MONKS WOOD EXPERIMENTAL STATION

SYMPOSIUM No. 1

March 23rd—25th, 1965

THE CONSERVATION OF INVERTEBRATES

THE NATURE CONSERVANCY

THE

CONSERVATION OF INVERTEBRATES

A Symposium held at Monks Wood Experimental Station

March 23rd - 25th 1965

Organised by the Conservation Research Section

Proceedings edited by

Dr. Eric Duffey and Dr. M. G. Morris

SYMPOSIUM on the

CONSERVATION of INVERTEBRATES

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PROGRAMME and SUMMARY

This meeting was the first staff symposium to be held at Monks Wood and was attended by 32 representatives from nearly all the regional offices in England, Wales and Scotland; the Research Stations and Specialist Branches. In addition, 5 invited ecologists attended to read papers or take part in the discussions and the organisers are grateful to them for their help and interest:- Mr. Charles Elton F.R.S., Dr. A. M. Massee, Dr. E. Broadhead, Mr. O. D. Hunt and Mr. W. O. Steel. Eleven papers were read during the three days and two field excursions arranged, to Woodwalton Fen N.N.R. and to Castor Hanglands N.N.R. and Barnack Hills and Holes S.S.S.I.

Discussions on the importance of invertebrate studies for ecological research in relation to conservation problems have been held from time to time by Conservancy scientific staff. Some of the problems were defined by Captain Diver in 1954 in a paper to the Scientific Policy Committee. The purpose of this Symposium was to discuss the practical aspects of invertebrate conservation under four main themes which had been arranged with Mr. T. Huxley:- (i) to examine the Conservancy's record and its achievements in this subject since 1949; (ii) to analyse the types of problems in the conservation of invertebrate animals on N.N.Rs. and the contribution made to them by current research; (iii) to assess the objects and value of invertebrate surveys and (iv) to discuss the purpose, use and organisation of invertebrate collections in the Conservancy.

The programme was as follows:-

Tuesday, March 23rd	Chairman: Dr. E. Duffey Opening Address - Invertebrate Conservation in relation to the Conservancy's commitments and the development of its research programme. Dr. E. Duffey.
Theme I	The fate of areas of invertebrate interest in England, Wales and Scotland known in 1949. Dr. J. F. D. Frazer.
	Extinctions and invasions: some case histories and conclusions. Dr. J. Satchell.
	Visit to Woodwalton Fen led by Dr. E. Duffey and Dr. M. G. Morris.

Wednesday, March 24th	Chairman: Dr. K. Mellanby Invertebrate conservation and management plans. Dr. E. Duffey.
	The conservation of the Large Blue Butterfly. Mr. O. D. Hunt.
Theme II	The Conservation of Dragonflies on Nature Reserves. Dr. N. W. Moore.
	Basic ecological knowledge required for invertebrate conservation. Dr. E. Broadhead.
	Visit to Barnack Hills and Holes S.S.S.I. and Castor Hanglands N.N.R. led by Dr. M. George.
Thursday, March 25th	Chairman: Dr. E. Duffey Why we need invertebrate surveys. Dr. M. G. Morris.
Theme III	Organisation and practice of intensive surveys. Mr. W. O. Steel.
	Some features of conservation interest arising from surveys. Dr. A. M. Massee.
Thursday, March 25th continued	The role of invertebrate collections in the Nature Conservancy. Mr. T. Huxley.
Theme IV	Continuation of Theme IV. Summing up followed by General Discussion.

Theme I - A review of the Conservancy's work in invertebrate conservation.

The discussions were greatly helped by a 20-page account prepared by Captain C. Diver describing the work of the Nature Reserves Investigation Committee in the 1940s concerning invertebrates and the facts available to the Committee preparing Command 7122. In this document, 18 sites were listed as P.N.N.Rs. primarily for zoological (mainly entomological) reasons. So little was known about the distribution, ecological requirements and populations of invertebrates that the safest solution to the problem of conservation was to ensure that the greatest variety of habitats was present on the proposed N.N.Rs. However, it was recognised at that time that selection based solely on vegetation types would fail to save many rare and localised populations. Reference was made during the discussion of this theme to an undated list prepared by the Royal Entomological Society (in the early 1940s?) of 158 sites worthy of preservation on entomological grounds. This list is not referred to in Cmd. 7122. The meeting agreed that since 1949, there had been very little progress in Conservancy thinking on problems of invertebrate conservation. A re-assessment was necessary in the light of modern knowledge of the British fauna. Invertebrate conservation could not be developed without due regard for the needs of other .... organisms and the whole should form part of a national conservation policy.

Theme II - Invertebrate conservation on Nature Reserves

An analysis of 550 research projects (in 69 Management Plans) showed that only 47 were concerned with studies on invertebrates. Less than half of these were being conducted by Conservancy staff and few were planned in relation to management requirements. The vast numbers of invertebrate species and shortage of specialists meant that management studies must be carefully selected. It was proposed that conservation research on invertebrates should be greatly expanded on two main lines:-

(a) studies on the faunas of habitats of special importance, either because such habitats are widespread on related Nature Reserves, or have to be maintained artificially (e.g. fen dykes; hazel coppice) or are subject to regular interference (e.g. sheep-grazed grassland; rabbit-disturbed Breck heath):

(b) the selection of a few, or perhaps only one, species of special interest which can be studied intensively in relation to habitat and the environmental factors influencing numbers and behaviour. The work on the Large Copper was quoted as an example of such a study which opened the way to work on related problems of management e.g. on water table control, involving the co-operation of other disciplines. The meeting suggested that management studies of this type, the results of which would have wide application, should be defined as part of the national conservation policy referred to in Theme I.

Theme III - The value of invertebrate surveys and how they should be developed.

There was general agreement that the present inadequate knowledge of the invertebrate fauna on Nature Reserves was a serious handicap to conservation and that the original intention in Cmd. 7122 to promote basic survey work of this type should be given more support. Mr. Steel, Drs. Massee and Morris referred to the work of past and existing survey teams, their achievements, the problems of organisation, finding enough specialists and adequate finance. Survey work on invertebrates had been conducted in many different ways with varying results but it was agreed that the best return for money spent was obtained from a specialist or groups of specialists working to an agreed plan. Such teams had made important contributions to a national inventory of wildlife on Nature Reserves. An analysis of records from 125 N.N.Rs., F.N.Rs., and L.N.Rs. showed that only three species of British butterflies had not been found on one or more of them, while 28 out of 40 British breeding dragonflies were represented on N.N.Rs. The meeting also noted that certain types of survey work outside Nature Reserves was important.

Theme IV - The organisation of invertebrate collections and their use.

The large number of invertebrate species and their complicated taxonomy made it difficult for conservation staff to document records and maintain collections. An investigation by Mr. T. Huxley showed that there were eight Stations where some attempt was being made to form collections but the extent and quality varied considerably. There was agreement that a properly organised invertebrate service was required in the Conservancy and that this was a natural extension of the management research and invertebrate survey discussed in Themes II and III. Initially at least, two centres were required, Edinburgh and Monks Wood, where curated invertebrate reference collections could be built up. It was accepted that voucher collections were required for Nature Reserves although specimens were not needed for all invertebrate groups. The Conservation Research Section would be responsible for the proposed collection at Monks Wood and the co-operation of the Biological Records Centre sought for documentation.

The main conclusions of the meeting are:-

(a) After 16 years, a careful review should now be made of the Conservancy's policy on selection of Reserves for invertebrates and of its commitments for research into management on the Reserves already established.

(b) Management studies and fundamental research on invertebrates should be more closely co-ordinated and planned as part of a national conservation policy.

