not recorded further north than the Firth of Tay (map 38) on the East Coast. On the other hand the similar Z. pusillus was recorded on 21 of the 24 East Coast sites including all those in the Dornoch and Moray Firth areas where the highest numbers were recorded. It was absent however on the North Coast and in the Outer Hebrides (map 39). Haplodrassus signifer and Drassodes cupreus are two large hunting spiders which are widespread throughout Great Britain particularly on heathlands and grasslands but previous records were not known for Scotland north of the Moray Firth, nor from the Outer Hebrides. The survey has shown, that both are fairly widely distributed, although only H. signifer was recorded in the Outer Hebrides (map 45). The two species nearly always occurred together. This is probably related to some aspect of the habitat itself, and not necessarily to geographical or climatic factors. For some time D. cupreus was regarded as a sub-species of D. lapidosus and has only recently been recognised as a distinct species. The latter was not recorded during the Survey although it is widespread and common in dry grassy places in England. Gnaphosa leporina is another large hunting spider which is rather scarce in Britain, but has been recorded as far north as central Scotland. During the Survey it was taken at five sites, all in the Moray Firth area in 1977, and was unrecorded elsewhere (map 40). The beetle Sepedophilus nigripennis had a similar distribution, being particularly common in the Moray Firth (map 22 and Section 7.4).

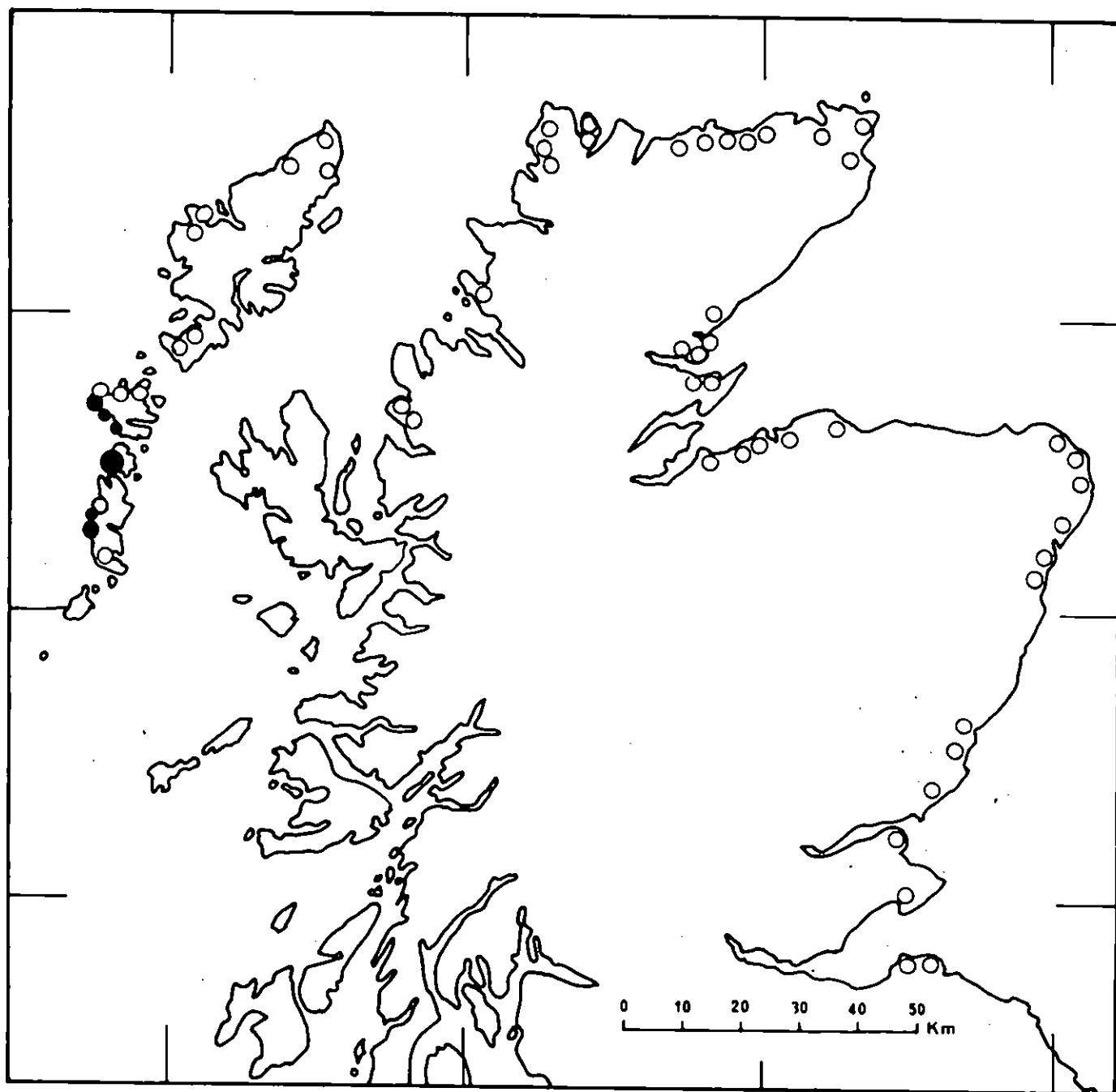


PARDOSA PALUSTRIS

Map 41

Specimens recorded per site

- 81 - 209
- 21 - 80
- 6 - 20
- 1 - 5
- Not Recorded

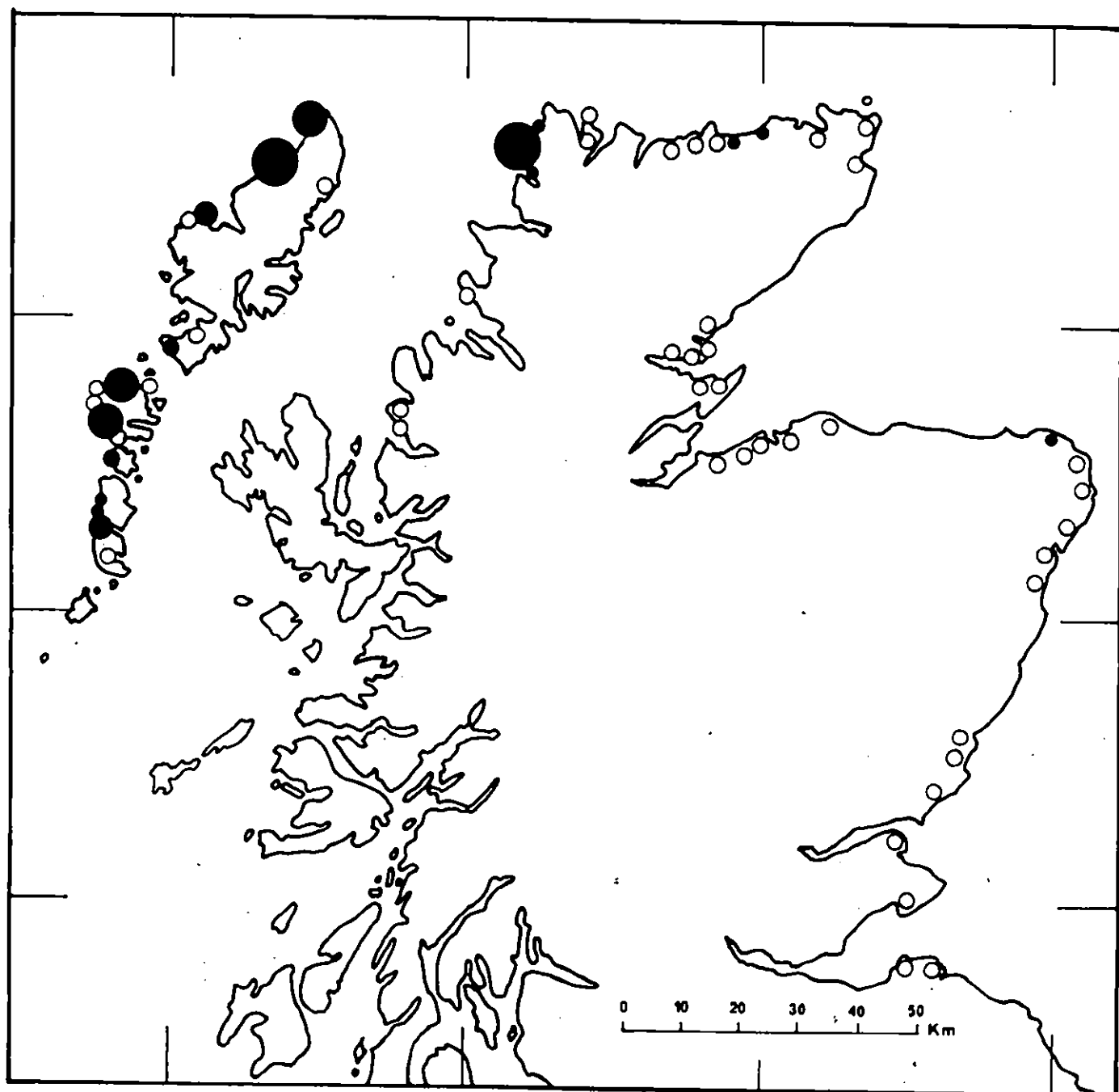


PARDOSA PURBECKENSIS

Map 42

Specimens recorded per site

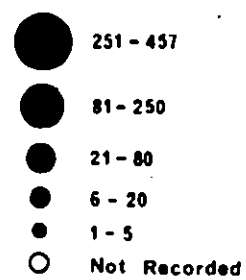
- 21-33
- 6-20
- 1-5
- Not Recorded

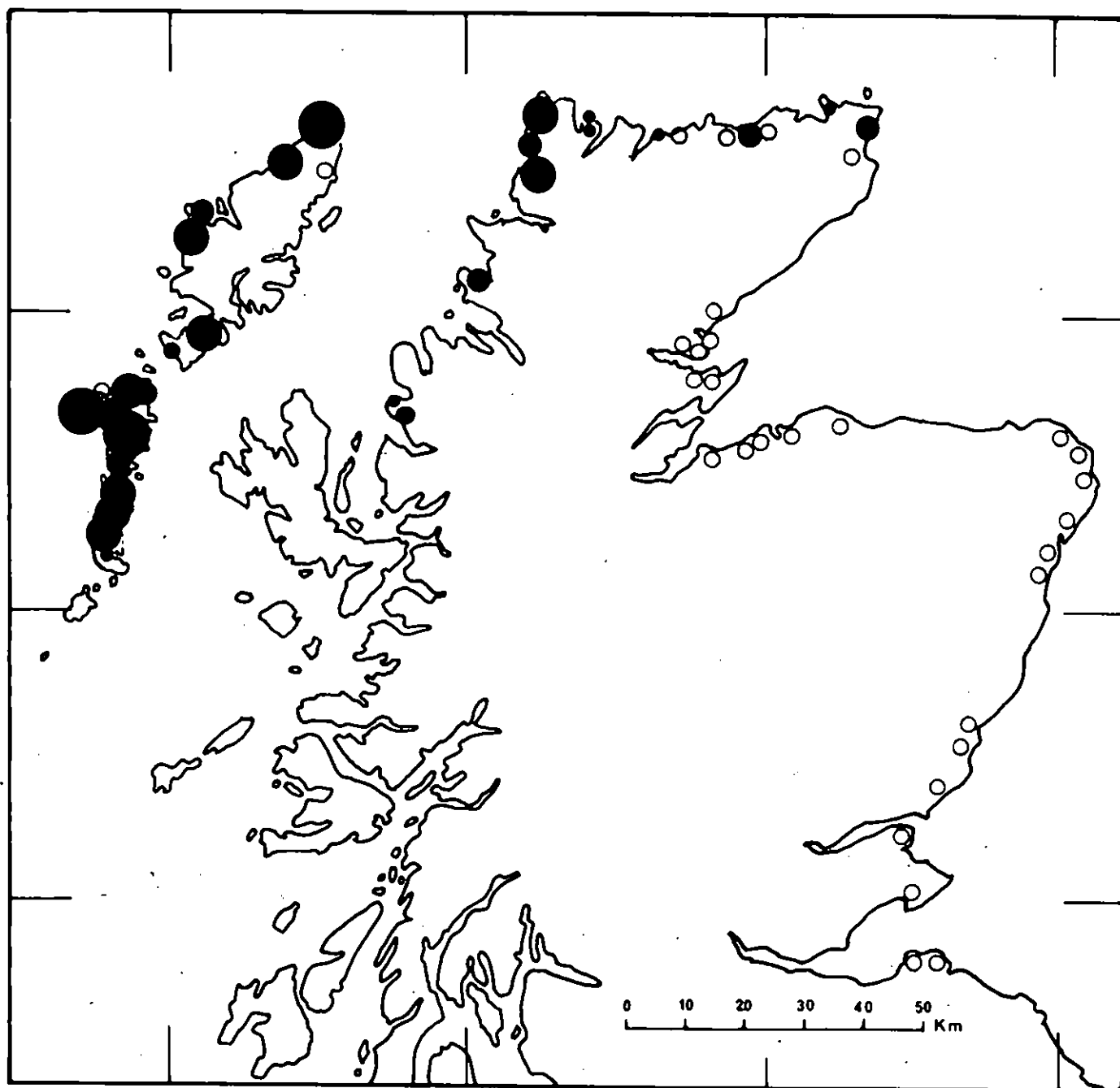


ERIGONE ARCTICA

Map 43

Specimens recorded per site

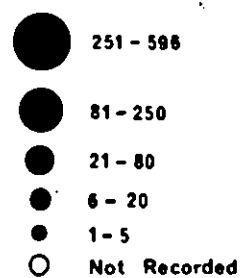




ERIGONE PROMISCUA

Map 44

Specimens recorded per site



11.4 The lycosids

A total of six species of Pardosa was recorded, including such ubiquitous species as Pardosa pullata, P. nigriceps and P. monticola. Perhaps the most abundant species on the Scottish dunes was P. palustris, a species which is widespread in Britain, although little is known about its ecological requirements. It tends to occur in fairly open situations, and for this reason is recorded in a wide range of different habitats but is seldom the most abundant lycosid. It occurs on agricultural land, open heathland, and on chalk downs. During the Scottish dune survey it was found in all geographical regions and sometimes occurred in particularly high numbers (map 41). It was least abundant on the Moray Firth sites, and this may be partly due to the nature of the habitat, and partly because the collections in that region were made in 1977. In England P. palustris has never been regarded as a species of coastal dunes and is infrequently recorded in this habitat but in Scotland it was second to P. pullata in abundance. However although P. pullata reached its abundance peak on the Moray Firth sites (Appendix 5) only 4 specimens of P. palustris were recorded there, suggesting that notwithstanding the broad overlap in ecological preferences, this particular region favoured the former species.

In England and Wales Pardosa purbeckensis is a salt marsh species, and although widespread, is seldom recorded away from its muddy habitat in the inter-tidal zone. Locket, Millidge and Merrett (1974) do not record it north of the Moray Firth on the east coast nor in the Outer or Inner Hebrides but in 1976 it was taken on the North and South Uists (map 42) and penetrated in some numbers onto the machair dune turf. It is very unusual for this species to occur regularly above the level of the highest spring tides but it seems possible that this happens in the Outer Hebrides because westerly winds bearing sea spray extend the influence of the inter-tidal zone further inland than elsewhere on the British coast.

11.5 The Erigone species

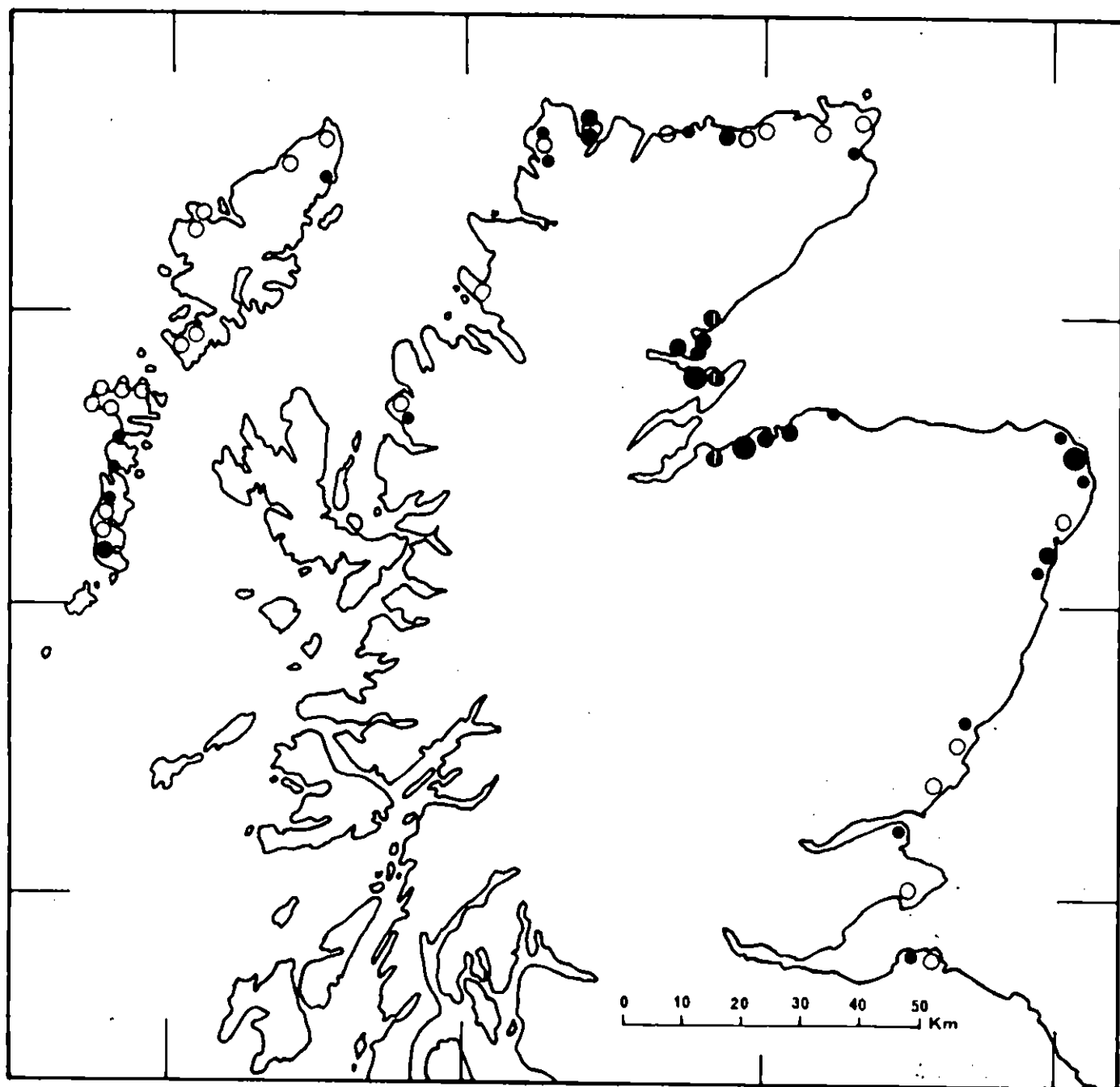
Four species of the genus Erigone were taken (excluding the single specimen of E. alctris). Erigone atra and Erigone dentipalpis are very widespread and common species throughout Great Britain and, although taken regularly on the Scottish dunes, they were not abundant. E. atra was much more frequent in the Outer Hebrides than was E. dentipalpis (264:1). In the other Regions there was not much difference between the numbers trapped of these two species. In parts of England E. dentipalpis tends to be active rather later in the season than E. atra but it is not known whether this phenological

difference occurs in Scotland. If it does E. dentipalpis may be under-recorded. Both species are new records for the Outer Hebrides.

E. arctica and E. promiscua are both associated with coastal habitats, the former almost entirely so but the latter being also widespread but local in inland situations, often on disturbed sites and in wet places. On the English and Welsh coasts E. arctica is confined to the beach drift-line on sandy shores or to the inter-tidal zone on salt marshes. It is rarely taken on the landward side of the main dune ridge and would not be expected to occur in the pitfall traps, most of which were in the marram transition zone and all well above the level of the highest tides. However large numbers were trapped in the Outer Hebrides and also at the north-west mainland sites (totalling 1,278 specimens) while only four were taken on the whole of the east coast (including the Moray Firth) (map 43). This unusual behaviour of E. arctica parallels that of Pardosa pubeckensis and perhaps in both cases, local climatic conditions such as high number of rain days and the influence of wind-blown sea spray enable them to penetrate inland, well above the high tide level. E. promiscua shows this influence even more strikingly, none being trapped at the East Coast and Moray Firth sites although 2,982 were taken on the west side especially on the Outer Hebrides and on the north-west mainland, (map 44), and a few also occurred on the North Coast. However it was not recorded everywhere on the Outer Hebrides, being absent from two sites on N. Uist and at Tolsta on the east coast of Lewis. The Erigone species are known to feed on small soft-bodied insects, particularly Collembola, and E. arctica has been shown to be one of the main predators of Hypogastrura viatica on an inter-tidal sand plain on the North Sea coast of the Netherlands (Van Wingerden 1977). It is not known whether this collembolan is numerous on the machair of the Outer Hebrides. However the occurrence of this or a similar species of collembolan would not explain the inland penetration of the much larger Pardosa purbeckensis.

11.6 The distribution of some species which are widespread in Britain.

Some very common species showed a pattern of distribution for which there is no easy explanation (Appendix 5). Pachygnatha degeeri, Pocadicnemis pumila and Meioneta rurestris are all abundant and widespread in grassy places but the results gave the first species a decided preference for the North Coast and the second and third were much more numerous on the East Coast. Hypomma bituberculatum is another common species normally associated with wet places. Very few specimens were taken except on the East Coast, which is the driest region! In spite of its preference for marshes, fens, wet marshes and some saltmarshes, H. bituberculatum is well-known as a coastal sand dune species but is usually taken in the fore-dunes (i.e. not far from



HAPLODRASSUS SIGNIFER

Map 45

Specimens recorded per site

- 21 - 37
- 6 - 20
- 1 - 5
- Not Recorded

high tide level) or else in wet dune slacks. A similar response is shown by Trichopterna thorelli, a rather local species found in bogs, fens, brackish meadows and salt marshes but which also occurs on dunes and in dry grassland. It was absent from the Outer Hebrides where it might have been expected but occurred in moderate numbers in the other three regions.

Oedothorax fuscus and O. retusus are widespread and abundant in Britain, often in disturbed or pioneer biotopes such as, abandoned arable land. They frequently occur together and it is not known how their ecological preferences differ. The Survey results show that many more specimens of the former were taken in the Outer Hebrides while the bias of the latter for the North Coast was even stronger. Meioneta beata is less common in Britain and has a preference for dry grassland, mainly in southern England. The Survey recorded it in each Region except the Moray Firth but many more specimens were trapped on the North Coast (corrected figures, Appendix 5, northwest to southeast are 13.7, 243.8, 0, 19.0). The puzzle here is why it was not more abundant on the drier East Coast.

Lepthyphantes tenuis and L. mengei are also common and widespread in Britain, particularly the former which is probably one of the most frequently taken British spiders. The Survey recorded surprisingly low numbers of L. tenuis with 53 out of the 86 specimens being taken on the East Coast. It is common on sand dunes in England and Wales but L. mengei is better known from inland grassy areas including bogs and marshes. Nevertheless more than twice as many specimens of L. mengei were taken than of L. tenuis.

11.7 Discussion

These differences in numbers between regions and unexpected distribution patterns may be due to several factors. It is possible that vegetation differences and local climatic conditions in the trapping areas so influenced the fauna that activity varied from place to place. This seems unlikely because the phenology of common species, as far as it is known, seems to vary little from one biotope to another. Some of these species may be on the edge of their range in Britain with a patchy distribution and possibly there is considerable variation in numbers from year to year. The weather during the summer of 1976 (particularly in the north and east) was unusual because of low rainfall and high temperatures and these conditions may have been responsible for creating an atypical distribution pattern by influencing the numbers of spiders caught of different species. Common species such as P. pumila, O. retusus and Tiso vagans were numerous on the East Coast in 1976 but scarce at the Moray Firth sites in 1977. Similarly, the very widespread and abundant lycosid Alopecosa pulverulenta was trapped in greater numbers at the Moray Firth sites than on the East Coast (corrected totals, Appendix 5, from northwest to

southeast were 0, 28.1, 299.2, 53.5). In these cases seasonal effects would appear to be the most convincing explanation.

Considerable variation in numbers of some species was recorded during 1976, sometimes at sites which were not separated by great distances. For example, the lycosid Xerolycosa miniata, a characteristic dune spider in the south of England, reached Lunan Bay on the Scottish East Coast (half way between Dundee and Aberdeen). It was recorded at five sites but 111 out of the total of 124 specimens were taken at Tentsmuir. Similarly, Pardosa palustris was scarce in some places and abundant elsewhere. In such cases it is unlikely that there were great differences in the performance of pitfall traps between sites and habitat differences seem to be partly responsible. Xerolycosa miniata prefers heathland type vegetation which is extensive at Tentsmuir while P. palustris is more active (and probably more abundant) where there is an open patchy vegetation and appears to avoid a closed dense plant cover. Haplodrassus signifer and Drassodes cupreus are hunting spiders with a similar life-style. The former was more numerous particularly on the Moray Firth sites but only at Culbin Bar 1 out of 31 sites, did H. signifer occur without D. cupreus, suggesting that the same habitat conditions suited both species (map 45).

12. THE LAND SNAIL FAUNA

Pitfall traps are generally regarded as an inefficient method of collecting Mollusca and, although at some sites many specimens were taken there was a marked bias towards the larger, more mobile and therefore, presumably, more easily trapped snails. A total of 26 species was recorded. Traps were placed mainly in the "marram transition zone" (fig 1), and snails were caught at 53 of the 58 sites. None was recorded at Ferry Links, Clashmore, Forvie, Don to Ythan and Tentsmuir. The highest total (11 species) was recorded at Balranald and Uig in the Outer Hebrides. The catch at some sites included small numbers of slugs which were not determined because of the difficulty of identifying preserved material. In addition the taxonomy of the slug families Testacellidae, Arionidae, Milacidae and Limacidae is at present being revised at species level, and not yet published in full.

Snails occur throughout dune systems, from the embryo dunes to stabilised meadow and slack areas although some species are restricted to particular zones. Apart from habitat structure and moisture, the occurrence of land snails is particularly influenced by the availability of food and of calcium carbonate for shell formation. The availability of this mineral in coastal dune soils is mainly determined by the amounts of shell sand deposited by sea and wind and its presence at some of the sites surveyed (see figures A and B of Ritchie, 1974) helps to explain the comparative richness of the

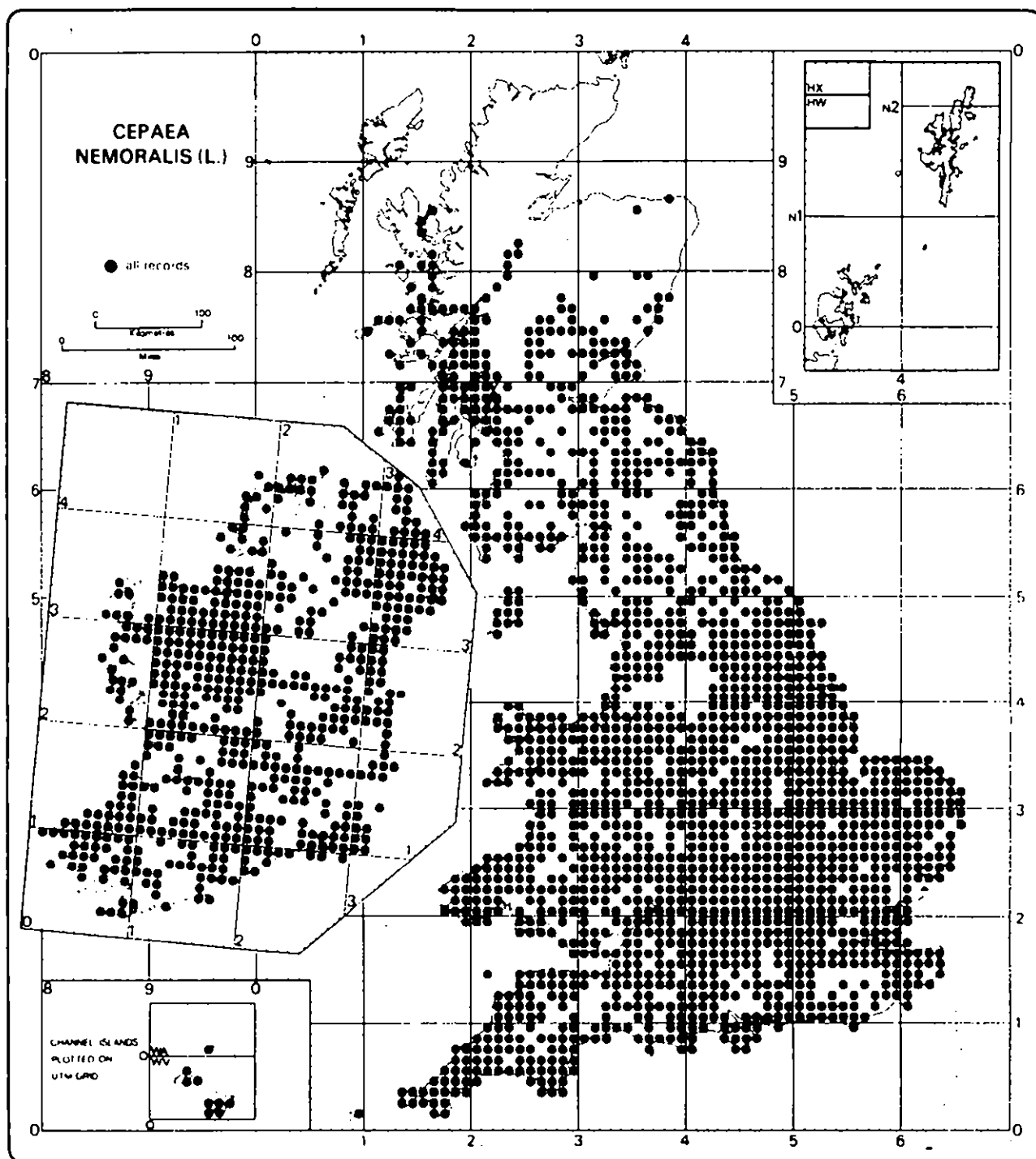
Table 1/4 Records of selected species of snails for some North Coast sites comparing those of the ITE Survey (X) with those of Cain et al (1969) (+)

	Oldshore More	Faraid Head	Bettyhill	Farr Bay	Strathy	Reay	Dunnet	Sand Wood
<i>Helicella itala</i>	X	+	X	+	X	+	+	X
<i>Arianta arbustorum</i>		+		+a	X	+a	X	
<i>Cepaea hortensis</i>	+	X	+		X	+		X

a = Records by Oldham (1929) included in Cain et al (1969).

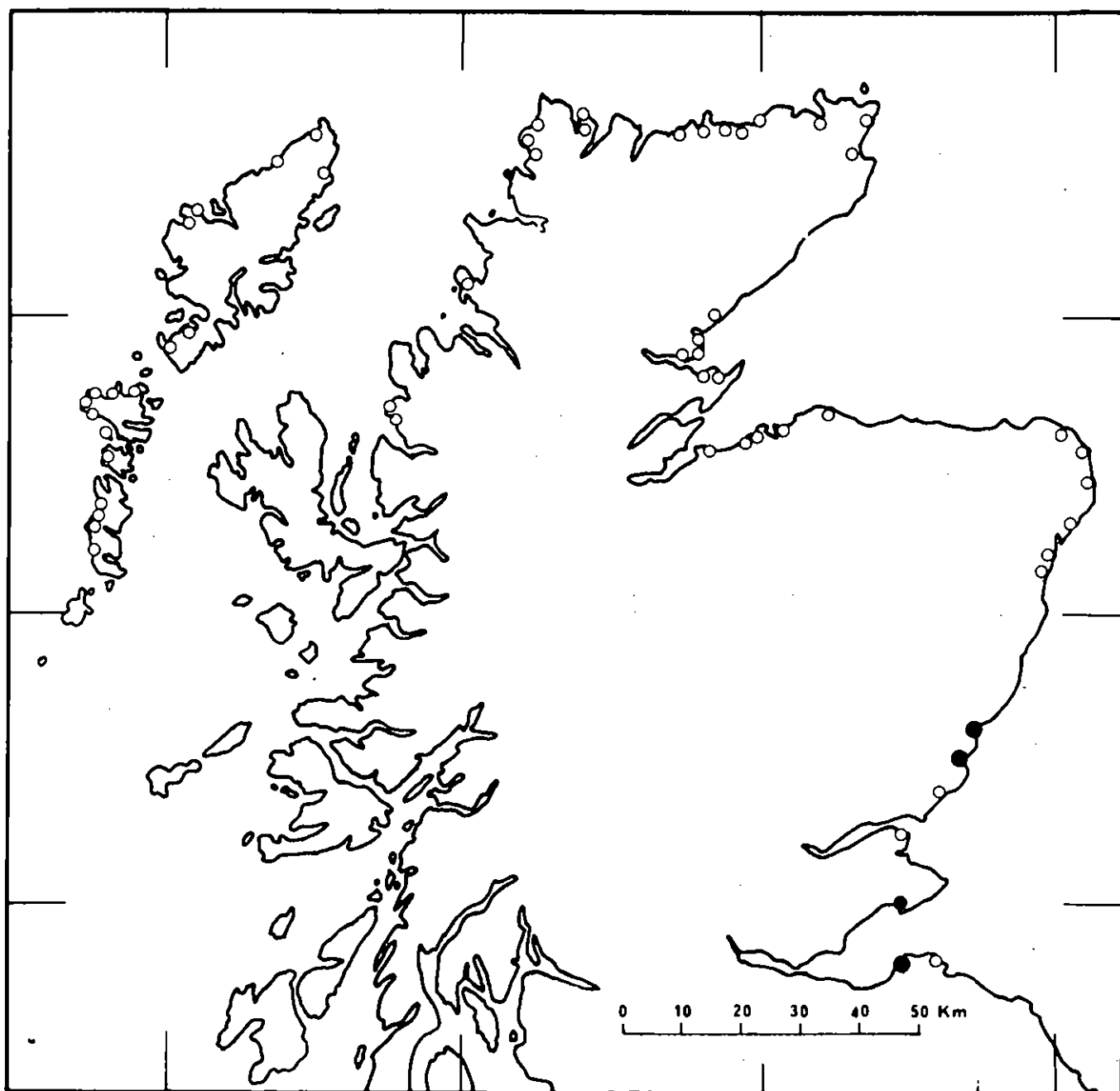
Table 15 Records of selected species of snails for three North Coast sites
 comparing those of ITE Survey (X) with those of Meiklejohn (1973)
 (+)

	Site		
	Reay	Dunnet	Freswick
<i>Cochlicopa lubrica</i>	X +		
<i>C. lubricella</i>	X +		
<i>Pupilla muscorum</i>	+		+
<i>Vallonia excentica</i>	+	+	
<i>Helicella caperata</i>		+	
<i>H. itala</i>		+	
<i>Arianta arbustorum</i>	+		



Map 46 The distribution in the British Isles of Cepaea nemoralis

(Kerney 1976)

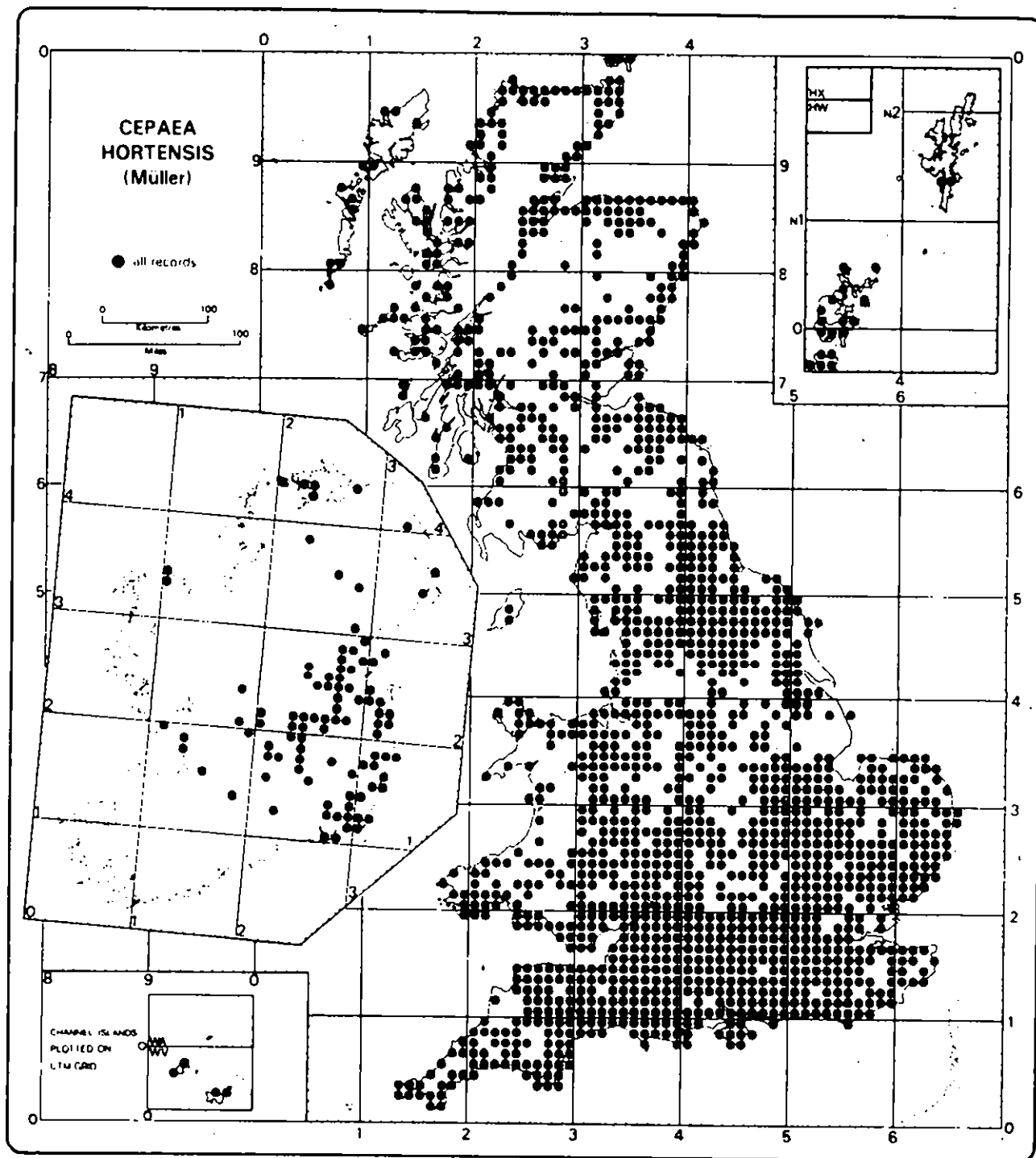


CEPAEA NEMORALIS

- 6-14
- 1-5
- Not Recorded

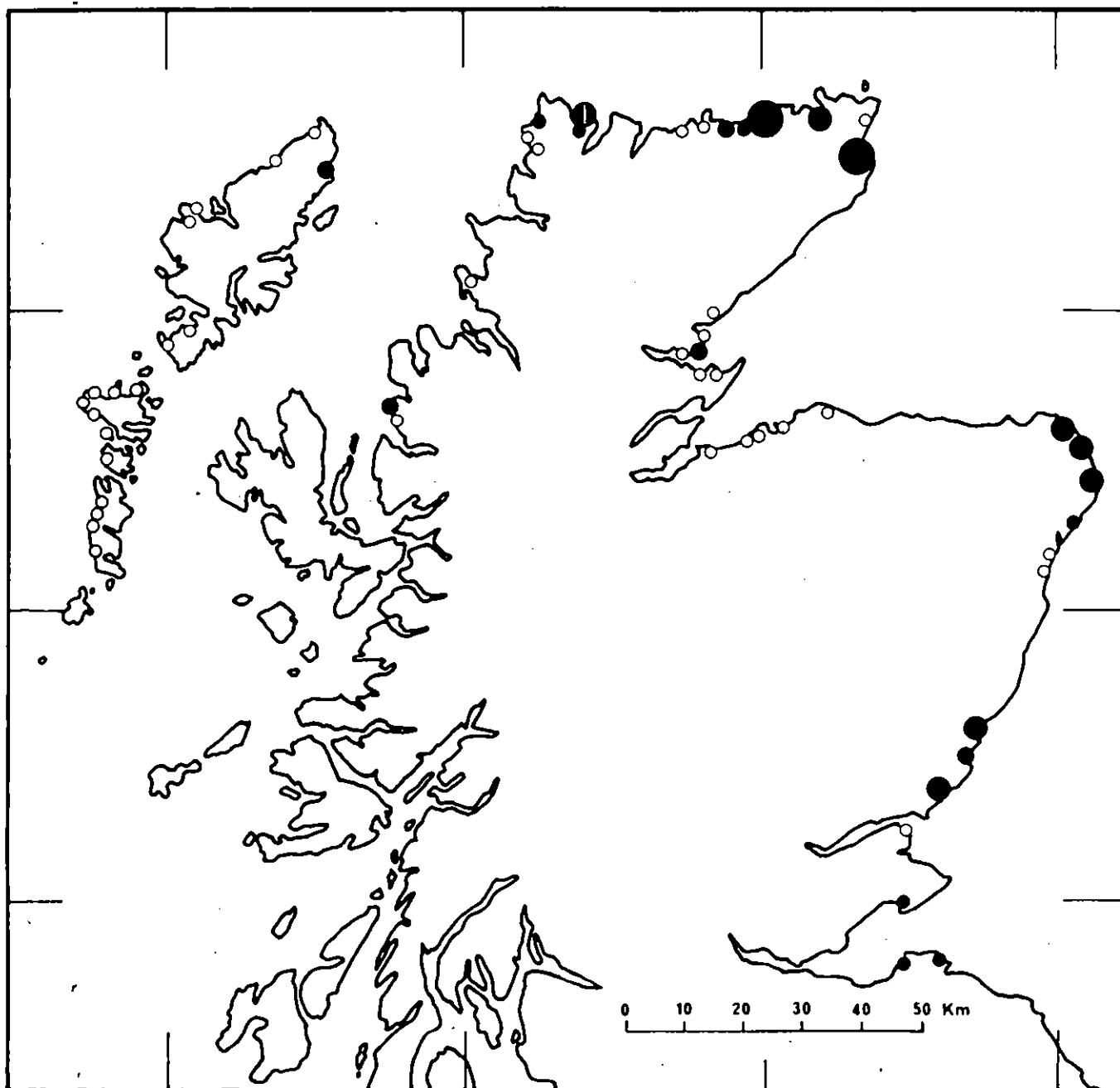
Map 47

Specimens recorded per site



Map 48 The distribution in the British Isles of Cepaea hortensis

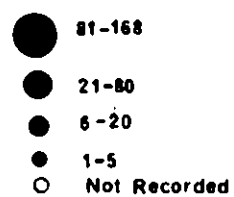
(Kerney 1976)