(c) Invertebrate surveys made important contributions to the knowledge of wildlife on Nature Reserves. This work should be expanded by providing more money and facilities for properly organised teams of specialists.

(d) An invertebrate service was required in the Conservancy and initially at least, two centres should be established where curated invertebrate reference and voucher collections would be held.

List of Participants

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OPENING ADDRESS

INVERTEBRATE CONSERVATION IN RELATION TO THE CONSERVANCY'S COMMITMENTS AND THE DEVELOPMENT OF ITS RESEARCH PROGRAMME

E. Duffey

Staff symposia to discuss Conservancy scientific commitments and problems during the last 15 years have only been organised in relation to Woodlands (Bangor, 11th-13th April 1961) and Soils. Conservation work in which invertebrate studies are of importance have been discussed by scientific staff from time to time but usually came to nothing because of the difficulty of appointing sufficient taxonomic specialists. In 1964, this question was raised again by Mr. Tom Huxley and the Conservation Research Section at this Station agreed to organise a staff symposium to discuss this subject in the light of the Conservancy's record and modern developments.

The themes of the Symposium concern the practical problems arising out of managing diverse faunas on Nature Reserves and other areas and the organisers have not included papers dealing with ecological theory except where it is relevant to the application of ecological knowledge to wildlife conservation. The programme begins with a survey of the Conservancy's plans and thinking about invertebrate conservation in its early years and its achievements since 1949. This is followed by an examination of invertebrate conservation problems, both on Nature Reserves and on unprotected areas, followed by a session to assess the objects and value of survey work. Finally, we shall discuss the purpose and use of invertebrate collections in the Conservancy.

During the final meeting on Thursday afternoon, we hope everyone will take advantage of the discussion to pool their ideas and suggestions for future work, particularly in relation to the Conservancy's scientific work and the contribution it is making to invertebrate conservation.

In the following account, I want to review some of the historical aspects of the Conservancy's work in this field and to examine the contribution invertebrate studies can make to broader problems of wildlife conservation as part of the total research effort by our scientific staff.

As a basis for this review, I am indebted to Captain Diver for a series of notes on the efforts to get the requirements of invertebrates included in the proposed National Nature Reserves before the Conservancy was brought into being. In 1943, the British Ecological Society produced a list of 66 major habitat types which it thought ought to be included in reserved areas. This has been largely accomplished and would probably meet, in most cases, the main entomological requirements. In 1945, the final report of the Nature Reserves Investigation Committee tried to strike a balance between the claims of the various scientific interests and 18 sites were listed primarily for entomological reasons:-

Castor Hanglands	Braunton Burrows
Chippenham Fen	Hawes Water (Silver Dale)
Monks Wood	Ham Street Woods
Blean Woods	Basingstoke Canal
Wye and Crundale Downs	Eglwyseg Mountain (Denbigh)
Denny Wood and Bog	Deal Sandhills
Morden Bog	Wicken Fen
Heaths from Studland to Arne	Woodwalton Fen
Birdlip Woods	Windsor Great Forest

So little was known about the distribution, ecological requirements and populations of invertebrates that the only way of dealing with the problem of conservation was to maintain the greatest variety of habitats on Nature Reserves. However, the Nature Reserves Investigation Committee were aware in 1945 that selection based solely on vegetation types would fail to save many rare and localised populations.

The 1945 report led to the first official body which was appointed by the Ministry of Town and Country Planning with Sir Julian Huxley as Chairman. All the 18 entomological sites mentioned were included and the original list of N.N.Rs. was expanded. A large number of scientific and natural history bodies were invited to submit evidence, but for some reason, one of the few which declined was the Royal Entomological Society. Captain Diver thinks this was partly due to the entomologists not forming a coherent integrated body of opinion; there were too many diverse interests and there was a fairly general feeling at the time that invertebrates could look after themselves. However, there is an undated list of 158 sites drawn up by the Royal Entomological Society which is not mentioned by the Huxley Committee. Many of the 158 sites are included in the present N.N.R. total of 111, in spite of the fact that only 18 have any reference to invertebrate interest in the Reasons for Establishment.

Selection of sites for invertebrates

There are approximately 21,000 species of insects of which about 5,000 are "determinable" in the sense that there are modern or useable keys. Some groups are very much more popular than others so that entomological Nature Reserves have been proposed largely on the basis of records received from amateurs or professionals behaving as amateurs. These groups are mainly Lepidoptera or Coleoptera with Hymenoptera, Odonata, Orthoptera and Neuroptera well behind. The completeness of invertebrate knowledge for Nature

Reserves also varies very much and is probably much better for sites in the South, South-Eastern and East Anglian regions than for most places elsewhere.

The Woodlands Symposium unfortunately only dealt with trees and did not attempt to analyse woodland entomological problems. However, 11 of the 50 woodland Nature Reserves and Forest Nature Reserves have an entomological interest quoted for them. Other major habitats do not come off so well e.g. there are 7 Chalk N.N.Rs. but only one has a reference to entomology; 112 S.S.S.Is. on chalk, but only 11 have a reference to invertebrates; perhaps even more striking is the fact that there are 21 chalk S.S.S.Is. in a county like Kent which is well worked entomologically and not one of these has any reference to an invertebrate interest. Similarly, there are 18 Chalk S.S.S.Is. in Wiltshire and no reference to invertebrates.

Dr. Frazer will be surveying the actual record and fate of sites originally proposed for entomological purposes but it is clear that the Nature Conservancy has no properly defined policy towards invertebrate conservation, nor has it any clear idea of the type of research required to ensure that Nature Reserve management gives adequate attention and resources to this problem. Beyond a general guide to conserving habitat variety, the Conservancy probably does not know what it is trying to conserve or what it should be conserving. However, until a clear answer to this can be found, most ecologists will agree that it is unlikely that there will be any serious omissions or errors if the 66 major habitat types proposed by the British Ecological Society are represented on the national series of Nature Reserves and that within each habitat type, there is a wide range of variation.

The Huxley Committee intended that Reserves should be managed. This we must assume, included invertebrates as well as other forms of wildlife. Their 1947 White Paper included three main proposals:-

(1) to establish a series of N.N.Rs.: this has more or less been accomplished.

(2) to establish a biological service.

(3) to establish research institutes in terrestrial ecology. This has also been achieved, at least to some extent. These institutes were to be planned on academic lines and to be independent.

The biological service was intended to accomplish the following:- (1) the setting up of an administrative headquarters - this is Belgrave Square; (2) the establishment of regional organisations - this has also been accomplished.

The biological service was to include three groups of specialists who were never appointed. (1) Ecological specialists in major habitats - Woodlands specialists were appointed but these were part of the research institutes' staff and thus separate from the biological service; (2) specialists in groups of organisms - of which none were appointed, and (3) specialists in other subjects such as soils, climatology, physiography - most of whom are now in post. It is not generally realised what a significant effect the failure to appoint specialists in habitats and groups of organisms has had on the development of conservation policy at national level and management policy on a Nature Reserve level. These specialists were not to be attached to research institutes and in the White Paper are referred to as "mobile". They were to work closely with the regional staff specifically on practical conservation problems doing the survey, study and field work necessary to formulate conservation policy, and to produce ecological information required by regional staff who were to be directly responsible for Nature Reserve management. Invertebrate studies would obviously have played a major part in the activities of this group of scientists and many of the group specialists would presumably have been invertebrate zoologists. The Conservancy has tried, to some extent, to fill the gap by the building of Monks Wood Experimental Station which specifically concerns itself with the field of applied ecology. The Conservation Research Section has terms of reference very close to these which we can assume were intended for the missing specialists i.e. to examine the different types of Nature Reserve management problems; to co-ordinate field studies on Nature Reserve management; to do research on practical conservation; to provide an advisory service for the conservation staff. This covers most of the subjects concerning the conservation of Nature Reserve types with the exception of woodlands, and it is made up of two different but complementary functions:-

(a) planning, initiating and doing research relevant to conservation and for Reserve management;

(b) the setting up of a co-ordinating and advisory group of people who would bring together common problems of management studies, index existing records and data relevant to conservation and management, and advise on the application of ecological knowledge to the Conservancy's commitments.

Studies and survey which the Conservancy must develop in relation to its commitments for invertebrate conservation and management on Nature Reserves and other sites of conservation interest can be grouped around the following basic points:-

(a) to prepare a national inventory of animals recorded on Nature Reserves; to bring together existing data which are very scattered and promote more survey work on the lines of that already being organised. The Huxley Committee recommended that the national series of Nature Reserves should include as many examples as possible of all the many different groups of living organisms which form part of our natural fauna and flora. We cannot measure the success of this without knowing what proportion of the fauna is represented on our Nature Reserves. This information is also basic to management programmes.

(b) a national index of ecological information derived from existing work published and unpublished, covering all aspects of ecological knowledge relevant to the maintenance and control of habitats important for invertebrates and the management of populations and species of animals on nature reserves or other areas of conservation value. This would also form the basis of the advisory service to the conservation staff. It would help to show where the main gaps in our knowledge are, and form a guide to future research by the Conservancy's applied ecologists.

(c) historical studies on the main factors which have influenced the development of major habitats in this country today, e.g. use and exploitation by man of areas such as the Chalk downs, Breckland heaths, the fens, upland pastures, moorlands and woodlands. Without this knowledge, it is not possible to understand the pattern of habitat distribution as it survives today nor the traditional techniques used perhaps for centuries, to maintain particular types of vegetation cover. All this obviously has a profound influence on invertebrates as well as other wildlife.

(d) the number of potential conservation research problems is so great and the number of research staff to work on them will be inadequate for a long period to come so that a Conservancy research policy based on practical conservation commitments must have an order of priority. I suggest this can be done by recognising a series of national conservation projects orientated around the main habitats so that under each heading are many sites sharing common problems as follows:-

Examples of the main land formations and habitats of conservation importance, most of which have some representation on National Nature Reserves

Lowland grassland and heaths.

(a) Chalk sites, excluding woods.

(b) New Forest heathlands and similar areas in southern England.

(c) Grassland heather heaths of Breckland and East Suffolk.

(d) Smaller units such as Cannock Chase and Charnwood Forest.

2. Wetlands.

(a) Norfolk Broads.

(b) Reservoirs and lakes (e.g. the Lake District and Scottish Lakes).

(c) Lowland fens and marshes.

(d) Bogs, mosses and mires in northern England and Scotland.

3. Woodlands.

(a) Surviving deciduous woods of different types.

(b) Native coniferous woods.

(c) Forest areas of special importance e.g. New Forest, Thetford Chase in Breckland and other man-made forests.

Coastlands.

(a) Sand-dune and shingle formations.

(b) Salt-marshes.

(c) Estuaries (e.g. effects of proposed barrages on wildlife).

(d) Rocky coastlines with special scientific interest (e.g. sea-bird colonies).

Uplands.

(a) Limestone areas in Pennines, Wales and Highlands.

(b) Grouse moors and sheep pastures in Wales, northern England and Scotland.

(c) Mountain areas influenced by hydro-electric schemes, afforestation and tourism.

6. Agricultural.

(a) Hedgerows.

(b) Ponds and ditches.

(c) Crops.

The following table attempts to show that ecological studies on Nature Reserve management are not isolated projects relevant only to the particular site or region where the work is being done. Management problems of the same type may be found on a series of very different Nature Reserves or on types of country of contrasting landscape. Seven types of country in which Nature Reserves are present have been taken from the preceding table to show that the same land-use factors influence conservation problems in many areas. The results of research on any one of these will therefore have wide application.

Conservation-Management Problems	Bedfordshire Chalk	Dorset heaths	New Forest	Norfolk Broads	Breckland	Lake District	South Wales sand-dunes
Grazing as a management technique	++	+	+		+	+	+
Burning used in land management		++	+			+	
Public activities modifying environment	++	++	++	++	+	++	++
Influence of agricultural reclamation	++	++			++		
Influence of forestry activities		+	++		++	+	+
Water pollution affecting wildlife conservation				++		+	
Toxic chemicals and/or fertilisers modifying environment	+	+		+	+		
History of human interference and exploitation having a bearing on present day scientific interest	++	++	++	++	++	++	+

(++ = well-established and widespread: + = in some areas only)

All the sites mentioned in the tables require basic survey work on invertebrates as part of the management studies. It is possible however, to assign degrees of priority or urgency to the problems of management in relation to the factors causing change or modification to the environment. The habitats undergoing change at different rates may be described as follows:-

(1) Ecologically stable formations where change is natural, proceeding slowly and relatively unaffected by human or animal interference. Examples are mountains, saltmarshes, some dune and shingle formations and some woodlands.

(2) Habitats which have a considerable degree of vegetational or structural uniformity such as grasslands, moorlands and some heaths. Reserves in this category are less complex ecologically than others although certain factors such as grazing or burning may be important in retaining the characteristic uniformity. Public use not significant.

(3) Ecologically complex, relatively unstable or heavily-exploited formations where change is, or might be, rapid. These include some woodlands which become Nature Reserves after heavy exploitation; fen areas where a falling water-table and/or traditional use is no longer practised; hydroseres subject to pollution; neglected grasslands invaded by scrub; heather moors being converted to poor grassland by over-grazing; heaths, grasslands and dune systems subject to intense public use.

The Conservancy will obtain a more valuable return for its research effort if its management studies are directed mainly to problems associated with categories (2) and (3). In both cases, ecological studies and experimental work in the field could be greatly aided by making use of invertebrate species as "indicators" of certain environmental conditions, of developing knowledge on the nature of invertebrate animal communities and of the methods of classifying animal habitats.

SUMMARY

1. Conservation studies on invertebrates can be of great value in management research and ecological field experiments. They can only be planned effectively as part of a national scientific conservation policy.

2. The type of applied ecological work which must be done is not the responsibility of the research stations apart from Monks Wood. It cannot be done by the Conservation staff in the Regions who have other commitments. It is too vast a subject for the present Conservation Research Section to make any effective impact and can only be solved by the appointment of more applied ecologists to the Conservancy and making greater use of "outside" specialists working to an agreed national plan.

3. The Conservancy's commitments on nature reserves and other areas for wildlife conservation and the associated research can be grouped under six main headings. These share a number of common factors which influence, modify, cause change or maintain component parts of the habitat. The sites, in relation to these factors, can be assigned to an order of management urgency, and would enable the Conservancy to frame a scientific conservation policy.

The subjects we shall deal with at this Symposium constitute a difficult and complex problem. A good deal of discussion will no doubt be necessary afterwards, but I would repeat Winston Churchill's instruction to his scientific advisers; "Let's not talk of the difficulties; the difficulties will speak for themselves". Let us spend our time looking for constructive ideas which will enhance and develop the Conservancy's research effort.