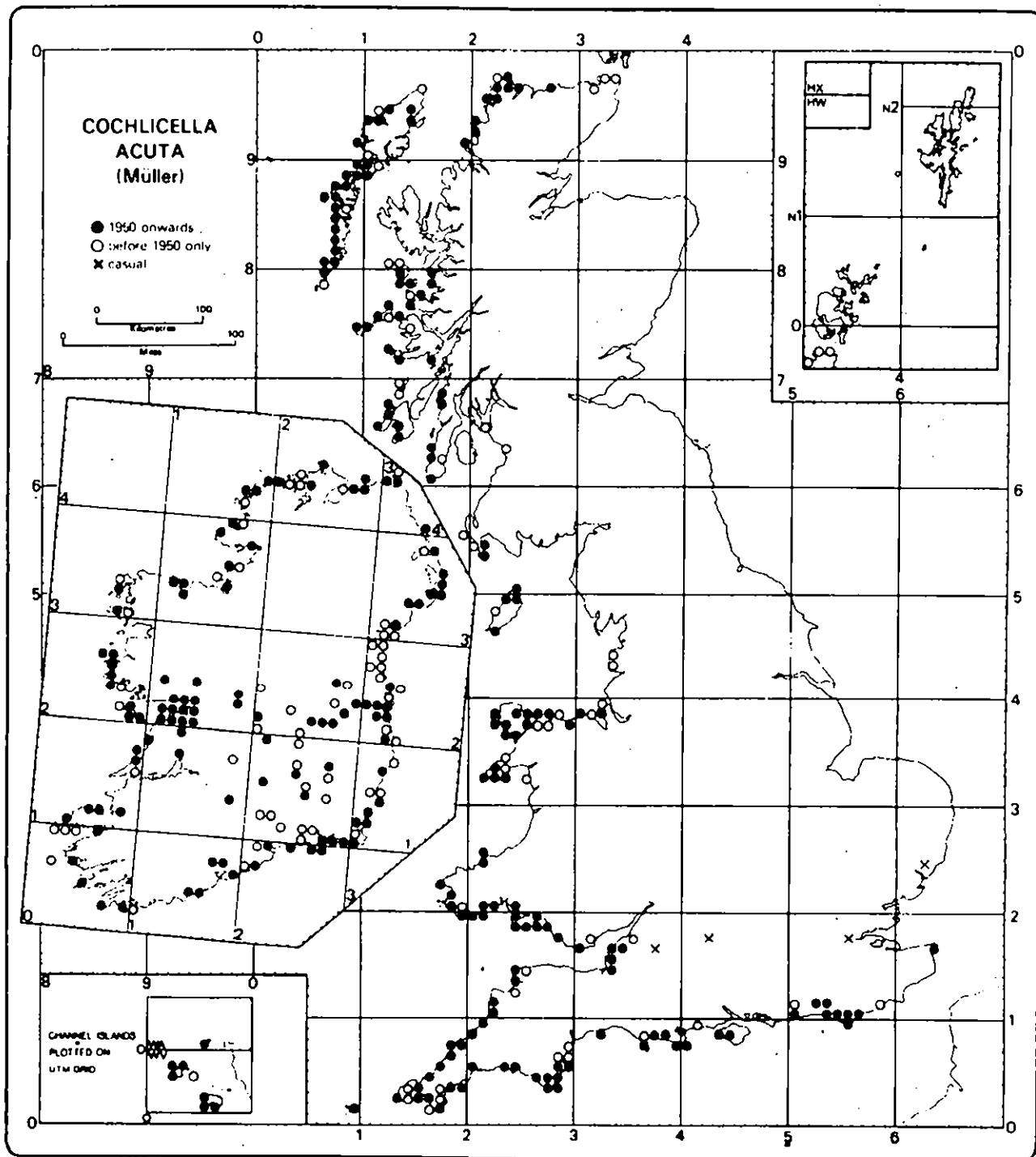


CEPAEA HORTENSIS

Map 49

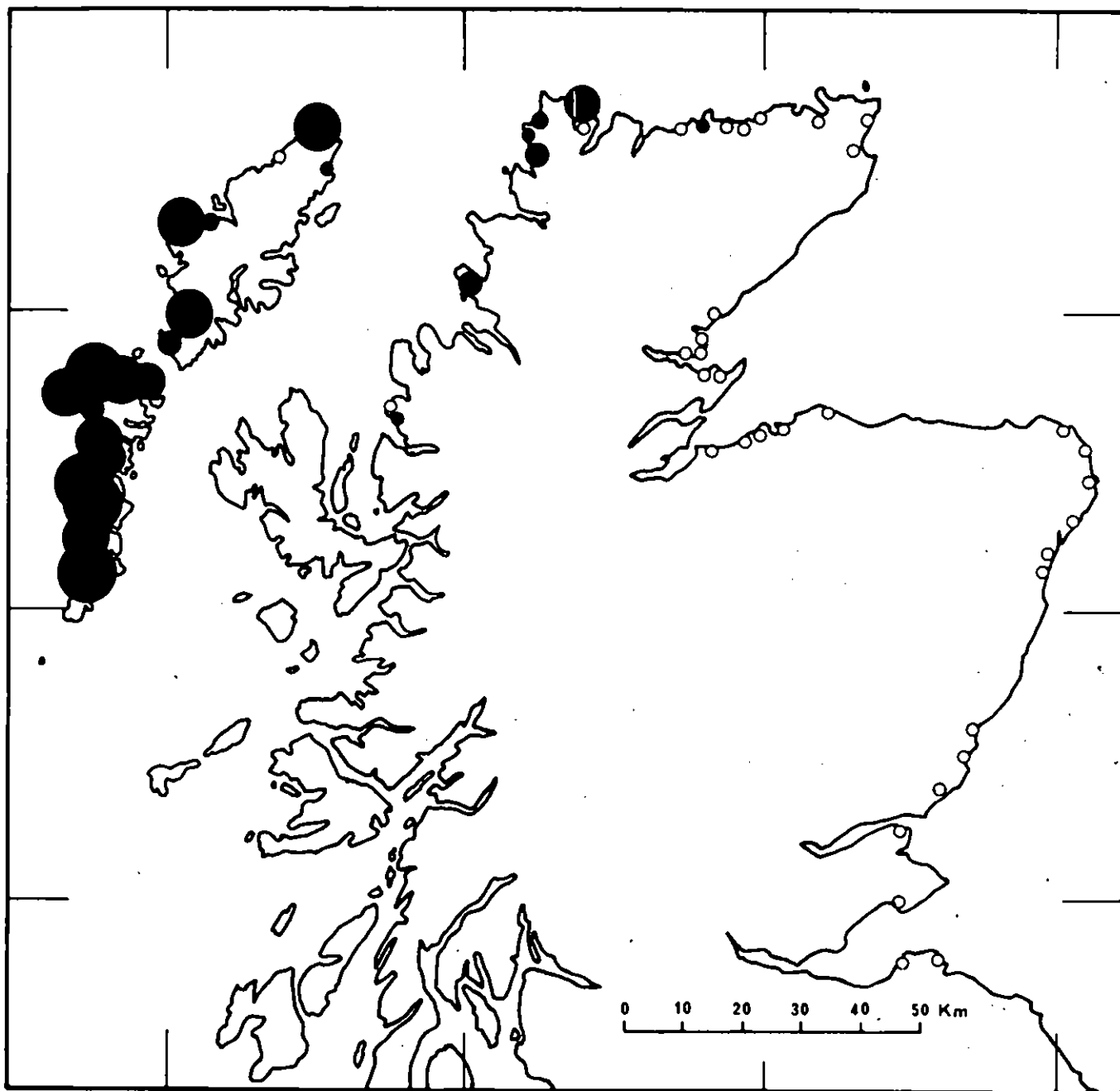
Specimens recorded per site





Map 50 The distribution in the British Isles of Cochlicella acuta

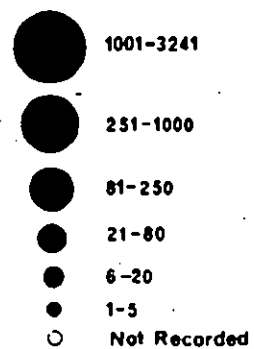
(Kerney 1976)

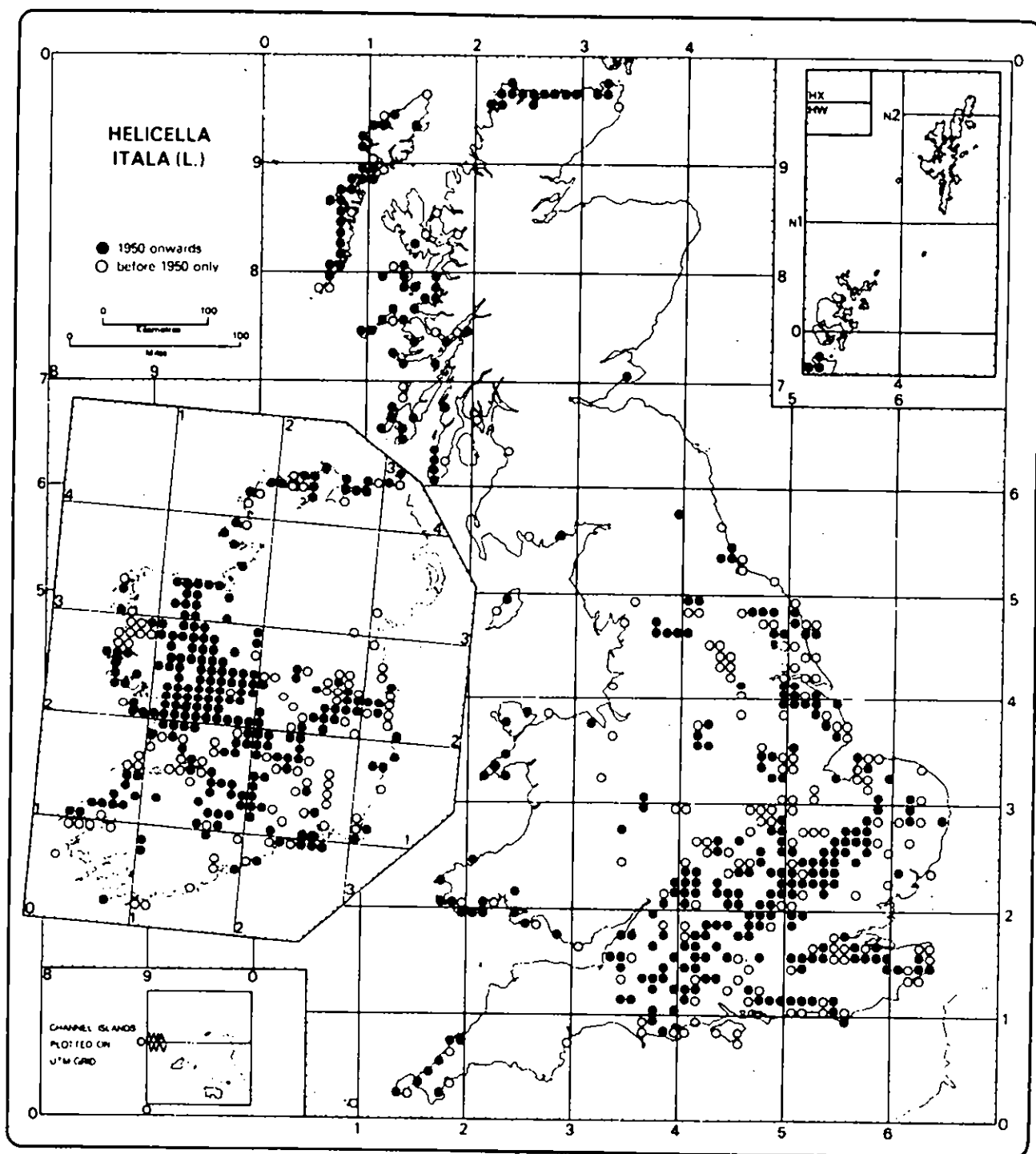


COCHLICELLA ACUTA

Map 51

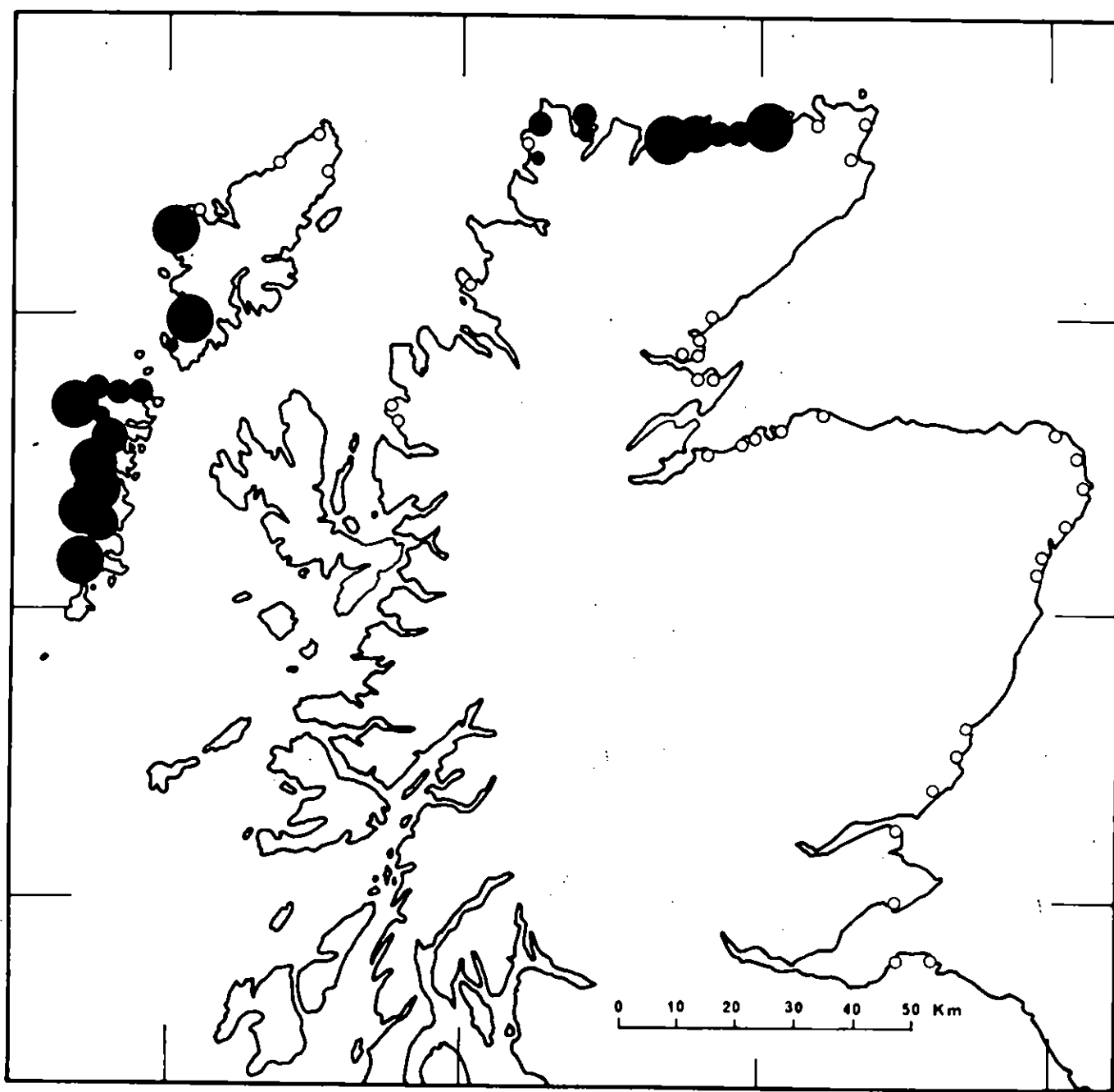
Specimens recorded per site





Map 52 The distribution in the British Isles of Helicella itala

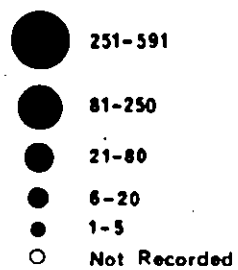
(Kerney 1976)