Summary of Discussion

It was pointed out that little was known about invertebrates in the early days of the Conservancy except that man was upsetting the whole environment in which they lived. The Conservancy however, had to carry out an acquisition programme with only very limited knowledge and they did the best that was possible at the time. Dr. Massee said that the reason why the entomologists did not submit evidence to the Nature Reserves Investigation Committee in the 1940s was because their numbers were made up chiefly of Lepidopterists. These acted as a kind of closed freemasonry; they knew where the great rarities occurred but this information was kept to themselves. It was not until the Protection Committee for British Insects was formed by W. G. Sheldon that they began to let others share their knowledge and the first lists of insects to be protected were drawn up in 1946.

The view was expressed by other members that survey work was not given high priority by the Conservancy's administration or scientists, because it was not considered to be intellectually satisfying. It is pointed out however, that invertebrate surveys on certain types of agricultural land are of particular value when planning research projects. Although hedgerows are one of the commonest habitats in our countryside, very little is known about the animals which live in them. Members emphasised that we needed to have a fresh look at the 1947 White Paper. The Conservancy had been engaged on research for a period of fifteen years and it has not yet taken a look back on its record of scientific achievement. We need to re-examine the proposals and plans which were outlined in the White Paper and see whether we are achieving what we set out to do in the beginning. Several members questioned the effectiveness of the Entomological Liaison Committee which has now been in existence for seven years. There was a general feeling that its record was not very good and that it had failed to take enough initiative over important issues concerning our invertebrate wildlife.

THE FATE OF AREAS OF INVERTEBRATE INTEREST AS LISTED IN 1949

J. F. D. Frazer

The Nature Conservancy, London.

The basis of this knowledge lies in the reports of the local N.R.I. sub-committees held by the Conservancy. These reports vary in quality and are devoid of the maps which originally accompanied them. The original questionnaire is missing but much of it can be deduced from the replies. It is apparent that committees were asked to suggest areas suitable for habitat, species, educational and amenity reserves, on both national and local scales. In addition, they listed whether these sites covered botanical, entomological, geological, ornithological or mammal interests. Some replies are carefully considered statements while others are briefer, and a few more lists of names. The reports on Regions 6 (South Lancs., and Cheshire) and 16 (Oxfordshire) are missing. Only one site is given as having invertebrate interest other than entomological (the Roman Snail, Helix pomatia).

These reports and Cmd. 7122 have formed the basis of the Table. Where areas are listed as having no statutory protection at present, the causes are varied. Some of the woods have been clear-felled while one has gone down to housing. Some areas are ploughed, others public open spaces. Some are at present under scientific investigation, and others proposed as S.S.S.Is. There is a small number of sites where neither the Regional staff nor local naturalists have any knowledge of existing entomological interest, or even of any scientific interest at all.

While Wales is covered by the N.R.I.C. reports, only six sites of entomological interest are mentioned. Scotland is not covered by these reports, but in Cmd. 7814, four areas are listed as of invertebrate interest. These are the Cairngorms ("Certain species of .... insects are peculiar to the Cairngorms plateau or are better represented here than elsewhere"); the Black Wood of Rannoch, now an S.S.S.I. ("The area is of general interest; its insect life particularly so"); Allt Volagir ("The insect life .... is also of great interest") now an S.S.S.I. where the interest is listed as purely botanical; and Craigs and Racks Moss ("Its insect life is especially worthy of further study") where part was formerly an S.S.S.I., now denotified as substandard.

Table - showing fate of English sites listed by N.R.I.C. committee or Cmd. 7122 as of entomological interest

Present Classification	N.N.Rs. proposed in Cmd 7122	N.R.I.C. Proposals	
		Major	Lesser
N.N.Rs., P.N.N.Rs., F.N.Rs., and S.S.S.I.(A)s.	27		
Statutory and non-statutory L.N.Rs. etc.	2	9	8
S.S.S.Is.	4	21	50
No statutory protection	-	5	24

Summary of Discussion

It was stated that very little seemed to be known about the invertebrate interest of nature reserves in Scotland and that reference to such an interest in management plans was very scanty. Each year new rarities were being discovered in Scotland, so that it was difficult to make a proper assessment of the entomological interest. In no case does a Scottish management plan make a recommendation for conserving invertebrate species or populations, or for conserving an area for that end. It was felt that Scotland should be regarded as an area where it is more profitable to conserve and do surveys because Scottish nature reserves are not subject to the public pressures found in southern England. The post of Historical Geographer is also one in which Scotland has considerable interest because a true understanding of populations, both botanical and zoological, is very dependent on what the past treatment of the land has been. It was pointed out that the Scottish entomology in the mid-1940s was a lot better known than is reflected in the management plans of Scottish Nature Reserves. Perhaps if Scotland had agreed in 1947 to combine their recommendations with England and Wales in Cmd. 7122, the zoological interest of their sites would have received more attention. It was said that in Wales, only about six sites had any entomological interest recorded for them. Almost all counties in Wales had scanty entomological information with the possible exception of Glamorgan which is the best-known. It was added that there was no provision for the management of the entomological interest on any of the Welsh Reserves at the present time. A member said that in Scotland, most of the entomological recording had been done by English entomologists. Many of the records are not localised to specific areas and in many cases only the rarities have been recorded. Dr. Massee pointed out that a great deal of information about the insect fauna of Scotland can be found in the diaries of a Mr. Harwood who lived in Aviemore just before the War.

His diaries contain a vast fund of information about the Coleoptera of the Highlands from 1923 onwards. He said that the diaries were now in the possession of Mr. Scarsdale Brown of Bournemouth, and on his death, would be handed to the Hope Department, Oxford. If the Conservancy would like to borrow them, Dr. Massee offered to make the necessary arrangements.

The discussion then turned to the conservation of species on the edge of their range. Dr. Satchell said that in his talk, he wanted to show that if a species is conserved on the edge of its range, the problem of ensuring survival is much greater because it is unable to withstand a large degree of interference. But elsewhere, near the centre of the species distribution, a good deal of human interference can be tolerated without danger. He questioned whether the establishment of Nature Reserves for species on the edge of their range was worthwhile. Other members expressed a different point of view and gave as an example, the Large Blue butterfly, an insect which should be conserved although it is on the edge of its range in this country.

EXTINCTIONS AND INVASIONS - SOME CASE HISTORIES AND CONCLUSIONS

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SUMMARY

The concept of a British invertebrate fauna as a static entity is inconsistent with the facts of its history. Evidence of the transitory nature of its composition is provided by the fossil record and by changes in species distributions within the last century.

Inspection of the case histories of extinction or near extinction of the few species adequately documented suggests wide changes in recent years in the balance between arctic/alpine and continental components. In Britain, continental species, because they are on the edge of their range, are particularly vulnerable to climatic change and, in the long term, are not a good conservation risk. An international approach is suggested whereby conservation measures for a species needing protection would be taken towards the centre of its range. Arctic-alpine species would be a special responsibility of Britain.

I. INTRODUCTION

Two aims of invertebrate conservation may be distinguished: (1) the maintenance of diversity; (2) the protection of particular species. If the former is the primary aim, attention will be concentrated on the effect on invertebrates of large-scale changes in land use, general measures such as insecticide control and the preservation of a representative series of plant associations. In practice, invertebrate conservation will be largely incidental to 'amenity' preservation and to the management of nature reserves selected mainly for botanical reasons. The limited public appeal of invertebrates may dictate such a policy.

A policy of preserving particular species requires a defined basis for their selection and criteria for judging where conservation measures are mostly likely to be effective. This paper offers evidence on these latter points from species which in Britain have become extinct or nearly so and from other species which have survived severe disturbance of their habitats.

II CHANGES IN THE COMPOSITION OF THE INVERTEBRATE FAUNA

(A) THE FOSSIL RECORD

The fossil shells of Mollusca provide evidence of invertebrate history in Britain since the late-Glacial.