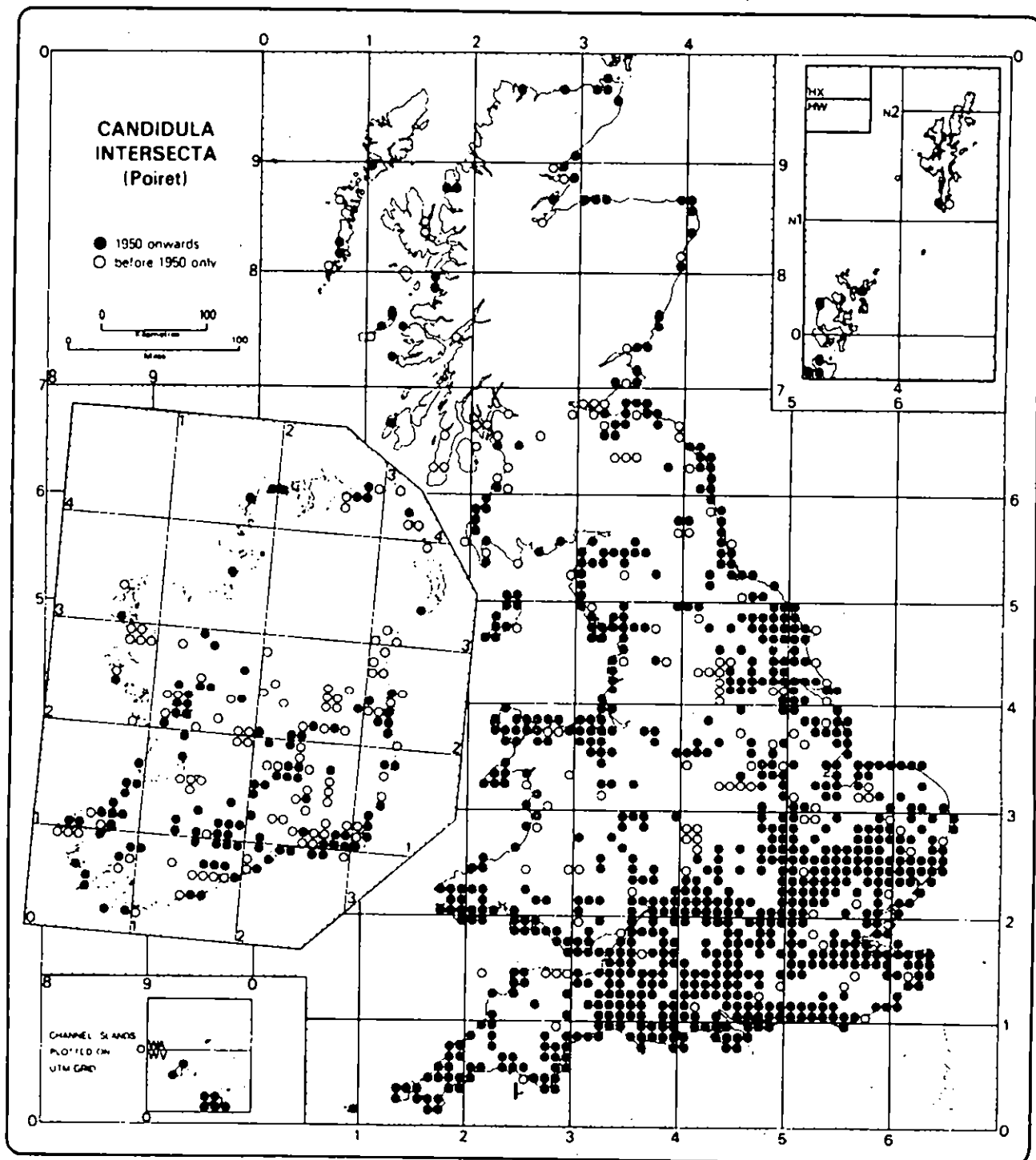


HELICELLA ITALA

Map 53

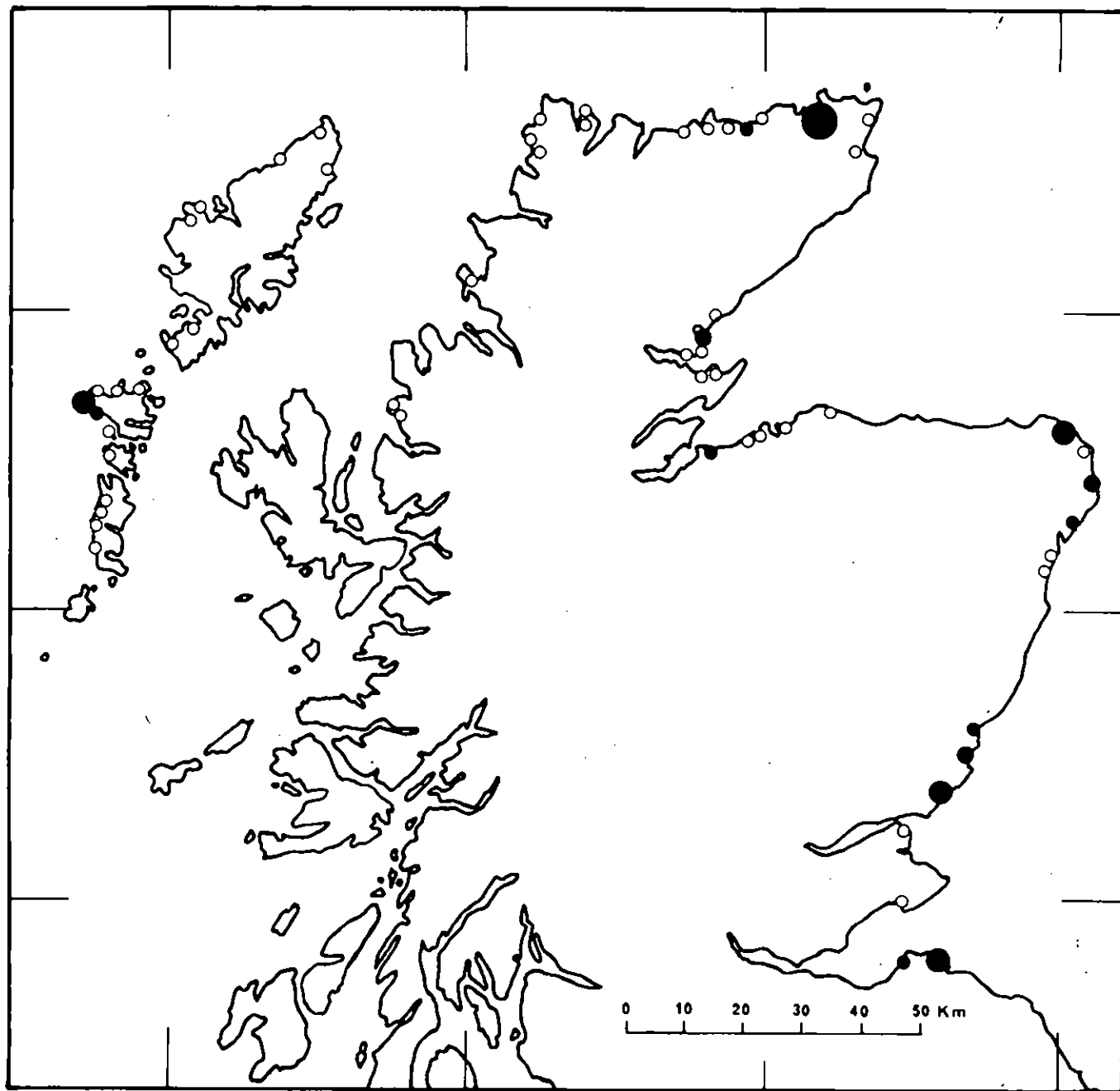
Specimens recorded per site





Map 54 The distribution in the British Isles of Candidula intersecta

(Kerney 1976)

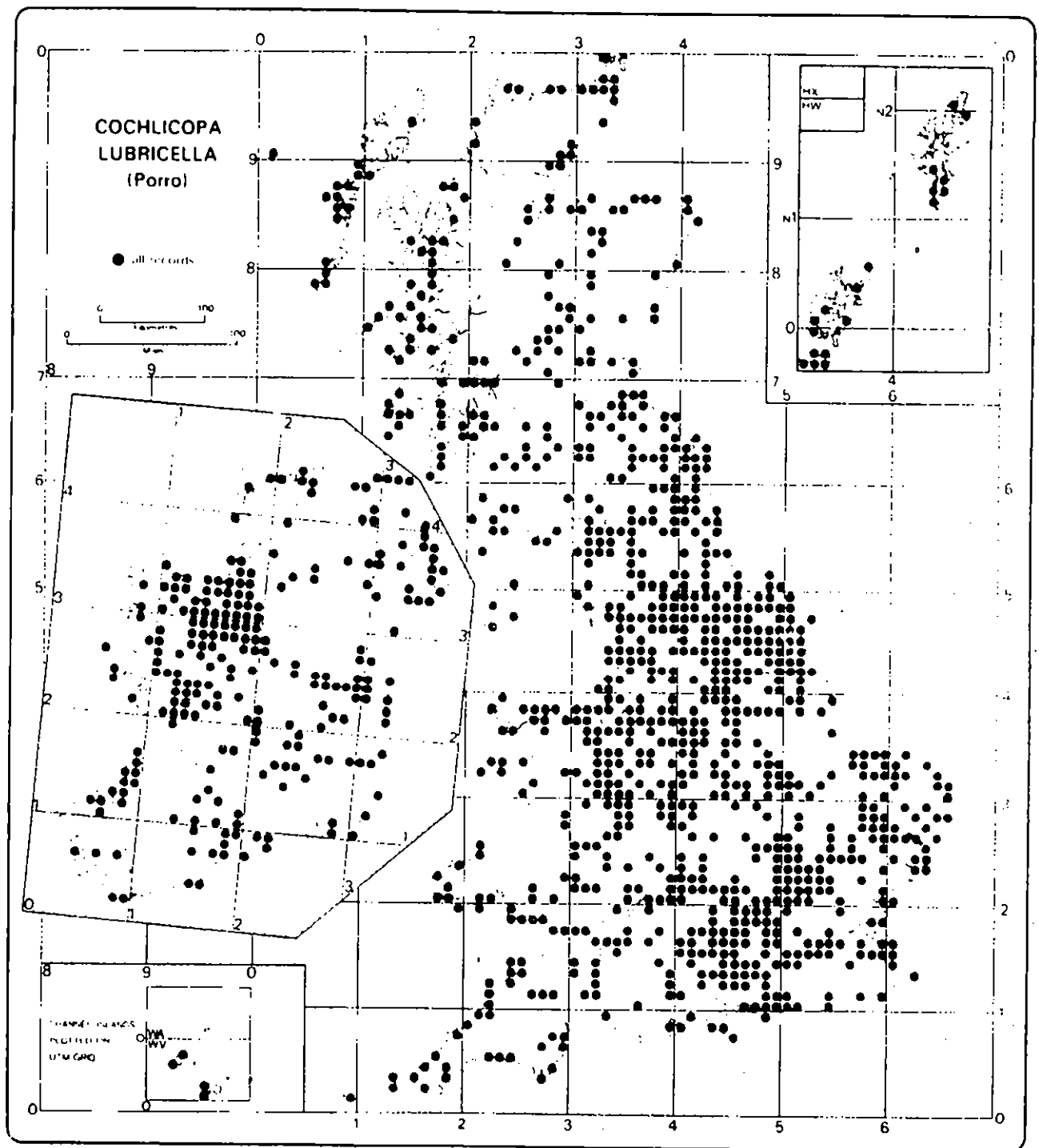


CANDIDULA INTERSECTA

Map 55

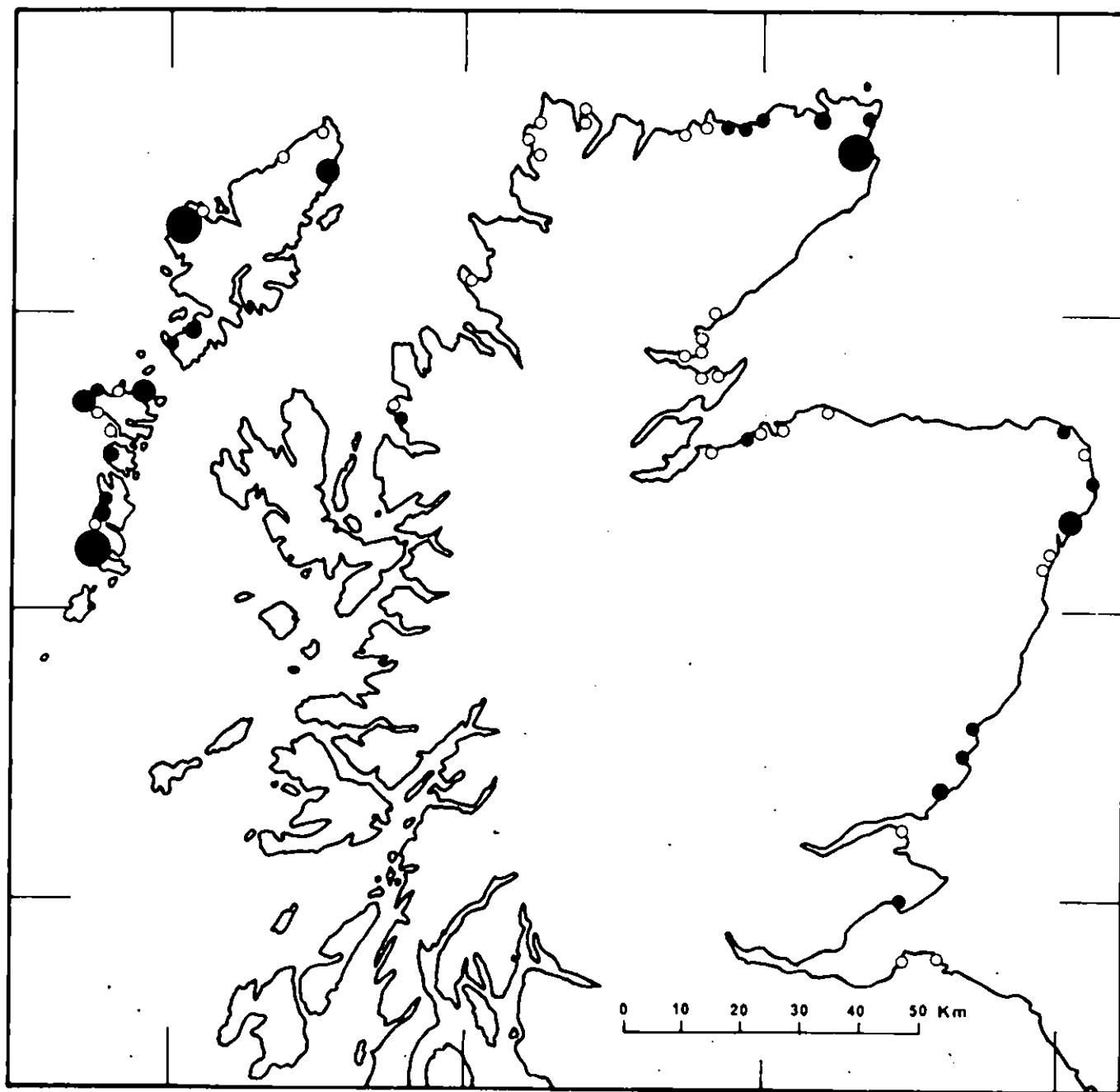
Specimens recorded per site

- 81-182
- 21-80
- 6-20
- 1-5
- Not Recorded



Map 56 The distribution in the British Isles of Cochlicopa lubricella

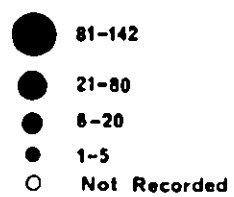
(Kerney 1976)

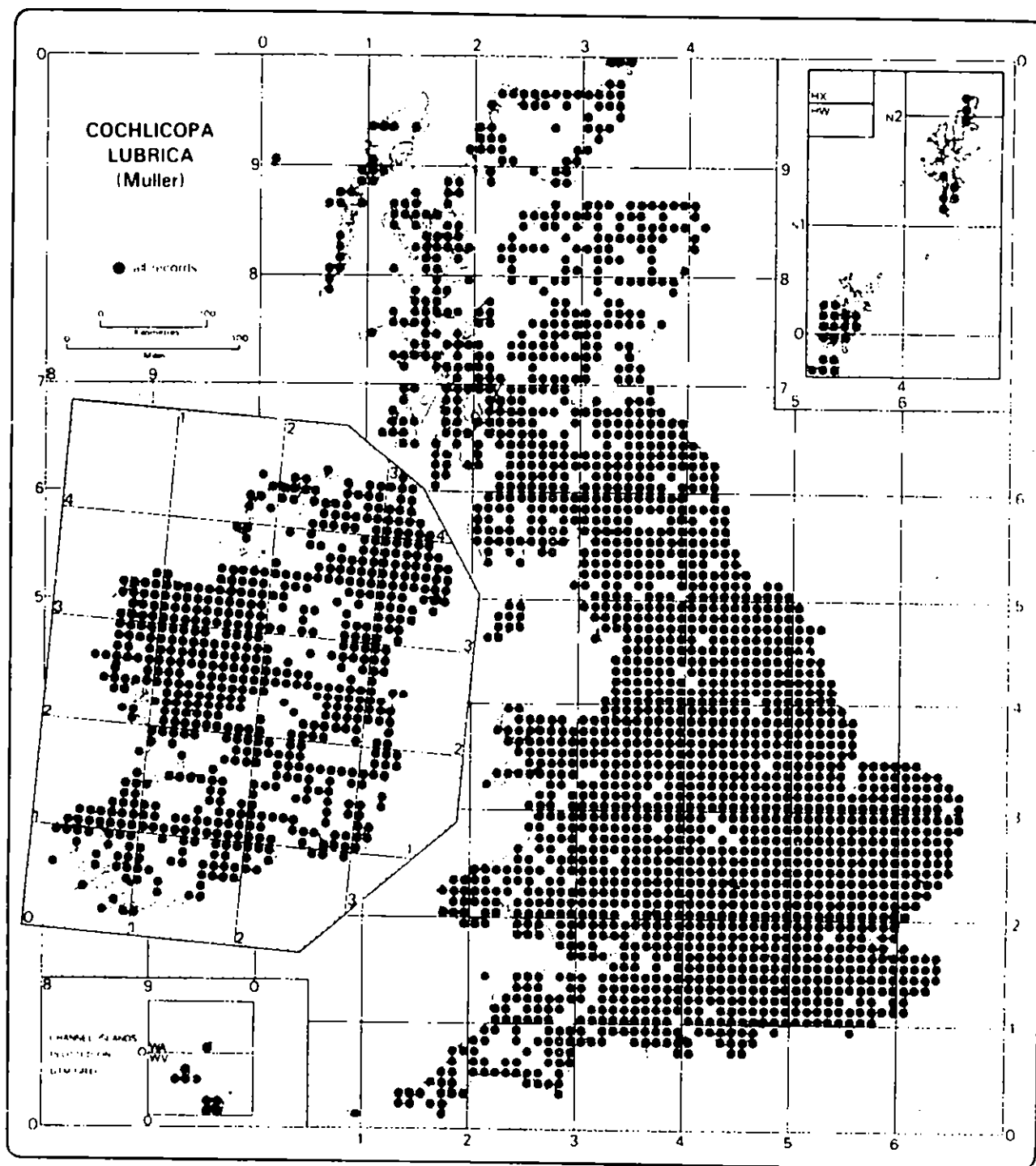


COCHLICOPA LUBRICELLA

Map 57

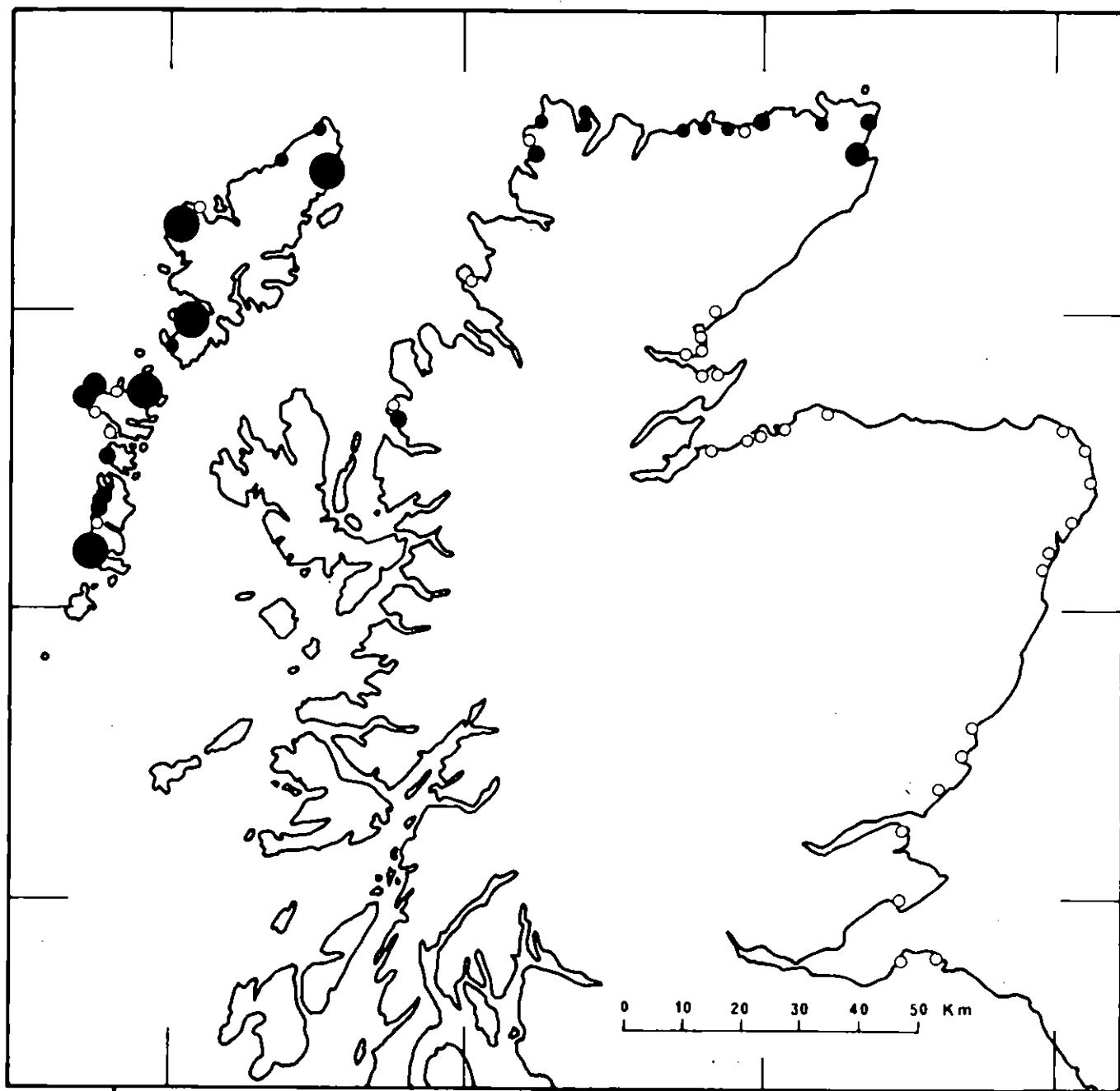
Specimens recorded per site





Map 58 The distribution in the British Isles of Cochlicopa lubrica

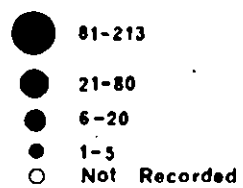
(Kerney 1976)



COCHLICOPA LUBRICA

Map 59

Specimens recorded per site



snail fauna on the Outer Hebrides and North Coast. Other factors, especially land use, clearly play a part in determining distribution and abundance, but the poverty of the snail faunas on the Moray Firth and, to a lesser extent, the East Coast, compared with the Outer Hebrides and North Coast, must, in some part, be due to the scarcity of calcium carbonate in the soils. All species of snail which have been studied are polyphagous, although some show marked food preferences. Most species eat decaying plants, algae and fungi rather than healthy phanerogams, while others are attracted to refuse and carrion.

There are no existing lists of snails for any of the sites visited, but scattered published records are compared with the results of the Survey for some sites in tables 14 and 15. It is probably that species lists for certain localities could be obtained from the Conchological Society or from participants in the Non-Marine Mollusca recording scheme. Cain, Cameron & Parkin (1969) studied the ecology and variation of three species of helicid snails, mainly on the north coast of Scotland. Their data include records from eight sites covered during the Survey. Of the 17 species/sites records, only ten are included by both Cain et al (1969) and the Survey (table 14). A further six records are included by Cain et al (1969) only. At Strathlyon 45 specimens Helicella itala were taken during the Survey but Cain et al (1969) and Oldham (1929) did not record it. Seven species at three sites in Caithness were recorded by Meiklejohn (1973). From nine species/site records, only two were recorded by both the Survey and Meiklejohn, the remainder being taken only by the latter (table 15).

Although the sampling method was not efficient for recording snails, several known geographical and ecological trends are evident. Cepaea nemoralis (maps 46 and 47) was not recorded further north than St. Cyrus and Montrose Links, whereas, C. hortensis (maps 48 and 49) was quite widely taken on the East and North Coasts. These patterns of distribution have already been demonstrated by Jones & Clarke (1969) and Kerney (1976). The restricted distribution of Cochlicella acuta (maps 50 and 51) and Helicella itala (map 52) agrees well with that shown by Kerney (1976) (map 53), and even the scattered occurrence of Candidula intersecta (maps 54 and 55) agrees, in an abbreviated form, with the known distribution of this introduced species. Cochlicopa lubricella (maps 56 and 57), although apparently less widespread in the British Isles than C. lubrica (maps 58 and 59), was recorded more widely on the 58 sites than was its congener. C. lubricella is believed to be able to tolerate drier conditions than C. lubrica and, although both species were taken at 26 sites, C. lubrica occurred only in the Outer Hebrides and on the North Coast.

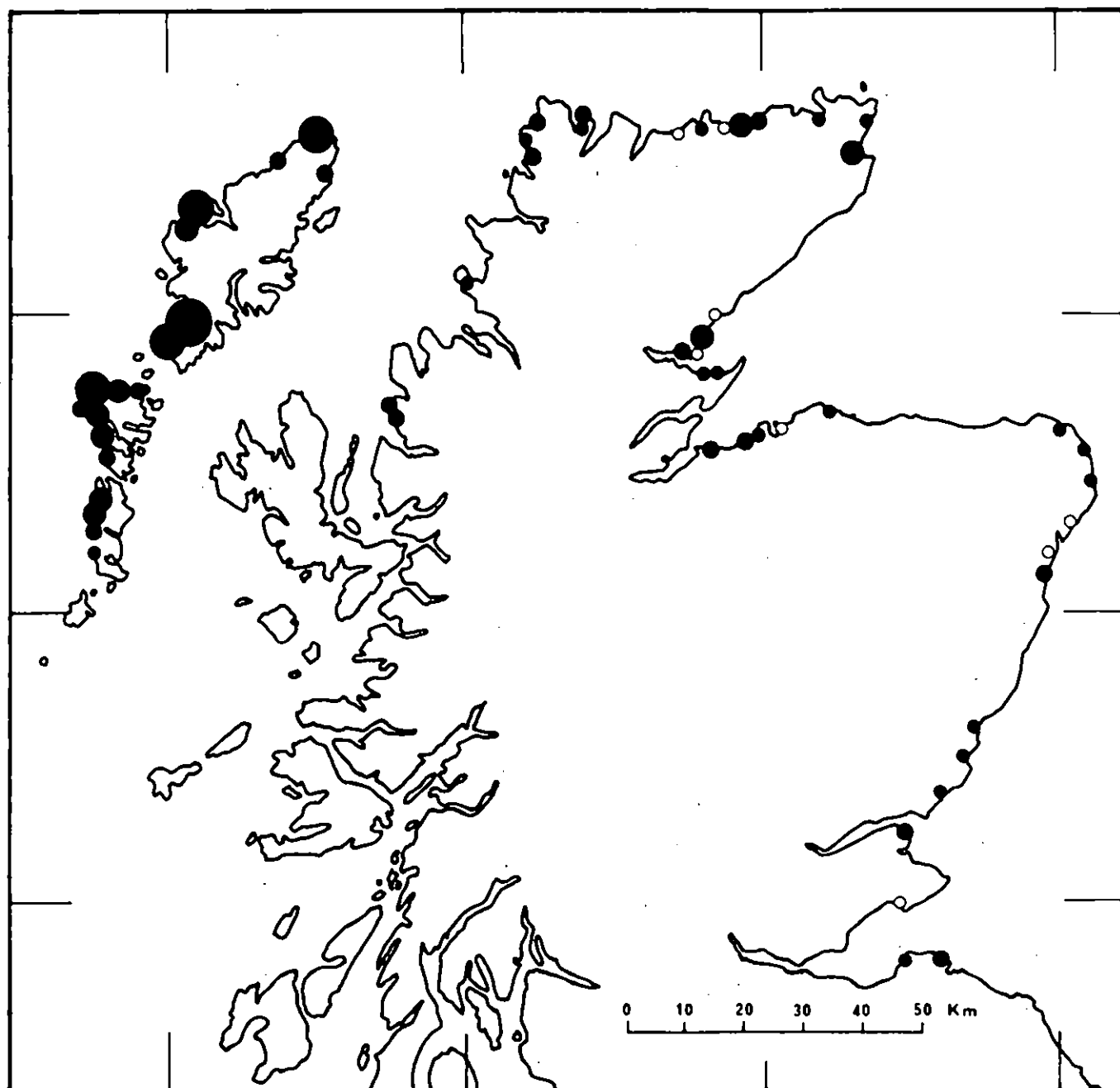
All the above species are characteristically associated with the "yellow dunes" and "marram transition" zones of dune systems. Other species typical of these habitats are Vitrina pellucida, Cepaea spp., Oxychilus spp. and Helix aspersa. Only the last species, which is not native to Britain, was unrecorded. Vitrina pellucida was the most widely distributed, occurring at 29 sites, mainly in the Outer Hebrides and on the North Coast. The fauna of predominantly grassy areas, such as some machair, is characterised by all the above species together with the two Cochlicopa spp., and Trichia hispida. Grazed machair tends to support some additional small species, such as Vallonia costata, V. excentrica, Vertigo pygmaea, Pupilla muscorum and possibly Lauria cylindracea. These five species occurred mainly at the Outer Hebrides and North Coast sites. The larger snails, such as Cochlicella acuta, Cepaea spp. and Helix aspersa are often absent from heavily grazed areas. The fauna of lush dune meadows and slacks is poorly represented because no traps were placed in this type of vegetation. However a few species thought to be typical of these habitats, such as Euconulus fulvus, Columella spp. and Arianta arbustorum, were recorded but at few sites.

13. DIPLOPODA AND TERRESTRIAL ISOPODA

Nine species of Diplopoda and four species of terrestrial Isopoda were recorded during the Survey. Pitfall traps are probably biased towards those species that are more abundant and active, and possibly also towards the less agile species (Banerjee 1967, 1970 and Fairhurst 1970 for Diplopoda, and Sutton 1972 for Isopoda). Species that spend most or all of their life in the soil or soil/litter interface are less likely to be caught than those that are, at least sometimes, active on the surface. Thus, soil species such as Brachyiulus pusillus and Trichoniscus pusillus, which were caught at few sites, may be more widespread than these records suggest. Seasonal patterns of activity, which have been observed with both groups, would also clearly bias the effectiveness of pitfall traps.

13.1 Diplopoda

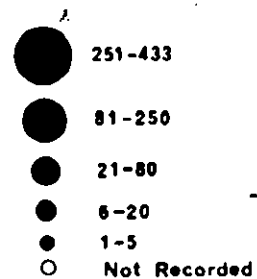
Cotton & Miller (1974), using pitfall traps, recorded an overall increase in the seasonal activity of Cylindroiulus latestriatus at Tentsmuir from March until September/October. There was a distinct seasonal peak during the last two months and differences in activity between sexes were also demonstrated. The period mid-June to late August is comparatively unfavourable for sampling this species by using pitfall traps (Cotton & Miller, 1974, and Fairhurst, in press). Cotton and Miller obtained most specimens in areas of stable microclimate, for example, the semi-fixed and fixed dunes. Information on the activity of Ommatoiulus sabulosus and Tachypodoiulus niger on sand dune systems in Lincolnshire and Anglesey is given by Fairhurst (1968, 1970, 1974

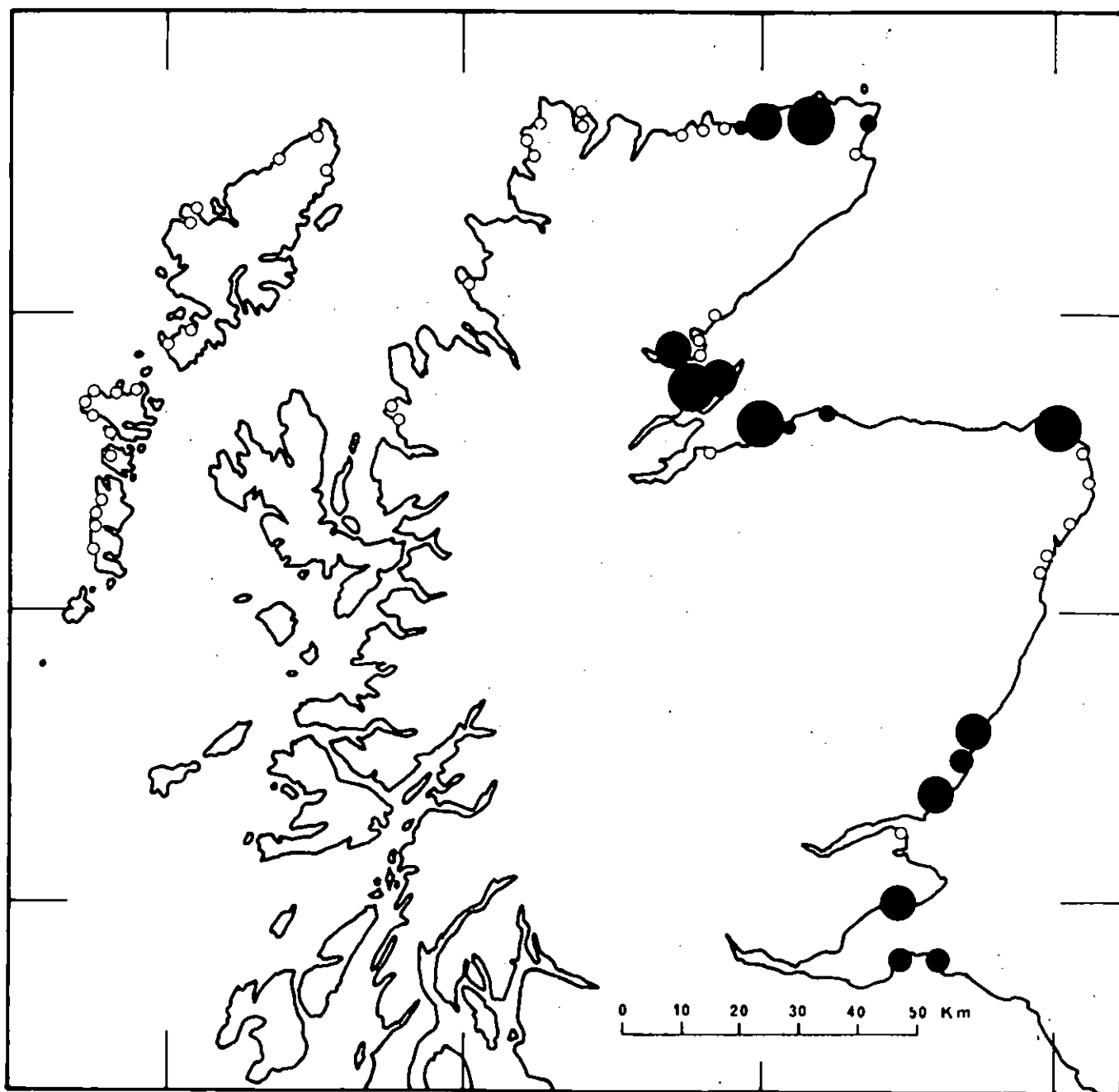


CYLINDROIULUS LATESTRIATUS

Map 60

Specimens recorded per site

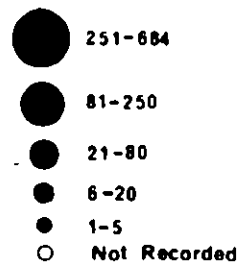


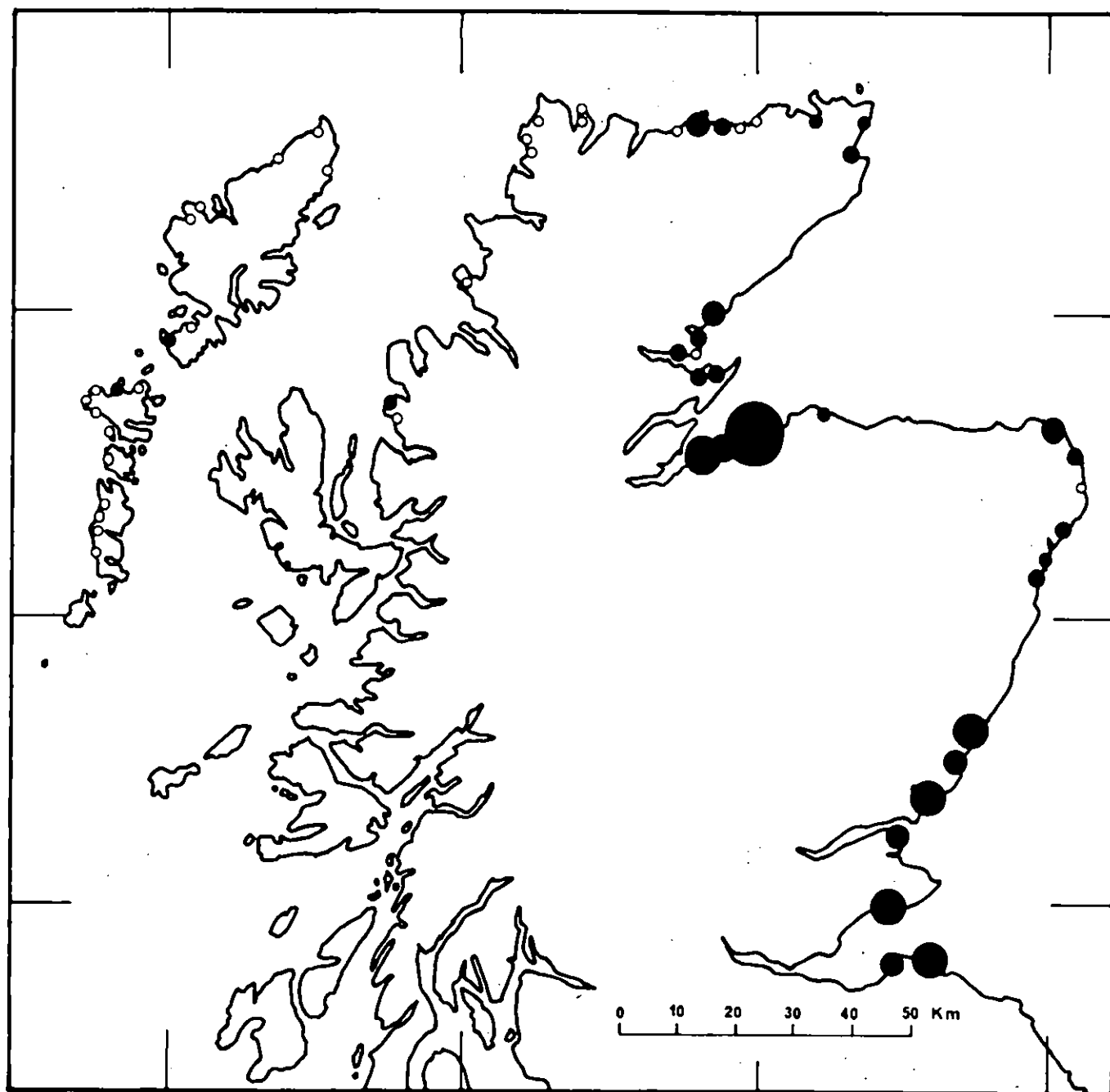


OMMATOIULUS SABULOSUS

Map 61

Specimens recorded per site

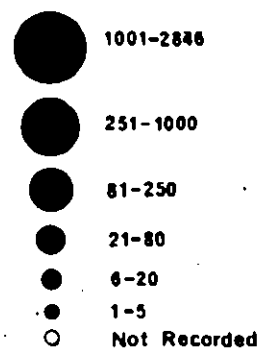


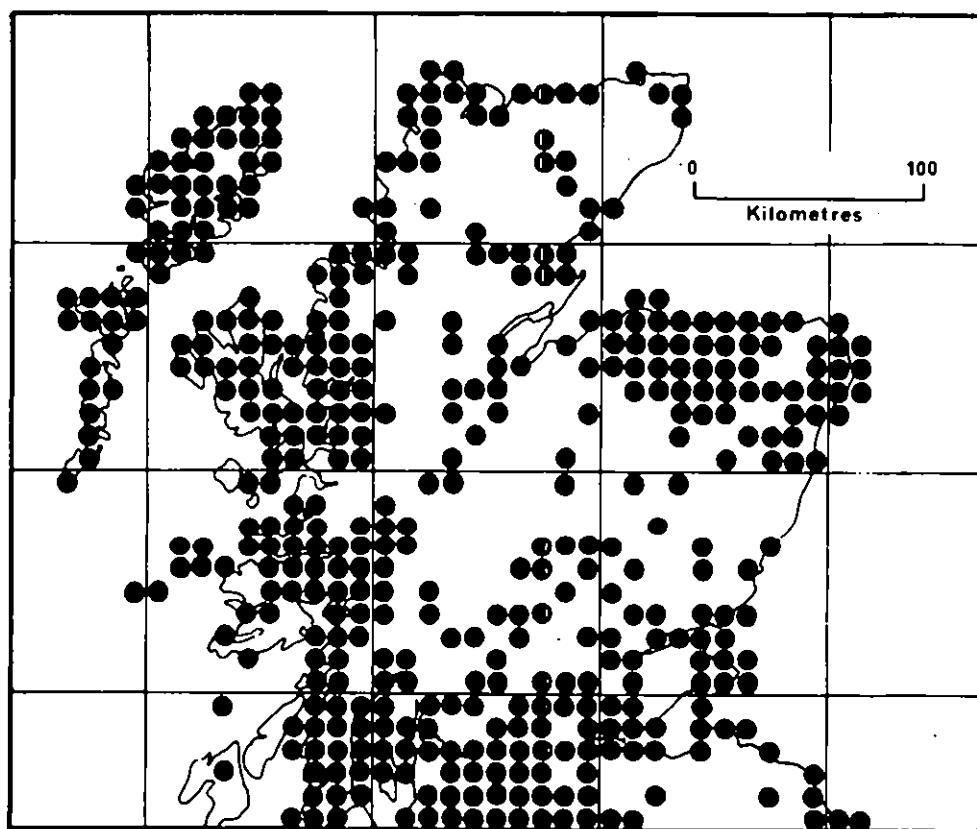


PORCELLIO SCABER

Map 62

Specimens recorded per site





PORCELLIO SCABER

Map 63

● Post 1960 records

and in press).

C. latestriatus is widespread in Britain on sand dunes and other sandy coasts throughout Britain. It was recorded at 51 of the 58 sites (map 60), the catch of individuals being greatest at the Outer Hebrides sites, particularly on Harris and Lewis. Records from this survey considerably extend the known (vice-county) distribution of this and other species (Blower, 1972).

O. sabulosus is also a species characteristic of dune grassland, particularly stabilised dunes and slacks. It was not recorded at any Outer Hebrides sites, and occurred at a total of 17 sites on the eastern half of the North Coast, the Moray Firth and the East Coast (map 61). Tachypodoiulus niger is commonly associated with O. sabulosus on coastal dunes in southern Britain, but appears to be absent from many similar areas in Scotland. It was recorded at only two southern East Coast sites. The morphologically similar species, Julus scandinavicus and Ophiulus pilosus, have slightly different ecologies (Blower & Gabbutt, 1964, Blower, 1970, Blower & Miller, 1974). J. scandinavicus is common on stabilised dunes, but O. pilosus, although more frequently found in the soil, has no special association with sandy substrates.