The illustration given (Fig.1) shows the species sucession from the sub-Boreal to historic times from a site on the North Downs. The succession starts in the Mesolithic with a community indicative of wet closed woodland with shade-loving species e.g. Carychium tridentatum and Discus rotundatus, and marsh species, e.g. Limnea truncatula and Succinea oblonga dominant. During the Neolithic and apparently associated with forest clearance the woodland species gave way to grassland species, at first of a kind that avoids bare downland and then, during a dry period, to xerophils such as Vallonia excentrica and the now extinct Monacha cartusiana. Helix aspersa, a now common species, arrived probably from the European mainland at about 250-300 A.D. Monacha cantiana, now generally distributed, arrived apparently in the Roman period.

A similar pattern of change is evident from fossil Coleoptera.

(B) RECENT CHANGES

(1) Changes associated with climatic trends

(a) The near extinction of the wood ant, Formica lugubris in Ireland. The history of F. lugubris in Ireland provides an example of the extinction of a species for reasons apparently unconnected with human activity. On the mainland, this wood ant is an upland and northern species generally confined to areas over 1000 feet above sea level in Wales, the Pennines, the Cleveland Hills, the Lake District and the Scottish Highlands. In Ireland it occurs only in the south where also it is found mainly in upland areas (Fig. 2). It has been recorded from 17 sites, the earliest records dating from the mid-nineteenth century and the majority from the 1920s. Since then, the species has virtually disappeared, only one colony, the most northerly one, remaining in 1963. On one site, the wood had then been felled while the remaining fifteen were unchanged (Collingwood, pers.comm.). No colony extinctions have been reported from Britain.

It will be seen from Fig.2 that all the extinct colonies lie on the warmer side of the 42° January isotherm while the surviving Irish colony and the British colonies are on its colder side. The extinct colonies were in the part of the species range in the British Isles which had the warmest winters. Moreover, during the period when the colonies died out, winter temperatures were above average for a longer period than at any time since the 1730s and before that, since the 'little climatic optimum' of the medieval period (Fig.3, Lamb 1965, Manley 1965). The allied species, Formica rufa, fails

Sequence of Mollusca at Devil's Kneading Trough adapted from Kerney et al. 1964.

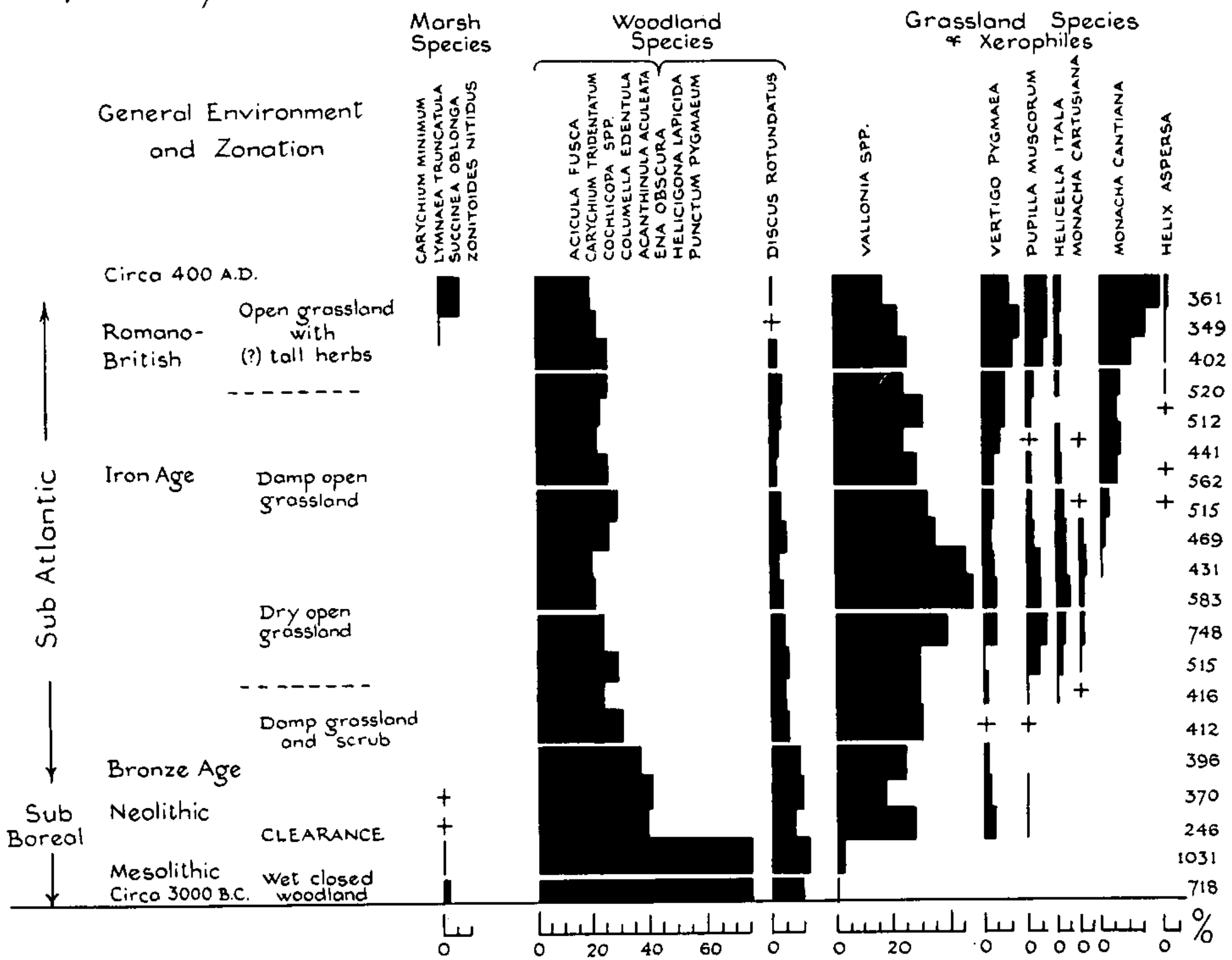
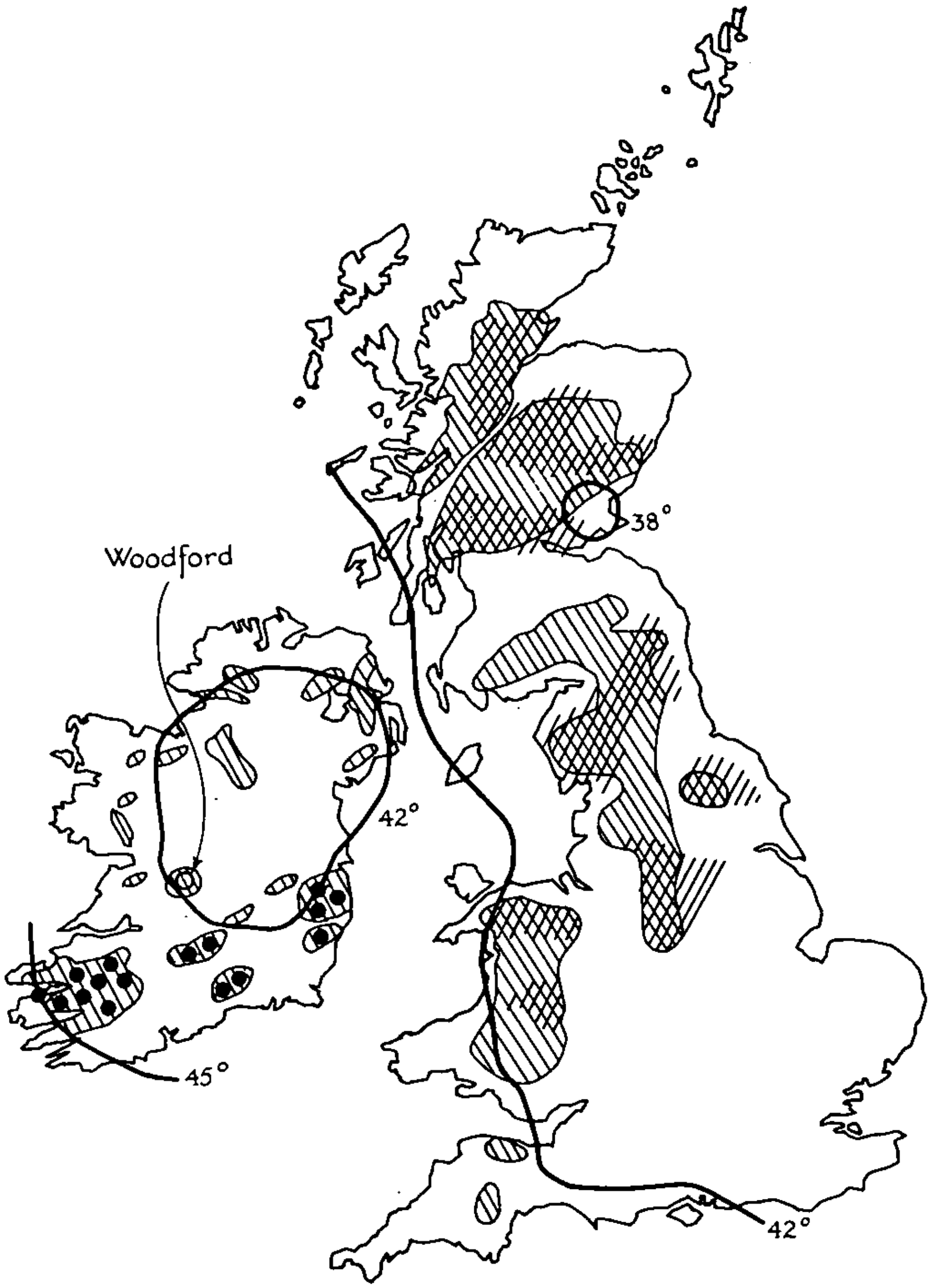