Brachyiulus pusillus, which has been found abundantly on some dune systems in Britain, was recorded at only four sites during the Survey. Although common and widespread, Cylindroiulus punctatus has been infrequently recorded in dune grassland, and is most abundant on base-poor soils in woodland. The habitats of the "flat-back" millipedes, Polydesmus angustus and P. inconstans (= P. coriaceus) are not clearly defined. Both species are adapted by their flattened shape for life in litter, especially woodland litter. Neither is known to be frequent in dune grassland, but Fairhurst (in press) recorded P. inconstans on dunes at Gibraltar point, Lincolnshire, where it was mainly restricted to a zone of Hippophae rhamnoides scrub.

13.2 Isopoda

The four species of woodlice recorded during the survey are all common and widespread in Britain. Porcellio scaber is particularly tolerant of dry sandy soils, and frequently occurs in large numbers in dune grassland. It was recorded in pitfall traps at 30 sites (map 62) and was collected by hand at four others. The highest numbers were recorded at the southern East Coast sites, but the total (2846) for Culbin Bar 2 was inexplicably high. Map 63 includes all the post-1960 records of P. scaber in Scotland (data from Isopoda Survey Scheme). The general impression from this distribution map is that P. scaber is as common in the west as in the east. The Survey results (map 62) must therefore be misleading but why this species should have been taken at only 3 sites out of 26 in the Outer Hebrides and west coast of mainland Scotland, is not known. Philoscia muscorum is also a common

grassland species, but one which seems to become localised in Scotland, mainly to coastal sites and river valleys. Its infrequent occurrence in the pitfall trap catches probably reflects its rather patchy distribution (Harding, 1976). The single occurrence of Oniscus asellus in the pitfall traps, at Melvich, was associated with domestic rubbish. This species is strongly synanthropic, although it occurs naturally, especially in woodland, throughout Britain. The small soil dwelling species Trichoniscus pusillus is susceptible to desiccation and is probably widespread in damp situations at some dune sites, but was recorded at only five.

Information from other collections of woodlice made at sites covered by the Survey, is available in a few cases. At Tentsmuir, in 1966, several days of collecting by hand revealed only Porcellio scaber. Records from hand collecting and litter samples from some Outer Hebrides sites, made by Dr and Mrs G.M. Collis and others, show that some of the species named above occur on dune and machair sites, but usually in association with driftwood or some human artefact (records held by the Isopoda Survey Scheme).

Studies of the population dynamics and ecology of woodlice and millipedes in dune grassland at Spurn Head, Yorkshire, have been made for the past 12 years by staff and students of the Zoology Department, Leeds University and are of relevance in interpreting the results of the Survey of Scottish coastal sites (Sunderland, Hassall & Sutton, 1976, Davis & Sutton, 1977, Sutton, pers. com.).

14 SUMMARY

14.1 An extensive survey of six groups of invertebrates was made simultaneously at 44 (1976) and 10 (1977) sand-dune sites on the coast of Scotland, using light traps and pitfall traps. The survey was unique, despite its limitations.

14.2 The objectives of the survey were:

1. To provide information which together with the botanical data, (I.T.E. Project 340), will form the basis for conservation evaluation of individual sites, and groups of sites, on sand dune formations and machair along the east, north and west coast of Scotland including the Outer Hebrides.
 2. To extend the existing knowledge of the occurrence and distribution of Lepidoptera, Carabidae and Araneae on Scottish sand dunes. (This objective was modified during later consultation with the Nature Conservancy Council to include all Coleoptera, the terrestrial Isopoda, Mollusca (Land snails) and the Diplopoda).
 3. To assess the validity and practicability of extensive "quick" survey for groups of widely separated sites in logistically difficult situations.
- All were fulfilled, the third only partially.

14.3 The pitfall traps functioned well. The destruction of a few by vandals had a negligible effect on the results. Mechanical faults impaired the efficiency of the light traps. In the Outer Hebrides the light traps operated during a period of low activity of night-flying moths.

14.4 One light trap and eight pitfall traps were used at each site. The light traps operated for two periods totalling 14-18 days and the pitfall traps for 35-37 days in June and July. The traps were usually grouped together in the 'marram transition zone'.

14.5 The groups of invertebrates identified to species were:-

Macrolepidoptera (from light traps)	
Coleoptera)
Araneae)
Diplopoda) all from pitfall traps
Terrestrial Isopoda (Oniscoidea))
Mollusca (Land snails))

A total of 119,617 specimens was taken, representing 655 species.

14.6 The information collected on distribution, numbers and habitat for individual species has greatly extended previous knowledge on Scottish sand-dune faunas. It also complements information in the Nature Conservation Review and adds new data to Biological Records Centre mapping schemes.

14.7 The 58 trapping sites fell naturally into 4 geographical regions: Outer Hebrides, North Coast, East Coast and Moray Firth. Differences between these regions formed a large part of the subsequent analyses.

14.8 Ordination of the sites by Reciprocal Averaging showed that the Lepidoptera, Coleoptera-Carabidae, other families of Coleoptera and the Araneae separated into distinct groups corresponding to the regions but with different degrees of overlap.

A few sites fell outside the regional grouping to which they belonged.

14.9 An Indicator Species Analysis showed that the Outer Hebrides formed one of the more distinct groupings of invertebrate faunas. Both the ISA (all groups) and the ISA for plant species (Project 340) separated the Outer Hebrides and North Coast sites from those on the East Coast and Moray Firth.

14.10 The fauna of Tolsta (Isle of Lewis, Outer Hebrides) was strongly linked with the northwest Scottish mainland sites throughout the ISA for some groups, but in the classification of plant communities (Project 340) it remained with other sites in the Outer Hebrides.

14.11 There was a southeast to northwest trend of decreasing species richness per site. Total numbers of species were negatively correlated with latitude. This held for the Lepidoptera and Araneae separately but not for the Coleoptera. The Mollusca showed a reverse trend, being richer in species on the machair dunes of the northwest.

14.12 The southeast sites on the East Coast showed the greatest habitat diversity (trees, bushes, ericaceous plants) and the highest totals of species and specimens per site. Some species, widespread in England, only reach Scotland along the southeast coastal strip.

14.13 The largest aggregation of rare beetles (unique to one site during the survey) occurred on the East Coast. The highest species totals for both the Lepidoptera and the Araneae were recorded on the southeast East Coast sites.

14.14 The Moray Firth sites showed characteristic features in the distribution and numbers trapped of some Lepidoptera, Coleoptera and Araneae. The different trapping year compared with the other regions may be responsible.

14.15 The Survey revealed some previously unknown changes in habitat preference. For example, some species well established on Scottish sand-dunes are not known to be associated with coastal dunes further south in Britain.

14.16 Extreme patchiness in distribution was occasionally recorded. A few species were numerous on one site (or a few) but scarce or absent elsewhere. Caution is advised in the interpretation of some distribution patterns.

15. AUTHORSHIP AND ACKNOWLEDGEMENTS

This volume was compiled and edited by Dr E. Duffey at Monks Wood Experimental Station. The main contributors are N. Greatorex-Davies (Lepidoptera), Dr R.C. Welch (Coleoptera), P. Harding (Mollusca, Diplopoda and Isopoda), Dr E. Duffey (Araneae).

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Number of species and specimens recorded per site for seven invertebrate groups.

Site Number	Lepidoptera		Coleoptera- Carabidae		Coleoptera- Other		Spiders		Mollusca		Diplopoda		Isopoda		Total	
	spp.	spec.	spp.	spec.	spp.	spec.	spp.	spec.	spp.	spec.	spp.	spec.	spp.	spec.	spp.	specimens
21	18	441	10	437	33	1108	16	390	7	3725	1	1			85	6102
22	14	276	14	305	47	1996	11	283	2	453	1	16			89	3329
23	6	38	11	1028	38	1069	13	326	5	3061	1	21			74	5543
26	19	696	12	327	40	1693	16	206	6	463	1	15			94	3400
27	3	4	12	414	44	585	12	261	5	3909	1	26			74	5195
28	14	210	9	174	26	342	13	479	3	906	1	74			66	2185
31	5	7	12	832	35	1651	10	276	3	45	1	77			66	2888
32			15	1386	45	1655	7	355	7	1304	1	113			75	4812
34	14	221	9	250	28	203	9	259	3	1001	1	46	1	4	65	1984
35	9	97	16	706	59	1300	12	418	11	1334	1	19			108	3874
36	10	22	8	223	49	1629	11	117	8	671	2	19			88	2681
39	14	96	9	337	25	425	5	40	4	75	1	185			58	1159
40	8	67	7	599	26	1153	13	376	7	1357	1	433			62	3985
41	4	8	12	655	36	1151	13	261	10	1141	1	45			76	3261
42	9	73	8	139	24	622	6	113	1	10	1	149			49	1106
43	6	43	13	458	25	629	6	374	2	3	1	15			53	1522
44	5	32	15	306	34	829	10	738	3	448	1	139			68	2492
45	11	39	10	542	31	435	22	351	8	272	1	10	1	2	84	1651
50S	16	391	7	120	17	170	13	87	6	34	1	15			60	817
50N	32	326	6	55	10	103	17	41	1	19	1	9	1	5	68	558
52	14	37	6	46	21	335	6	146	1	23	1	4			49	591
53	23	456	6	242	15	104	12	204	5	42	1	19			62	1067
54	13	106	5	129	17	56	8	557	1	2	1	1			45	851
56S	18	137	5	31	30	229	22	290	9	25	3	5	2	6	89	723
56N	20	143	8	249	46	547	21	197	7	285	1	16			103	1437
57	22	276	6	141	21	88	14	58	3	366					66	929
58	28	322	7	209	27	157	16	140	4	99	1	2	2	28	85	957
59	35	485	9	340	31	210	23	209	10	147	1	5	1	12	110	1408
60	39	533	9	235	25	871	18	414	5	77	2	26	1	1	99	2157
61	25	98	6	288	59	381	27	367	6	657	3	191			126	1982
62	15	56	11	63	65	1000	36	279	7	246	6	753	3	7	143	2404
63	20	156	6	52	48	424	22	186	3	50	2	9	1	3	102	880
64	9	31	8	629	25	201	18	342	4	35	1	9			65	1247
65	24	452	8	363	32	284	22	227	5	389	1	62	1	14	93	1791

Site Number	Lepidoptera		Coleoptera- Carabidae		Coleoptera- Other		Spiders		Mollusca		Diplopoda		Isopoda		Total	
	spp.	specs.	spp.	specs.	spp.	specs.	spp.	specs.	spp.	specs.	spp.	specs.	spp.	specs.	spp.	specimens
66	31	259	8	44	23	72	21	197			2	22	1	29	86	623
67	44	350	7	60	30	125	22	261	5	32	3	53	2	10	113	891
68	42	1184	9	187	39	282	18	163	1	13					109	1829
69	48	742	6	86	26	85	19	157			4	94	1	6	104	1170
70A	38	570	6	2191	14	24	15	221	1	2	2	361	1	8	77	3377
70B	31	337	9	2387	20	81	16	152	2	2	2	207	1	14	81	3180
71	25	365	11	897	36	255	23	205	3	3	1	9	1	83	100	1817
72A	34	152	13	221	23	106	23	279	3	4	1	6	1	22	98	790
72B	23	152	12	211	33	255	29	361	2	5	2	536	1	2846	102	4366
74	41	412	11	111	22	61	22	76	2	2	1	2	1	11	100	675
75	26	127	7	342	21	540	15	78	1	11	2	12	1	2	73	1112
79	25	626	10	172	56	418	26	255	5	102	6	586	1	72	126	230
80	15	79	14	502	36	123	22	322	1	43	1	2	1	18	90	1089
81	29	157	13	87	66	316	30	178	6	92	7	457	1	9	152	1296
82	36	971	15	44	59	1387	29	392	5	36	3	144	2	76	149	3050
83	33	592	11	269	19	116	29	380					1	1	93	1358
84	29	211	13	213	28	85	25	416			1	8	1	11	97	944
86	41	196	16	94	59	652	23	222	6	49	3	136	1	141	149	1490
87	60	1057	8	43	49	993	28	663	7	24	5	105	2	51	159	2936
88	50	404	9	63	45	586	24	407	7	174	6	386	1	82	142	2102
90	54	574	17	275	31	133	27	458			1	6	1	39	131	1485
91	26	1549	11	43	65	530	33	281	4	21	4	189	2	168	145	2781
93	43	493	9	60	49	285	38	461	5	23	6	113	2	127	152	1572
95	49	1057	14	125	75	605	30	470	5	35	3	148	2	146	178	2486

Appendix 2 Lepidoptera species and total specimens for each of the four Regions

	Outer Hebrides	North Coast	Moray Firth	East Coast
<i>Hepialus humuli</i>	0	1	0	0
<i>Hepialus lupulinus</i>	0	0	0	5
<i>Hepialus fusconebulosa</i>	2	73	28	26
<i>Egyaena filipendulae</i>	0	0	27	23
<i>Macrothylacia rubi</i>	0	2	2	7
<i>Philudoria potatoria</i>	0	6	0	0
<i>Idaea aversata</i>	0	0	2	17
<i>Xanthorhoe designata</i>	0	2	0	0
<i>Xanthorhoe munitata</i>	1	4	33	4
<i>Xanthorhoe montanata</i>	0	11	0	19
<i>Xanthorhoe fluctuata</i>	1	0	2	0
<i>Scotopteryx chenopodiata</i>	0	50	154	548
<i>Scotopteryx luridata</i>	0	0	26	4
<i>Epirrhoe alternata</i>	27	8	6	91
<i>Epirrhoe galiata</i>	0	0	8	0
<i>Camptogramma bilineata</i>	0	6	41	55
<i>Entephria caesiata</i>	0	0	0	17
<i>Pelurga comitata</i>	0	0	2	0
<i>Cosmorhoe ocellata</i>	14	34	62	34
<i>Eulithis testata</i>	0	0	0	1
<i>Eulithis populata</i>	0	0	0	3
<i>Eulithis pyraliata</i>	0	17	0	61
<i>Ecliptopera silaceata</i>	0	0	0	2
<i>Chloroclysta citrata</i>	0	0	2	0
<i>Chloroclysta truncata</i>	0	1	0	1
<i>Cidaria fulvata</i>	0	0	1	7
<i>Plemyria rubiginata</i>	0	0	0	1
<i>Thera obeliscata</i>	0	1	45	8
<i>Thera cognata</i>	0	4	7	0
<i>Colostygia pectinataria</i>	0	1	71	39
<i>Hydriomena furcata</i>	0	0	0	13
<i>Hydriomena impluviata</i>	0	0	0	7
<i>Perizoma blandiata</i>	23	0	1	0
<i>Perizoma albulata</i>	41	29	19	52
<i>Perizoma flavofasciata</i>	0	0	0	1
<i>Perizoma didymata</i>	1	0	0	0
<i>Eupithecia centauriata</i>	23	0	13	25

<i>Eupithecia absinthiata/goossensiata</i>	0	0	15	5
<i>Eupithecia vulgata</i>	0	0	9	0
<i>Eupithecia tripunctaria</i>	0	0	1	0
<i>Eupithecia subfuscata</i>	0	14	4	16
<i>Eupithecia icterata</i>	0	0	2	0
<i>Eupithecia distinctaria</i>	0	0	3	0
<i>Eupithecia nanata</i>	0	4	14	0
<i>Eupithecia pusillata</i>	0	4	0	0
<i>Gymnoscelis rufifasciata</i>	0	1	1	0
<i>Chesias rufata</i>	0	0	4	0
<i>Aplocera plagiata</i>	0	6	0	0
<i>Abraxas grossulariata</i>	0	3	0	0
<i>Lomaspilus marginata</i>	0	0	0	1
<i>Semiothisa liturata</i>	0	0	5	4
<i>Semiothisa clathrata</i>	0	0	0	1
<i>Opisthograptis luteolata</i>	0	2	0	3
<i>Crocallis elinguaris</i>	0	0	0	2
<i>Biston betularia</i>	0	0	0	4
<i>Peribatodes rhomboidaria</i>	0	0	0	1
<i>Alcis repandata</i>	0	0	10	0
<i>Cleorodes lichenaria</i>	0	0	2	0
<i>Ematurga atomaria</i>	0	0	0	1
<i>Bupalus piniaria</i>	0	0	29	39
<i>Cabera pusaria</i>	0	0	3	0
<i>Campaea margaritata</i>	0	0	1	1
<i>Hylaea fasciaria</i>	0	0	1	12
<i>Gnophos obfuscatus</i>	0	3	46	0
<i>Dyscia fagaria</i>	0	1	7	0
<i>Perconia strigillaria</i>	0	0	1	0
<i>Laothoe populi</i>	0	4	1	3
<i>Deilephila porcellus</i>	0	0	19	17
<i>Phalera bucephala</i>	0	0	0	1
<i>Cerura vinula</i>	0	0	0	1
<i>Pheosia gnoma</i>	0	0	0	6
<i>Ptilodon capucina</i>	0	0	2	2
<i>Dasychira fascelina</i>	0	0	11	0
<i>Eilema lurideola</i>	0	0	506	7
<i>Arctia caja</i>	105	26	123	92
<i>Spilosoma lubricipeda</i>	0	17	0	88

<i>Tyria jacobaeae</i>	0	0	0	5
<i>Euxoa tritici</i>	80	717	0	2294
<i>Euxoa cursoria</i>	0	147	0	15
<i>Agrotis vestigialis</i>	147	967	40	281
<i>Agrotis segetum</i>	0	0	0	22
<i>Agrotis clavis</i>	0	0	150	38
<i>Agrotis exclamationis</i>	0	58	82	135
<i>Agrotis ipsilon</i>	1	0	0	1
<i>Agrotis ripae</i>	0	0	0	67
<i>Axylia putris</i>	0	0	0	7
<i>Ochropleura plecta</i>	0	31	2	10
<i>Standfussiana lucernea</i>	1	17	2	0
<i>Rhyacia simulans</i>	3	0	0	0
<i>Noctua pronuba</i>	134	156	6	792
<i>Noctua orbona</i>	0	0	0	1
<i>Noctua comes</i>	0	13	30	62
<i>Noctua janthina</i>	0	1	0	3
<i>Graphiphora augur</i>	0	0	0	3
<i>Lycophotia porphyrea</i>	2	17	851	320
<i>Diarsia mendica</i>	0	6	19	46
<i>Diarsia rubi</i>	0	0	8	0
<i>Xestia c-nigrum</i>	0	3	1	22
<i>Xestia triangulum</i>	0	1	0	4
<i>Xestia baja</i>	0	0	0	2
<i>Xestia sexstrigata</i>	0	32	2	58
<i>Xestia xanthographa</i>	0	61	0	2
<i>Anarta myrtilli</i>	0	0	1	0
<i>Hada nana</i>	8	86	68	83
<i>Sideridis albicolon</i>	0	0	0	29
<i>Mamestra brassicae</i>	0	1	0	2
<i>Lacanobia oleracea</i>	1	5	16	24
<i>Ceramica pisi</i>	0	5	2	37
<i>Hecatera bicolorata</i>	0	0	0	2
<i>Hadena rivularis</i>	0	0	0	1
<i>Hadena confusa</i>	0	0	26	20
<i>Hadena bicruris</i>	0	0	0	26
<i>Cerapteryx graminis</i>	72	306	49	219
<i>Mythimna conigera</i>	0	52	27	41
<i>Mythimna ferrago</i>	0	0	9	2
<i>Mythimna impura</i>	18	32	292	312

<i>Mythimna pallens</i>	0	0	0	25
<i>Mythimna comma</i>	0	0	28	27
<i>Cucullia umbratica</i>	0	0	1	0
<i>Blepharita adusta</i>	9	69	7	8
<i>Acronicta euphorbiae</i>	0	0	1	0
<i>Acronicta rumicis</i>	0	3	1	0
<i>Amphipyra tragopoginis</i>	0	1	0	25
<i>Rusina ferruginea</i>	0	45	104	153
<i>Thalpophila matura</i>	0	189	421	252
<i>Euplexia lucipara</i>	0	3	0	1
<i>Phlogophora meticulosa</i>	0	0	0	1
<i>Apamea monoglypha</i>	496	405	785	450
<i>Apamea lithoxylaea</i>	0	18	3	23
<i>Apamea crenata</i>	0	14	4	4
<i>Apamea furva</i>	0	8	16	0
<i>Apamea remissa</i>	4	5	12	6
<i>Apamea sordens</i>	0	0	0	13
<i>Oligia strigilis</i>	0	0	0	1
<i>Oligia versicolor</i>	0	0	1	0
<i>Oligia fasciuncula</i>	0	3	83	33
<i>Mesoligia literosa</i>	0	17	4	14
<i>Mesapamea secalis</i>	1068	102	22	325
<i>Photodes minima</i>	0	0	1	0
<i>Photodes elymi</i>	0	0	2	29
<i>Luperina testacea</i>	59	0	0	107
<i>Amphipoea lucens</i>	2	17	0	2
<i>Amphipoea oculea</i>	0	1	0	0
<i>Celaena leucostigma</i>	0	0	0	2
<i>Hoplodrina alsines/blanda</i>	0	0	87	25
<i>Caradrina morpheus</i>	2	0	0	24
<i>Caradrina clavipalpis</i>	6	4	0	0
<i>Stilbia anomala</i>	0	3	0	0
<i>Pyrrhia umbra</i>	0	0	0	42
<i>Colocasia coryli</i>	0	0	0	1
<i>Diachrysia chrysitis</i>	7	17	1	21
<i>Plusia festucae</i>	3	2	1	0
<i>Autographa gamma</i>	1	4	0	13
<i>Autographa pulchrina</i>	7	13	0	20
<i>Autographa bractea</i>	0	26	7	3
<i>Syngrapha interrogationis</i>	0	0	1	0
<i>Abrostola triplasia</i>	1	7	1	3

Appendix 3 Coleoptera - Carabidae species and total specimens for each of the four Regions.

	Outer Hebrides	North Coast	Moray Firth	East Coast
<i>Cychrus caraboides</i>	0	3	1	1
<i>Carabus granulatus</i>	5	8	2	0
<i>Carabus nemoralis</i>	0	1	3	8
<i>Carabus problematicus</i>	0	4	37	51
<i>Carabus violaceus</i>	0	0	0	4
<i>Leistus fulvibarbis</i>	0	0	0	1
<i>Leistus rufescens</i>	1	14	55	53
<i>Nebria brevicollis</i>	63	2	0	7
<i>Nebria gyllenhali</i>	2	0	0	0
<i>Nebria salina</i>	0	37	2	32
<i>Notiophilus aquaticus</i>	27	6	10	25
<i>Notiophilus biguttatus</i>	14	3	0	0
<i>Notiophilus germinyi</i>	0	0	0	1
<i>Notiophilus substriatus</i>	10	1	0	0
<i>Loricera pilicornis</i>	122	30	0	1
<i>Dyschirius globosus</i>	870	0	13	6
<i>Dyschirius politus</i>	38	6	0	1
<i>Broscus cephalotes</i>	5	2	4	105
<i>Trechus obtusus</i>	24	22	2	20
<i>Asaphidion pallipes</i>	0	1	0	0
<i>Bembidion guttula</i>	0	0	0	1
<i>Bembidion pallidipenne</i>	2	0	0	0
<i>Stomis pumicatus</i>	0	0	0	2
<i>Pterostichus adstrictus</i>	0	0	1	0
<i>Pterostichus madidus</i>	0	21	0	0
<i>Pterostichus melanarius</i>	0	0	0	2
<i>Pterostichus niger</i>	40	2	33	14
<i>Pterostichus strenuus</i>	2	0	0	2
<i>Calathus erratus</i>	0	41	337	253
<i>Calathus fuscipes</i>	5413	1949	5280	851
<i>Calathus melanocephalus</i>	1736	470	737	132
<i>Calathus mollis</i>	235	484	41	315
<i>Laemostenus terricola</i>	2	0	0	0
<i>Synuchus nivalis</i>	1	1	2	0
<i>Agonum albipes</i>	1	0	0	0

Appendix 3 (continued)

<i>Agonum dorsale</i>	0	0	0	1
<i>Amara aenea</i>	40	9	78	19
<i>Amara aulica</i>	33	4	0	0
<i>Amara bifrons</i>	272	29	0	11
<i>Amara communis</i>	0	31	1	0
<i>Amara eurynota</i>	1	0	0	0
<i>Amara familiaris</i>	130	8	2	19
<i>Amara lunicollis</i>	0	0	8	0
<i>Amara plebeja</i>	0	0	0	1
<i>Amara tibialis</i>	25	0	16	6
<i>Harpalus rufipes</i>	1	0	0	0
<i>Harpalus latus</i>	3	0	10	2
<i>Harpalus rubripes</i>	0	0	46	0
<i>Harpalus tardus</i>	0	0	0	3
<i>Bradycellus harpalinus</i>	0	0	2	1
<i>Badister bipustulatus</i>	0	2	8	20
<i>Dromius linearis</i>	0	1	4	11
<i>Dromius melanocephalus</i>	0	0	0	2
<i>Dromius notatus</i>	0	0	2	2
<i>Metabletus foveatus</i>	0	0	0	6

Appendix 4 Coleoptera - Hydrophilidae to Scolytidae species and total specimens for each of the four Regions.

	Outer Hebrides	North Coast	Moray Firth	East Coast
<i>Helophorus aquaticus</i>	1	1	0	0
<i>Helophorus arvernicus</i>	0	0	0	1
<i>Helophorus brevipalpis</i>	3	0	0	11
<i>Helophorus flavipes</i>	1	0	0	0
<i>Sphaeridium scarabaeoides</i>	1	0	0	2
<i>Cercyon atomarius</i>	3	0	0	12
<i>Cercyon haemorrhoidalis</i>	4	1	0	4
<i>Cercyon melanocephalus</i>	3	3	1	10
<i>Megasternum obscurum</i>	2200	158	1	93
<i>Cryptopleurum minutum</i>	0	0	0	1
<i>Saprinus aeneus</i>	0	0	0	3
<i>Ptenidium nitidum</i>	0	8	0	1
<i>Ptenidium punctatum</i>	0	0	0	2
<i>Acrotrichus atomaria</i>	61	5	0	4
<i>Leiodes dubia/obesa</i>	1457	272	32	34
<i>Agathidium atrum</i>	0	0	0	1
<i>Agathidium laevigatum</i>	11	16	11	13
<i>Agathidium marginatum</i>	0	0	0	2
<i>Ptomophagus subvillosus</i>	0	0	2	14
<i>Nargus velox</i>	0	0	3	2
<i>Choleva agilis</i>	0	0	0	4
<i>Choleva fragniezi</i>	0	1	2	0
<i>Choleva glauca</i>	2	14	0	2
<i>Choleva jeanneli</i>	0	0	0	3
<i>Choleva oblonga</i>	0	3	2	4
<i>Sciodrepoides watsoni</i>	0	132	12	124
<i>Catops chrysomeloides</i>	1	9	8	40
<i>Catops coracinus</i>	0	4	0	8
<i>Catops fuliginosus</i>	0	16	13	78
<i>Catops grandicollis</i>	0	1	4	1
<i>Catops kirbii</i>	0	3	5	1
<i>Catops morio</i>	49	0	4	19
<i>Catops nigricans</i>	0	1	0	1
<i>Catops tristis</i>	0	43	0	3
<i>Microphorus humator</i>	2	0	1	1
<i>Microphorus investigator</i>	2	6	1	58

Appendix 4 (continued)

<i>Microphorus vespilloides</i>	0	3	0	14
<i>Thanatophilus rugosus</i>	0	30	1	5
<i>Thanatophilus sinuatus</i>	3	0	0	0
<i>Silpha atrata</i>	0	2	2	2
<i>Silpha tyrolensis</i>	1064	0	0	0
<i>Scydmorephes helvolus</i>	0	0	1	0
<i>Stenichnus collaris</i>	12	2	16	5
<i>Micropeplus porcatus</i>	3	1	0	0
<i>Micropeplus staphylinoides</i>	565	36	13	103
<i>Metopsia retusa</i>	0	1	2	1
<i>Megarthus depressus</i>	0	0	0	7
<i>Anthobium atrocephalum</i>	0	0	2	0
<i>Anthobium unicolor</i>	0	0	0	2
<i>Lesteva longoelytrata</i>	0	0	0	1
<i>Omalium caesum</i>	0	0	1	0
<i>Omalium excavatum</i>	1	0	0	0
<i>Omalium exiguum</i>	1	7	0	0
<i>Omalium oxyacanthae</i>	0	3	0	1
<i>Omalium rivulare</i>	1	0	0	0
<i>Bledius fuscipes</i>	0	1	0	0
<i>Bledius longulus</i>	530	122	0	1
<i>Anotylus maritimus</i>	1	0	0	0
<i>Anotylus nitidulus</i>	1	0	0	0
<i>Anotylus rugosus</i>	1	4	0	1
<i>Anotylus sculpturatus</i>	15	0	1	7
<i>Anotylus tetracarlinatus</i>	0	0	0	10
<i>Oxytelus laqueatus</i>	0	1	0	1
<i>Stenus boops</i>	0	7	0	0
<i>Stenus brunnipes</i>	78	23	3	3
<i>Stenus clavicornis</i>	15	5	3	17
<i>Stenus crassus</i>	0	1	0	0
<i>Stenus impressus</i>	1	5	4	8
<i>Stenus nanus</i>	542	5	0	1
<i>Stenus picipes</i>	3	0	0	1
<i>Stenus subaeneus</i>	0	0	0	1
<i>Othius angustus</i>	9	14	3	11
<i>Othius laeviusculus</i>	0	1	0	0
<i>Othius myrmecophilus</i>	0	0	0	2
<i>Othius punctulatus</i>	0	1	1	2
<i>Gyrophypnus angustatus</i>	44	8	0	4
<i>Gyrophypnus fracticornis</i>	0	1	0	0

Appendix 4 (continued)

<i>Xantholinus glabratus</i>	246	33	0	9
<i>Xantholinus laevigatus</i>	53	35	7	17
<i>Xantholinus linearis</i>	139	44	21	24
<i>Philonthus cognatus</i>	51	19	0	2
<i>Philonthus fimetarius</i>	3	0	0	0
<i>Philonthus laminatus</i>	156	4	0	0
<i>Philonthus marginatus</i>	4	8	0	12
<i>Philonthus succicola</i>	228	2	0	1
<i>Philonthus tenuicornis</i>	0	0	0	11
<i>Philonthus varians</i>	0	4	0	3
<i>Philonthus varius</i>	209	10	0	9
<i>Gabrius osseticus</i>	0	0	0	1
<i>Gabrius subnigritulus</i>	2	0	0	0
<i>Platydracus stercorearius</i>	0	0	10	23
<i>Staphylinus aeneocephalus</i>	8	8	1	0
<i>Staphylinus brunnipes</i>	0	17	14	14
<i>Staphylinus globulifer</i>	0	0	0	1
<i>Staphylinus melanarius</i>	4	0	3	2
<i>Staphylinus olens</i>	0	3	0	0
<i>Quedius boops</i>	9	1	3	4
<i>Quedius fuliginosus</i>	50	6	0	1
<i>Quedius humeralis</i>	0	0	2	0
<i>Quedius molochinus</i>	0	16	10	14
<i>Quedius picipes</i>	0	0	0	1
<i>Quedius scintillans</i>	6	0	0	0
<i>Quedius semiaeneus</i>	33	1	1	2
<i>Quedius semiobscurus</i>	0	12	3	0
<i>Quedius tristis</i>	3	26	5	6
<i>Mycetoporus angularis</i>	0	1	0	0
<i>Mycetoporus piceolus</i>	0	0	5	29
<i>Mycetoporus clavicornis</i>	0	0	0	1
<i>Mycetoporus lepidus</i>	0	0	1	5
<i>Mycetoporus nigricollis</i>	0	0	1	0
<i>Mycetoporus rufescens</i>	0	1	4	0
<i>Mycetoporus splendidus</i>	1	2	12	4
<i>Bolitobius analis</i>	0	0	6	5
<i>Sepedophilus marshami</i>	0	0	1	2
<i>Sepedophilus nigripennis</i>	0	0	145	25
<i>Tachyporus atriceps</i>	0	0	3	5
<i>Tachyporus chrysomelinus</i>	1331	201	21	107

Appendix 4 (continued)

<i>Tachyporus hypnorum</i>	164	15	2	39
<i>Tachyporus nitidulus</i>	0	0	3	7
<i>Tachyporus obtusus</i>	0	0	1	2
<i>Tachyporus pusillus</i>	631	50	1	3
<i>Tachinus corticinus</i>	0	1	2	28
<i>Tachinus elongatus</i>	0	1	0	0
<i>Tachinus laticollis</i>	86	0	0	3
<i>Tachinus marginellus</i>	0	3	0	3
<i>Tachinus proximus</i>	0	0	0	1
<i>Tachinus signatus</i>	250	8	0	13
<i>Cypha punctum</i>	0	0	0	2
<i>Encephalus complicans</i>	0	0	0	1
<i>Falagria thoracica</i>	0	34	0	0
<i>Boreophila islandica</i>	0	1	0	0
<i>Aloconota gregaria</i>	0	13	4	79
<i>Amischa analis</i>	0	3	12	11
<i>Amischa cavifrons</i>	78	26	3	0
<i>Geostiba circellaris</i>	7	0	3	25
<i>Liogluta granigera</i>	0	15	0	0
<i>Atheta elongatula</i>	6	3	0	3
<i>Atheta melanocera</i>	0	0	1	0
<i>Atheta excellens</i>	0	2	0	0
<i>Atheta divisa</i>	0	2	0	2
<i>Atheta euryptera</i>	0	3	0	2
<i>Atheta amicula</i>	4	9	0	28
<i>Atheta glabricula</i>	0	1	0	0
<i>Atheta indubia</i>	0	11	0	3
<i>Atheta liliputana</i>	0	23	0	0
<i>Atheta gagatina</i>	1	4	1	0
<i>Atheta clientula</i>	0	0	1	0
<i>Atheta fungi</i>	310	29	5	255
<i>Atheta orbata</i>	0	1	4	0
<i>Atheta aterrima</i>	1	1	0	8
<i>Atheta exigua</i>	184	0	3	0
<i>Atheta muscorum</i>	0	0	0	9
<i>Atheta parvula</i>	0	2	0	1
<i>Atheta celata</i>	1	12	0	0
<i>Atheta brunneipennis</i>	0	0	0	5
<i>Atheta graminicola</i>	0	1	0	0
<i>Atheta pertyi</i>	0	0	0	8

Appendix 4 (continued)

<i>Atheta triangulum</i>	3	15	0	1
<i>Atheta xanthopus</i>	0	0	0	1
<i>Atheta crassicornis</i>	0	0	0	1
<i>Atheta atramentaria</i>	0	32	2	41
<i>Atheta macrocera</i>	0	6	0	0
<i>Atheta nigripes</i>	0	0	0	2
<i>Atheta setigera</i>	0	1	0	0
<i>Atheta longicornis</i>	0	1	0	0
<i>Drusilla canaliculata</i>	0	529	175	2504
<i>Ocalea picata</i>	0	1	0	0
<i>Oxypoda brachyptera</i>	0	0	0	5
<i>Oxypoda haemorrhoea</i>	1	3	4	16
<i>Oxypoda islandica</i>	0	0	2	2
<i>Oxypoda opaca</i>	1	0	0	1
<i>Oxypoda soror</i>	0	2	0	0
<i>Oxypoda spectabilis</i>	0	2	0	2
<i>Oxypoda umbrata</i>	0	4	1	1
<i>Tinotus morion</i>	3	1	0	8
<i>Aleochara bilineata</i>	0	1	0	0
<i>Aleochara bipustulata</i>	2	1	1	48
<i>Aleochara cuniculorum</i>	1	0	0	0
<i>Aleochara lanuginosa</i>	0	0	0	8
<i>Aleochara obscurella</i>	1	0	0	1
<i>Aleochara sparsa</i>	1	5	0	3
<i>Geotrupes stercorarius</i>	10	3	0	0
<i>Geotrupes vernalis</i>	133	31	9	0
<i>Aegialia arenaria</i>	0	1	0	0
<i>Aegialia sabuleti</i>	0	0	0	1
<i>Aphodius ater</i>	0	1	0	1
<i>Aphodius depressus</i>	1	0	0	0
<i>Aphodius fimetarius</i>	4	2	0	0
<i>Aphodius rufipes</i>	0	2	1	1
<i>Aphodius rufus</i>	0	2	0	0
<i>Aphodius sphacelatus</i>	2	0	0	0
<i>Aphodius villosus</i>	0	0	0	1
<i>Serica brunnea</i>	3180	1520	74	239
<i>Phyllopertha horticola</i>	0	7	0	0
<i>Calyptomerus dubius</i>	0	0	0	2
<i>Simplocaria semistriata</i>	100	5	3	2
<i>Cytilus sericeus</i>	0	2	0	0

Appendix 4 (continued)

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<i>Byrrhus fasciatus</i>	127	88	2	16
<i>Byrrhus pustulatus</i>	0	0	57	0
<i>Dryops ernesti</i>	0	0	0	4
<i>Agrypnus murinus</i>	0	0	0	1
<i>Hypnoidus riparius</i>	76	26	0	0
<i>Athous haemorrhoidalis</i>	1	2	3	0
<i>Ctenicera cuprea</i>	0	3	3	1
<i>Agriotes acuminatus</i>	0	0	13	0
<i>Agriotes obscurus</i>	46	3	0	7
<i>Agriotes sputator</i>	0	0	0	1
<i>Cantharis nigricans</i>	0	1	1	0
<i>Rhagonycha femoralis</i>	0	2	0	4
<i>Rhagonycha fulva</i>	0	0	0	6
<i>Malthodes pumilus</i>	0	1	0	0
<i>Meligethes aeneus</i>	5	0	0	2
<i>Meligethes erythropus</i>	0	3	11	1
<i>Epuraea aestiva</i>	5	0	0	2
<i>Cryptophagus dentatus</i>	0	7	0	45
<i>Cryptophagus intermedius</i>	1	0	0	0
<i>Cryptophagus scanicus</i>	1	0	0	0
<i>Cryptophagus setulosus</i>	4	27	37	32
<i>Micrambe villosus</i>	5	1	0	3
<i>Micrambe vini</i>	1	18	0	1
<i>Atomaria atricapilla</i>	5	42	5	52
<i>Atomaria fuscata</i>	0	0	0	9
<i>Atomaria lewisi</i>	1	0	0	0
<i>Atomaria nitidula</i>	708	69	2	28
<i>Atomaria ruficornis</i>	0	0	0	1
<i>Coccidula rufa</i>	0	0	7	7
<i>Rhyzobius litura</i>	0	0	0	1
<i>Scymus schmidtii</i>	0	0	0	6
<i>Nephus redtenbacheri</i>	4	5	2	6
<i>Coccinella septempunctata</i>	0	0	4	1
<i>Coccinella undecimpunctata</i>	12	1	2	13
<i>Aridius bifasciatus</i>	0	0	0	13
<i>Aridius nodifer</i>	0	0	1	2
<i>Lathridius anthracinus</i>	1	0	0	0
<i>Lathridius pseudominutus</i>	0	2	0	0
<i>Enicmus transversus</i>	0	1	0	7
<i>Corticaria crenulata</i>	10	0	65	105
<i>Corticaria punctulata</i>	0	3	0	0

Appendix 4 (continued)

<i>Corticaria umbilicata</i>	0	4	45	249
<i>Corticarina fuscata</i>	39	29	118	173
<i>Typhaea stercorea</i>	0	2	0	1
<i>Orthocerus clavicornis</i>	0	0	20	0
<i>Lagria hirta</i>	0	0	37	0
<i>Phaedon tumidulus</i>	0	0	0	2
<i>Phyllodecta vulgatissima</i>	0	0	0	4
<i>Phyllotreta undulata</i>	0	0	1	0
<i>Longitarsus curtus</i>	0	0	0	4
<i>Longitarsus jacobaeae</i>	405	62	0	210
<i>Longitarsus luridus</i>	228	23	0	4
<i>Longitarsus succineus</i>	591	496	2	174
<i>Longitarsus suturellus</i>	0	1	11	4
<i>Crepidodera ferruginea</i>	61	6	0	150
<i>Chaetocnema concinna</i>	0	0	1	44
<i>Chaetocnema hortensis</i>	0	0	0	1
<i>Psylliodes marcida</i>	1	0	0	0
<i>Cassida rubiginosa</i>	0	0	1	0
<i>Apion cruentatum</i>	1	0	0	0
<i>Apion carduorum</i>	0	2	2	3
<i>Apion loti</i>	89	8	50	45
<i>Apion ononis</i>	0	0	0	1
<i>Apion apricans</i>	284	0	0	1
<i>Apion dichroum</i>	369	15	1	4
<i>Otiorhynchus arcticus</i>	0	3	10	0
<i>Otiorhynchus atroapterus</i>	83	76	238	30
<i>Otiorhynchus ovatus</i>	0	0	112	66
<i>Phyllobius pyri</i>	0	0	0	2
<i>Phyllobius viridicollis</i>	0	7	0	0
<i>Strophosomus melanogrammus</i>	0	0	21	0
<i>Strophosomus sus</i>	0	0	1	2
<i>Philopodon plagiatus</i>	389	181	184	48
<i>Barynotus squamosus</i>	0	0	0	2
<i>Sitona griseus</i>	0	0	11	20
<i>Sitona hispidulus</i>	0	0	0	1
<i>Sitona lepidus</i>	162	20	0	10
<i>Sitona lineellus</i>	218	27	42	31
<i>Hypera plantaginis</i>	0	0	0	2
<i>Hypera postica</i>	23	0	8	0
<i>Hypera punctata</i>	2	1	0	2

Appendix 4 (continued)

<i>Grypus equiseti</i>	0	0	0	1
<i>Micrelus ericae</i>	0	0	1	3
<i>Ceuthorhynchidius troglodytes</i>	1	0	0	0
<i>Ceutorhynchus contractus</i>	20	1	0	1
<i>Ceutorhynchus quadridens</i>	1	0	0	2
<i>Rhinoncus castor</i>	0	0	0	1
<i>Rhinoncus pericarpus</i>	81	0	2	0
<i>Miccotrogus picirostris</i>	0	1	0	2
<i>Miarus campanulae</i>	0	0	0	4
<i>Mecinus pyraister</i>	21	1	0	2
<i>Hylastinus obscurus</i>	0	0	0	1

Appendix 5 Araneae. Species and total specimens for each of the four Regions. Figures in parentheses are amended totals adjusted to a mean of 116 pitfall traps per Region.