Fig. 1

Distribution of the Wood Ant Formica lugubris



— Isotherms °F January means 1901 30

Uplonds over 1000 feet approx.

//// Vice County distribution

● Extinct colonies O Surviving Irish colony.

Fig. 2

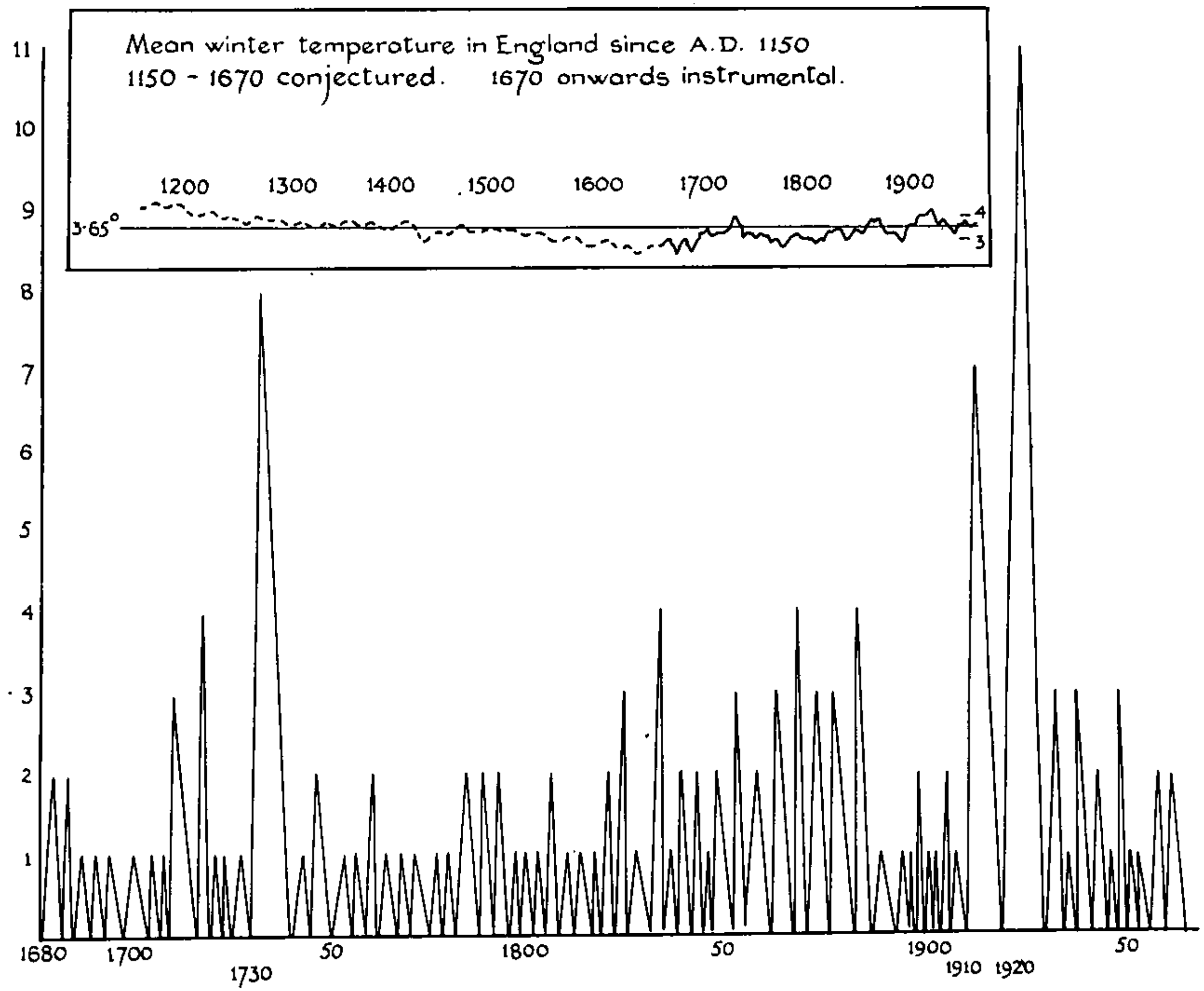


Fig. 3. Number of successive winters with mean winter temperature (Dec. - Feb) above the average for 1681 - 1963

to produce sexual forms when kept under isothermal conditions (Gosswald and Bier 1954). Collingwood (1958) suggests that a similar reproductive failure caused the disappearance of F. lugubris in Ireland and quotes in support an observation of Stelfox that he found no sexual forms in colonies in Wicklow visited in the years 1921-26. If this explanation is correct, it seems that F. lugubris must have arrived in Ireland since the medieval period as it could hardly have survived the mild winters of the twelfth, thirteenth and fourteenth centuries.

(b) Changes in the distribution of certain Lepidoptera. A possibly comparable case is that of the Mountain Ringlet, Erebia epiphron, described (Ford, 1946) as 'our only truly Alpine butterfly'. It was recorded in Sligo and Mayo at the turn of the century but is now apparently extinct in Ireland and survives only in the Lake District and Scotland.

The moth, Hyppa rectilinea, a northern species with a range extending to Siberia, was at one time found in Yorkshire but has likewise withdrawn northwards and is not now found south of Cumberland.

During the same period, several species with a southern and continental distribution have extended their range northwards e.g. the White Admiral, Limenitis camilla (Fig.4) or have established their first recorded breeding populations in Britain (Fig.5).

(c) Changes in the distribution of littoral species. Changes in sea water temperatures linked with the changes in air temperature referred to above are described by many authors. Lamb and Johnson (1959), from an examination of all the available data on Arctic ice, reported a long period of minimum amount in the north Atlantic from about 1920 to the late 1940s. Crisp (1965) calculated a shift of about 80 kilometres in the isotherms of the English Channel between the 1930s and 1950s. Corresponding with these sea temperature changes the distributions of northern littoral species have contracted and southern species have extended northwards.

Between the 1930s and 1950s, the kelp Laminaria ochroleuca and the hermit crab Clibanarius misanthropus extended their range from the coast of France to the south of Britain. The topshell Monodonta lineata extended northwards from Cardigan Bay to Anglesey while the northern dog-whelk Nucella lapillus retreated northward from the warmer parts of the Gulf of Gascony.

Between 1934 and 1951, the arctic-boreal barnacle Balanus balanoides all but disappeared from the south-west shores of Britain and its place was taken by the more southern species Cthalamus stellatus (Southward 1958). Within the territory common to both species, they monopolised almost the whole intertidal zone of exposed coasts and competed strongly for space. Extreme temperatures appear to have had little effect on the abundance of either species but whereas

B. balanoides can breed only after it has been pre-conditioned for several weeks at temperatures below 10°C., C. stellatus requires temperatures exceeding about 15°C in order to breed. Thus warm conditions favour Cthalamus and cold conditions Balanus, wherever they are in competition (Crisp 1965). The example further illustrates the risk of extinction of species at the edge of their range.

(2) Changes associated with exceptional weather

The distribution of many invertebrates though controlled in part by climate, may also be determined by short spells of extreme weather occurring very infrequently but persisting in their effects for many years. The winter of 1963, in the English Lowlands the coldest since 1740 (Lamb 1963), provides a good example of such effects on invertebrate populations.

(a) The effect of winter 1963 on littoral invertebrates. The effects of the extreme cold of the early months of 1963 on the littoral fauna of the coasts of Dorset to Hampshire, the Bristol Channel and Caernarvonshire have been reported by Crisp and co-workers (Crisp et al 1964). Although many species suffered heavy mortality, few suffered significant and pronounced changes in their range. In general, sessile forms were able to tolerate very low temperatures and those which were not able to tolerate low temperatures were able to move into the warmer sub-littoral. Exceptionally heavy mortality was nevertheless recorded in the oyster Anomia ephippium, the topshells Monodonta lineata and Gibbula umbilicalis and the crab Porcellana longicornis. The large topshell, Monodonta lineata was completely destroyed in Lyme Bay in South Wales and in Tremadoc Bay by the sudden onset of severe frosts, but as the populations of the more maritime promontories of south Devon, Pembroke and North Wales survived, there is no reason to suppose that the bays will not eventually be re-populated from these sources.

(b) The effect of winter 1963 on freshwater molluscs. The data of Fig.6 are from unpublished records of a naturalist with many years knowledge of the Mollusca of the Southwell district. They refer to nine freshwater bodies including three canals, two ponds, a lake and a river and compare the species of molluscs recorded between 1949 and 1963 with those recorded in 1964. Between 1949 and 1964, two of the sites had been filled in or drained. Of the 29 species which had been plentiful in one or another of the sites, only one, Planorbis leucostoma was still abundant in 1964 in any site. Fourteen species were still present but scarce and fourteen were not found in any of the sites. The list of species recorded from Cossall Canal was reduced from sixteen to seven. Sites which initially had few species had none in 1964.

The data may be compared with those of Boycott (1928) who recorded the molluscs present in 76 closed ponds in 1915 and again in 1925. From the 18 species occurring in the 76 ponds, Boycott made 168 species-pond records in 1915. In 1925, he made 93 new records, 108 were the same as in 1915 and 60 of the originals were not found.

The White Admiral (*Limenitis camilla*)

From Ford 1946

- ● Extension of range since 1920
- △ Distribution prior to 1920

Fig. 4

Breeding populations of moths 'New to Britain' established 1939-62.

	Distribution
1. Lithophane leautieri	S. France, Spain, N. Africa
2. Eupithecia phoeniciata	S. France, S. Spain, Italy, N. Africa
3. Eupithecia millefoliata	Central & S. Europe, Asia Minor
4. Hydraecia hucherardi	France
5. Xanthorhoe biriviata	France, Central & E. Europe to Siberia
6. Calamia tridens	Europe, Finland, Italy, Caucasus
7. Sedina büttneri	N. Europe, France to Poland
8. Eupithecia egenaria	

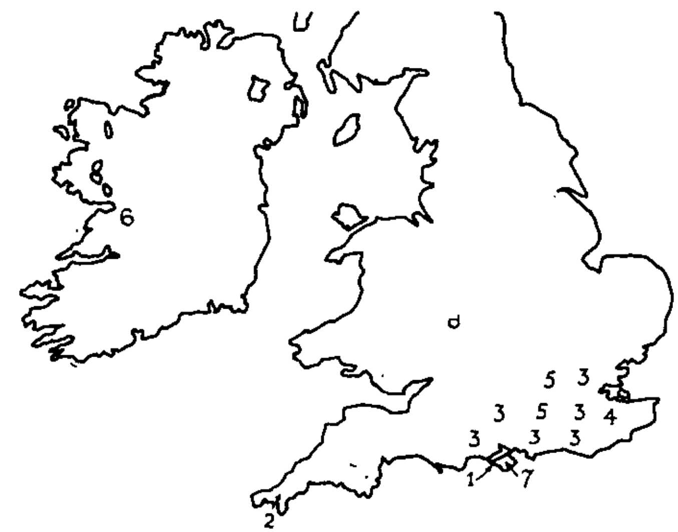


Fig. 5

Effect of winter 1963 on some freshwater molluscs in Notts & Lincs.

SPECIES RECORDED AS PLENTIFUL 1949-1963	Catchment Drain Lincoln	River Witham	Cossall Canal	Clumber Park Lake	Old Bilsthorpe Pond	High Wood Pond	Railway Cutting Southwell	Trent Canal Shardlow	Nottingham Canal	
	STATUS IN 1964									
Planorbis leucostoma	Abundant									
Sphaerium lacustre					S					15 Species
Lymnaea stagnalis			S							
Planorbis vortex			S							
Anodonta cygnea			S							
Anodonta anatina			S							
Segmentina complanata				S						
Sphaerium corneum				S						
Physa fontinalis		S		S						
Planorbis contortus		S								
Lymnaea peregra		S	S	S						
Planorbis carinatus		S	-							
Viviparus viviparus		S	-							
Planorbarius corneus	-	S								
Bythynia tentaculata	-	-								
Viviparus fasciatus	-	-								
Unio pictorum						Drained			Filled in	14 Species
Unio tumidus										
Sphaerium rivicola										
Pisidium amnicum										
Bythynia leachi										
Lymnaea auricularia										
Planorbis planorbis										
Planorbis albus										
Lymnaea truncatula										
Planorbis laevis										
Planorbis crista										
Physa heterostropha										
Dreissena polymorpha									-	

S = Scarce
\- = Not found

Fig 6

Distribution of lowland peat mosses north of Morecambe Bay.
— The habitat of Plebejus argus var mosseyi