	Outer Hebrides	North Coast	Moray Firth	East Coast
Number of sites	18 sites	16 sites	11 sites	13 sites
Pitfalls	144	128	88	104
<hr/>				
Species				
<i>Amaurobius similis</i>	0	0	0	1
<i>Drassodes cupreus</i>	0	15 (14)	42 (55)	27 (30)
<i>Haplodrassus signifer</i>	19 (15)	38 (34)	133 (175)	50 (56)
<i>Zelotes pusillus</i>	0	0	212 (279)	86 (96)
<i>Zelotes electus</i>	0	0	0	31 (35)
<i>Zelotes latreillei</i>	0	0	7	0
<i>Gnaphosa leporina</i>	0	0	50 (66)	0
<i>Micaria pulicaria</i>	0	5 (4)	73 (96)	20 (22)
<i>Clubiona reclusa</i>	0	0	0	4
<i>Clubiona stagnatilis</i>	0	1	0	0
<i>Clubiona neglecta</i>	1	1	8	9
<i>Clubiona lutescens</i>	0	0	0	1
<i>Clubiona trivialis</i>	0	2	1	0
<i>Clubiona diversa</i>	2	4	4	3
<i>Cheiracanthium erraticum</i>	0	0	0	3
<i>Agroeca proxima</i>	0	23 (21)	0	3 (3)
<i>Scotina gracilipes</i>	0	0	2	3
<i>Xysticus cristatus</i>	399 (321)	74 (67)	7 (9)	67 (75)
<i>Xysticus erraticus</i>	0	2	1	1
<i>Oxyptila trux</i>	0	0	0	36 (40)
<i>Philodromus cespitum</i>	0	0	0	1
<i>Tibellus maritimus</i>	0	0	0	2
<i>Tibellus oblongus</i>	0	0	1	3
<i>Heliophanus flavipes</i>	0	0	4	2
<i>Euophrys aequipes</i>	0	0	2	2
<i>Pardosa agricola</i>	0	0	4	0
<i>Pardosa purbeckensis</i>	70 (56)	0	0	0
<i>Pardosa monticola</i>	260 (209)	0	39 (51)	176 (196)
<i>Pardosa palustris</i>	333 (268)	301 (273)	4 (5)	575 (641)
<i>Pardosa pullata</i>	11 (9)	252 (228)	860 (1134)	879 (980)
<i>Pardosa nigriceps</i>	6 (5)	57 (52)	86 (113)	404 (451)

Appendix 5 (continued)

<i>Xerolycosa miniata</i>	0	0	0	124 (138)
<i>Alopecosa pulverulenta</i>	0	31 (28)	227 (299)	48 (53)
<i>Alopecosa accentuata</i>	0	1	5	4
<i>Trochosa terricola</i>	15 (12)	31 (28)	13 (17)	25 (28)
<i>Arctosa perita</i>	160 (129)	79 (72)	22 (29)	91 (101)
<i>Hahnia nava</i>	0	50 (45)	40 (53)	6 (7)
<i>Ero cambridgei</i>	0	2	0	0
<i>Ero furcata</i>	0	1	0	6
<i>Steatoda phalerata</i>	0	0	31 (41)	26 (29)
<i>Enoplognatha ovata</i>	0	0	0	2
<i>Enoplognatha thoracica</i>	0	0	1	1
<i>Robertus lividus</i>	0	0	3	1
<i>Pachygnatha degeeri</i>	52 (42)	187 (169)	17 (22)	83 (93)
<i>Ceratinella brevipes</i>	11	11	0	4
<i>Walckenaera acuminata</i>	3	14	11	14
<i>Walckenaera antica</i>	7	25	7	6
<i>Walckenaera melanocephala</i>	0	0	3	0
<i>Walckenaera monoceros</i>	0	0	0	4
<i>Walckenaera vigilax</i>	9	15	0	4
<i>Dicymbium nigrum</i>	5	11	0	2
<i>Dicymbium brevisetosum</i>	3	0	0	0
<i>Dismodicus bifrons</i>	0	4	1	1
<i>Hypomma bituberculatum</i>	1 (1)	3 (3)	3 (4)	47 (52)
<i>Gonatium rubens</i>	0	1	6	7
<i>Peponocranium ludricrum</i>	0	2	1	7
<i>Pocadicnemis pumila</i>	0	47 (43)	9 (12)	162 (181)
<i>Pocadicnemis juncea</i>	0	1	0	7
<i>Oedothorax tuberosus</i>	0	0	0	1
<i>Oedothorax fuscus</i>	223 (180)	44 (40)	0	0
<i>Oedothorax retusus</i>	23 (18)	389 (352)	2 (3)	74 (82)
<i>Trichopterna thorelli</i>	0	63 (57)	22 (29)	39 (43)
<i>Pelecopsis parallela</i>	0	0	14	0
<i>Pelecopsis nemoralis</i>	0	0	0	1
<i>Pelecopsis mediocris</i>	0	7	0	0
<i>Cnephalocotes obscurus</i>	0	0	0	7
<i>Silometopus elegans</i>	0	1	0	0
<i>Silometopus incurvatus</i>	0	0	0	10
<i>Evansia merens</i>	0	0	2	4
<i>Tiso vagans</i>	254 (205)	416 (377)	14 (18)	145 (162)

Appendix 5 (continued)

<i>Troxochrus scabriculus</i>	0	7	0	2
<i>Troxochrus cirriferus</i>	0	1	1	1
<i>Minyriolus pusillus</i>	0	0	9	0
<i>Tapinocyba praecox</i>	0	2	2	4
<i>Monocephalus fuscipes</i>	3	31	0	13
<i>Gongylidiellum vivum</i>	1	0	4	9
<i>Micrargus herbigradus</i>	0	1	0	1
<i>Micrargus apertus</i>	0	1	0	0
<i>Erigonella hiemalis</i>	0	1	0	3
<i>Savignya frontata</i>	5	6	0	0
<i>Diplocephalus latifrons</i>	0	3	0	0
<i>Typhocrestus digitatus</i>	16	12	2	1
<i>Milleriana inerrans</i>	0	0	0	3
<i>Erigone dentipalpis</i>	1 (1)	79 (72)	4 (5)	54 (60)
<i>Erigone atra</i>	264 (213)	60 (54)	2 (3)	80 (89)
<i>Erigone promiscua</i>	2588 (2085)	394 (357)	0	0
<i>Erigone arctica</i>	813 (655)	465 (421)	0	4 (4)
<i>Erigone "aletris"</i>	0	0	0	1
<i>Agyneta subtilis</i>	0	0	62 (82)	28 (31)
<i>Agyneta conigera</i>	2	1	5	4
<i>Agyneta decora</i>	8 (6)	59 (53)	25 (33)	5 (6)
<i>Agyneta cauta</i>	0	31 (28)	0	3 (3)
<i>Meioneta rurestris</i>	0	0	0	49 (55)
<i>Meioneta saxatilis</i>	0	0	0	64 (71)
<i>Meioneta beata</i>	17 (14)	269 (244)	0	17 (19)
<i>Naro minutus</i>	0	0	1	0
<i>Centromerus prudens</i>	0	1	2	7
<i>Centromerus dilutus</i>	0	0	1	2
<i>Centromerita concinna</i>	0	0	1	6
<i>Bathyphantes gracilis</i>	15 (12)	1 (1)	0	6 (7)
<i>Bathyphantes parvulus</i>	0	0	1 (1)	998 (1113)
<i>Bathyphantes nigrinus</i>	0	0	0	1
<i>Poeciloneta globosa</i>	0	0	0	2
<i>Stemonyphantes lineatus</i>	0	0	2	1
<i>Bolyphantes luteolus</i>	1	0	0	0
<i>Lepthyphantes obscurus</i>	0	1	1	2
<i>Lepthyphantes tenuis</i>	21	11	1	53
<i>Lepthyphantes zimmermanni</i>	0	1	0	3
<i>Lepthyphantes cristatus</i>	0	2	0	1

Appendix 5 (continued)

<i>Lepthyphantes menzei</i>	0	87 (79)	28 (37)	66 (74)
<i>Lepthyphantes ericaeus</i>	2	3	1	33
<i>Lepthyphantes insignis</i>	0	0	0	1
<i>Linyphia montana</i>	0	0	0	1
<i>Microlinyphia pusilla</i>	0	3	1	0
<i>Allomengea scopigera</i>	0	1	0	0

Appendix 6 Mollusca species and total specimens for each of the four Regions.

	Outer Hebrides	North Coast	Moray Firth	East Coast
<i>Oxyloma pfeifferi</i>	0	0	0	0
<i>Cochlicopa lubrica</i>	982	122	0	0
<i>Cochlicopa lubricella</i>	435	168	1	46
<i>Columella edentula</i>	0	0	1	1
<i>Columella aspera</i>	0	6	0	0
<i>Vertigo substriata</i>	3	0	0	0
<i>Vertigo pygmaea</i>	3	3	0	2
<i>Pupilla muscorum</i>	0	8	0	0
<i>Lauria cylindracea</i>	8	1	1	0
<i>Vallonia costata</i>	5	9	0	2
<i>Vallonia excentrica</i>	14	3	0	0
<i>Punctum pygmaeum</i>	0	0	2	0
<i>Vitrina pellucida</i>	594	163	18	5
<i>Nesovitrea hammonis</i>	2	0	2	1
<i>Aegopinella pura</i>	2	0	3	0
<i>Oxychilus cellarius</i>	0	1	0	2
<i>Oxychilus alliarius</i>	15	44	1	38
<i>Euconulus fulvus</i>	0	1	1	1
<i>Candidula intersecta</i>	49	186	27	124
<i>Helicella itala</i>	3667	1077	0	0
<i>Cochlicella acuta</i>	14350	256	0	0
<i>Trichia striolata</i>	3	0	7	0
<i>Trichia hispida</i>	15	0	0	84
<i>Arianta arbustorum</i>	0	49	0	0
<i>Cepaea nemoralis</i>	0	0	0	37
<i>Cepaea hortensis</i>	19	399	10	257

Appendix 7 Diplopoda species and total specimens for each of the four Regions.

	Outer Hebrides	North Coast	Moray Firth	East Coast
<i>Polydesmus angustus</i>	0	8	0	359
<i>Polydesmus inconstans</i> (= <i>P. coriaceus</i> sensu Blower, 1974)	1	2	0	58
<i>Iulus scandinavicus</i>	0	8	55	217
<i>Ophiulus pilosus</i>	0	34	0	242
<i>Cylindroiulus punctatus</i>	0	2	0	6
<i>Cylindroiulus latestriatus</i>	1408	182	60	49
<i>Brachyiulus pusillus</i>	0	1	0	88
<i>Ommatoiulus sabulosus</i>	0	873	1188	1211
<i>Tachypodoiulus niger</i>	0	0	0	22

Appendix 8 Isopoda species and total specimens for each of the four Regions.

	Outer Hebrides	North Coast	Moray Firth	East Coast
<i>Trichoniscus pusillus</i>	2	4	0	71
<i>Philoscia muscorum</i>	0	7	1	132
<i>Oniscus asellus</i>	0	1	0	0
<i>Porcellio scaber</i>	4	63	3030	738

Appendix 9 Additional Coleoptera records for 3 North Coast and 11 Moray Firth Sites.

Welch (in press, A) published a list of 22 species of littoral and psammophile Coleoptera from shore and strand-line refuse at 24 Outer Hebrides sites. With the exception of records for the Monach Isles, collected by D.G. Goddard and M.E. Bacchus in 1970, the remainder were all recorded by hand-collecting during the course of this survey in June and July 1976.

On 23 and 25 June 1976, W.H. Rispin collected from similar habitats at three North Coast sites, and from 15 to 25 June 1977 N. Greatorex-Davies and T. Brundle collected at all the Dornoch and Moray Firth sites included in this survey. They also sampled the area of sandy beach between Inver and Portmahomack on the Tarbat peninsula. The majority of the species recorded from this region were collected from seaweed. However at Lossiemouth several species were collected in the dunes and under Lotus corniculatus. The Carabidae from Findhorn and the single female Sinodendron cylindricum from Whiteness were also collected in the dunes. This last species attacks several tree species but is more commonly found as both adult and larva boring into dead Fraxinus. Britton (1956) regarded it as rare in Scotland. The pine weevil Hyllobius abietis was found in the Landrover after leaving Culbin Forest and was presumed to have originated from this site (B). Two Rhagium bifasciatum (Cerambycidae) found dead amongst the Lamophila at Lossiemouth had almost certainly originated from the conifer plantations just inland from the sampling site.

Metabletus foveatus was trapped at Tentsmuir and Fraserburgh during the Survey. On 22 June 1977 three specimens were taken from under Lotus at Lossiemouth. Lindroth (1977) records this species from the West Lowlands only in Scotland. Similarly he gives "England, N. to Cumberland and Scotland: west Lowlands." for Bembidion minimum. R.A. Crowson (1971, Entomologist's mon. Mag., 106:95-96) recorded this species in salt marshes at Tynninghame and remarked that it was "hitherto known only from the Solway Coast in Scotland." Single specimens were collected in seaweed at Morrich More on 18 June 1977 and between Inver and Portmahomack on 20 June, with a further two specimens at Culbin Bar on 22 June. Phyconoma migrans was first described from specimens collected on the southern shore of the Beaully Firth in 1968. During 1971 and 1972 it was recorded from Keiss Links and three localities on the Isle of Wight. (see Welch 1974 and Appleton, D. 1974, Entomologist's mon. Mag., 109:101). In June 1977 it was fairly common in seaweed along the southern coast of the Dornoch Firth between Tain and Portmahomack, and a single female was taken from a dead gul at Lossiemouth.

Appendix 9 (continued)

Of the 86 species of Coleoptera listed below, the 37 species preceded by an asterisk have not been recorded elsewhere during the present survey.

I/P = Inver/Portmahomack

+ = Species not recorded from this site during Survey

x = Species previously recorded from this site during Survey

l = record based on larval specimen(s) only

? = identity of specimen not confirmed at species level

Site Nos	53	54	57	66	67	68	69	70	1/P	71	72A	72B	74	75
<u>CARABIDAE</u>														
• <i>Cicindela campestris</i> L.													+	
<i>Nebria brevicollis</i> (F.)									+					
<i>Notiophilus aquaticus</i> (L.)	+	+	+											
<i>Dyschirius globosus</i> (Hbst.)									+					
• <i>D. salinus</i> Schaum											+			
<i>Broscus cephalotes</i> (L.)											+1		+	
• <i>Aepus marinus</i> (Stroem)							+							
• <i>Bembidion</i> (<i>Peryphus</i>) <i>tetracolum</i> Say	+								+					
• <i>B.</i> (<i>Emphanes</i>) <i>minimum</i> (F.)								+	+					
<i>Calathus erratus</i> Sahlb.													x	
<i>C. fuscipes</i> (Goeze)			+								x			
<i>C. melanocephalus</i> (L.)								x						
<i>C. mollis</i> (Marsh)													+	
• <i>Agonum fuliginosum</i> (Pz.)								+						
<i>Amara communis</i> (Pz.)								+						
<i>A. familiaris</i> (Duft.)				+				+					+	
• <i>Harpalus</i> (<i>s.str.</i>) <i>affinis</i> (Schr.)														
<i>H. (s.str.) tardus</i> (Pz.)											+			
• <i>Dicheirotichus gustavi</i> Crotch								+	+		-	+		
<i>Metabletus foveatus</i> (Fourc.)														+
<u>HYDROPHILIDAE</u>														
<i>Cercyon haemorrhoidalis</i> Steph.												+		
• <i>C. littoralis</i> (Gyll.)		+		+	+	+	+	+	+		+	+		+
<u>PTILIIDAE</u>														
• <i>Ptenidium punctatum</i> (Gyll.)							+	+	+					
<u>SILPHIDAE (larvae)</u>														
<i>Thanatophilus</i> sp. ?nigosus (L.)														+1
<i>Silpha</i> ?atrata L.									+1					
<u>STAPHYLINIDAE</u>														
• <i>Omalium laeviusculum</i> Gyll.		+		+	+	+	+	+	+		+		+	+
• <i>O. riparium</i> (Pk.)				+	+	+	+	+	+		+	+	+	+
• <i>O. rugulipenne</i> Rye					+	+							+	
<i>Bledius longulus</i> Er.									+		+			
<i>Anotylus maritimus</i> Th.		+		+		+		+				+		+
<i>Gyrohypnus fracticornis</i> (Muell.)									+					

[illegible]

[illegible]

Appendix 10 List of species of Lepidoptera recorded at only one site or from sites within one Region. See table 1 for site names.

* = species represented by a single specimen

Hebrides

* <i>Perizoma didymata</i>	45
<i>Rhyacia simulans</i>	36,39

North Coast

* <i>Hepialus humuli</i>	63
<i>Eupithecia pusillata</i>	57
<i>Abraxas grossulariata</i>	50N
* <i>Amphipoea oculea</i>	53
<i>Philudoria potatoria</i>	50N&S
<i>Xanthorhoe designata</i>	50N,60
<i>Aplocera plagiata</i>	50N,57
<i>Stilbia anomala</i>	59,65

Moray Firth

* <i>Eupithecia tripunctaria</i>	74
<i>Eupithecia icterata</i>	66
<i>Chesias rufata</i>	72
* <i>Perconia strigillaria</i>	72
* <i>Anarta myrtilli</i>	69
* <i>Cucullia umbratica</i>	68
* <i>Acronicta euphorbiae</i>	75
* <i>Oligia versicolor</i>	74
* <i>Photedes minima</i>	69
* <i>Syngrapha interrogationis</i>	69
<i>Epirrhoe galiata</i>	66,70B,72
<i>Pelurga comitata</i>	69,70A
<i>Chloroclysta citrata</i>	66,67
<i>Eupithecia vulgata</i>	68,69,71,72,74
<i>Eupithecia distinctaria</i>	66,70B
<i>Cleorodes lichenaria</i>	67,70B
<i>Alcis repandata</i>	70,72,74,75
<i>Cabera pusaria</i>	69,70A,72
<i>Dasychira fascelina</i>	67,69,70B,72A&B,74
<i>Diarsia rubi/florida</i>	68,71

East Coast

<i>Entephria caesiata</i>	83
* <i>Eulithis testata</i>	83
<i>Ecliptopera silaceata</i>	90
* <i>Plemyria rubiginata</i>	90
<i>Hydriomena impluviata</i>	90
* <i>Perizoma flavofasciata</i>	87
* <i>Lomaspilus marginata</i>	90
* <i>Semiothisa clathrata</i>	88
<i>Crocallis elinguaris</i>	90
<i>Biston betularia</i>	90
* <i>Peribatodes rhomboidaria</i>	93
* <i>Ematurga atomaria</i>	83
* <i>Phalera bucephala</i>	90
* <i>Cerura vinula</i>	86
<i>Agrotis segetum</i>	95
* <i>Noctua orbona</i>	90
<i>Hecatera bicolorata</i>	87
* <i>Hadena rivularis</i>	87
* <i>Phlogophora meticulosa</i>	93
* <i>Oligia strigilis</i>	93
<i>Celaena leucostigma</i>	83
* <i>Colocasia coryli</i>	90
<i>Hepialus lupulinus</i>	87,88
<i>Eulithis populata</i>	88,90
<i>Hydriomena furcata</i>	84,86,90
<i>Pheosia gnoma</i>	87,90
<i>Tyria jacobaeae</i>	88,93,95
<i>Agrotis ripae</i>	86-88,90,91,95
<i>Axylia putris</i>	87,95
<i>Graphiphora augur.</i>	33,90
<i>Xestia baja</i>	87,90
<i>Sideridis albicollis</i>	82,86,90,95
<i>Hadena bicruris</i>	86-88
<i>Mythimna pallens</i>	93,95
<i>Apamea sordens</i>	79,87,88,95
<i>Pyrrhia umbra</i>	36-88,95

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