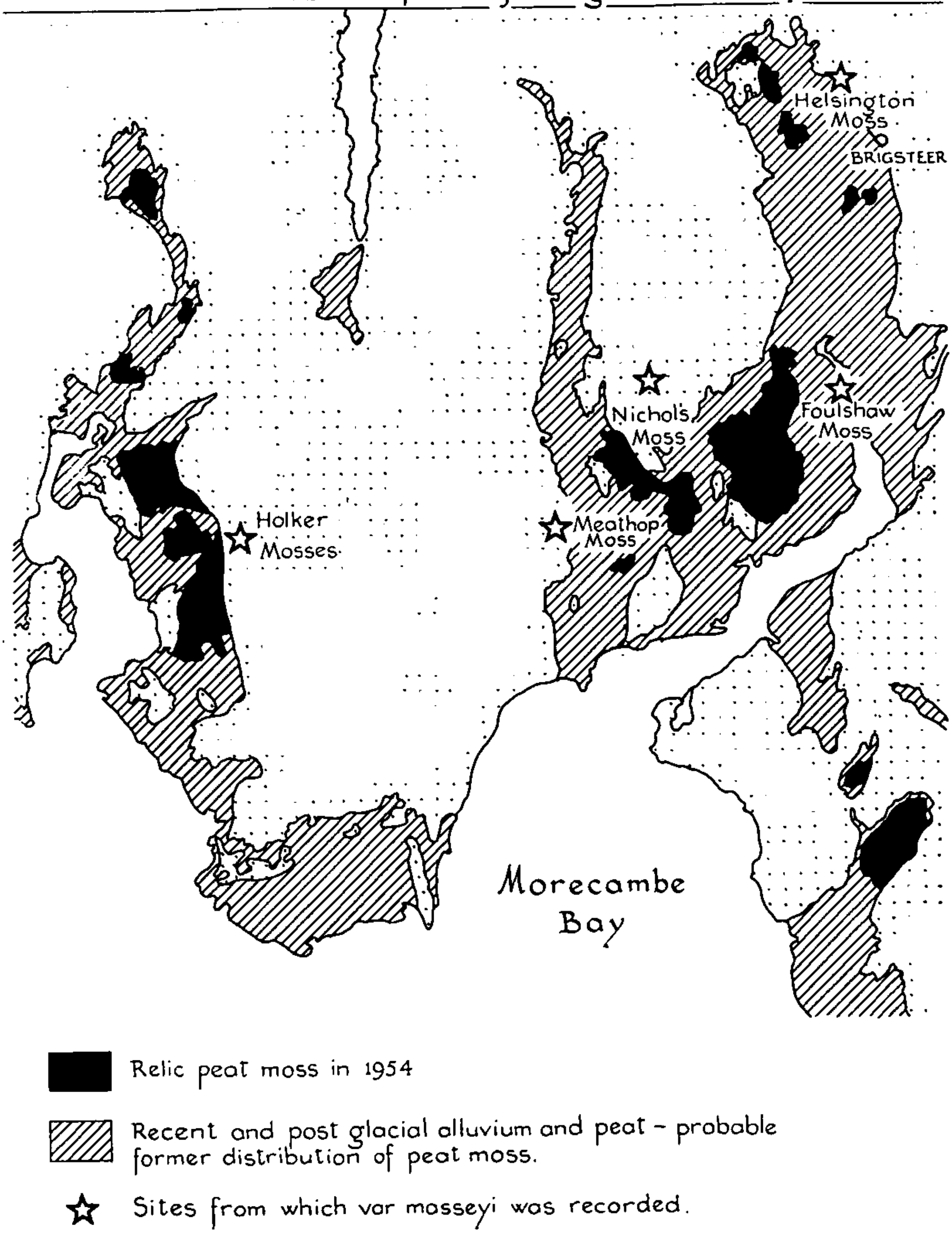


Fig. 7

Boycott concluded that there was a considerable amount of coming and going between ponds but any deficiency in the collecting technique would tend to give an exaggerated impression of such movement. In the Notts. and Lincs. data, only one species was found in 1964 which had not been taken from the same site before, whereas Boycott made more than half as many records again on his second survey. The impression is gained that the winter of 1963 certainly reduced and perhaps exterminated the mollusc populations of many freshwater bodies and that because of their greater isolation, their recolonisation is likely to be considerably slower and more fortuitous than in intertidal habitats.

(3) Interaction of habitat disturbance and exceptional weather
Although exceptional weather may alter the balance of invertebrate populations for many years and perhaps for many decades, it seems unlikely that exceptional weather, outside the range of what has been experienced by the fauna since the post-glacial, will now cause the extinction of any native species. Many species however, must now be at risk because the extent of their habitat has become too small to provide refuges from which they could be recolonised. The extinction, or near extinction, of the race masseyi of the Silver Studded Blue (Plebejus argus) illustrates the process.

(a) The disappearance of var. masseyi of the Silver Studded Blue. The race masseyi of this butterfly is distinguished mainly by large patches of blue on the wings of the female which in the typical form are brown. Its recorded distribution is restricted to the so-called mosses or lowland mires of Morecambe Bay, particularly Meathop and Holker Mosses where it was much sought by collectors. It was last recorded on these mosses in 1921 when, in the third week of May when the larvae would be nearly fully fed, there was an exceptionally severe late frost. An eye-witness account (Wright 1942) describes how all the vegetation on the mosses was blackened up to a height of about nine feet while on the crags about thirty feet above, the vegetation was hardly affected. Unless it is supposed that this event was unprecedented, the question arises how var. masseyi survived previous late May frosts. Although there is no published record of the former extent of these mosslands, the available evidence suggests that they originally occupied most of the valley and coastal areas shown on the Geological Survey map as alluvium (Fig. 7). In the Lyth Valley for example, scattered fragments of mosses, now tree-covered, remain as far inland as the village of Brigsteer where several families made a livelihood from peat cutting within the last half century. At this point, the moss would have been well above the level up to which, near the coast, the vegetation was killed by the late frost of 1921. It may be supposed that in previous centuries, these valley heads provided the refuges from which, after similar frosts, the coastal mosses were recolonised. The butterfly has in fact been recorded twice since 1921, although not within the last twenty years - on both occasions from points on the inland side of the remaining mosses.

The case has practical interest in that Meathop Moss has now been made a local Nature Reserve, largely for entomological reasons. Although at one time the best known locality for var. masseyi, its earlier declaration as a reserve would not have prevented the butterfly's extinction.

(4) Survival in relation to range

From the examples quoted above of the ant Formica lugubris in Ireland, the barnacle Balanus balanoides on the coasts of South-West England and from the similar case of the Scotch Argus butterfly in Northumberland, Durham, North Yorkshire and Westmorland, it is evident that northern species are liable to extinction at the southern end of their range when human pressure is slight or even absent. The same is true of southern species at the northern end of their range.

The slow erosion of populations of the mollusc Ena montana (Fig.11) in southern England where it reaches the North-West limit of its European distribution, is in part attributable to the gradual disappearance of old woodland and in part to its failure to colonise new woods, even those planted in the eighteenth century which now form apparently suitable habitats (Boycott 1939). Many other species well known to be at risk in Britain e.g. the Large Copper butterfly, the Large Blue butterfly, the spider Ereseus niger, the snail Monacha cartusiana are likewise at the extreme northern edge of their range although some of these are also subject to human pressure.

A number of southern species of moths which had recently established breeding populations in Britain were cited earlier. As colonists at the edge of their range it would be surprising if they survived for long. The resistance of climatic and biotic pressures against such invasions is illustrated by the history in Britain of the American Tingid bug Stephanitis rhododendri. First recorded in Britain in 1901, its distribution in 1939 (Fox-Wilson 1939) was as shown in Fig.8 but is now apparently reduced to a few sites in South-East England.

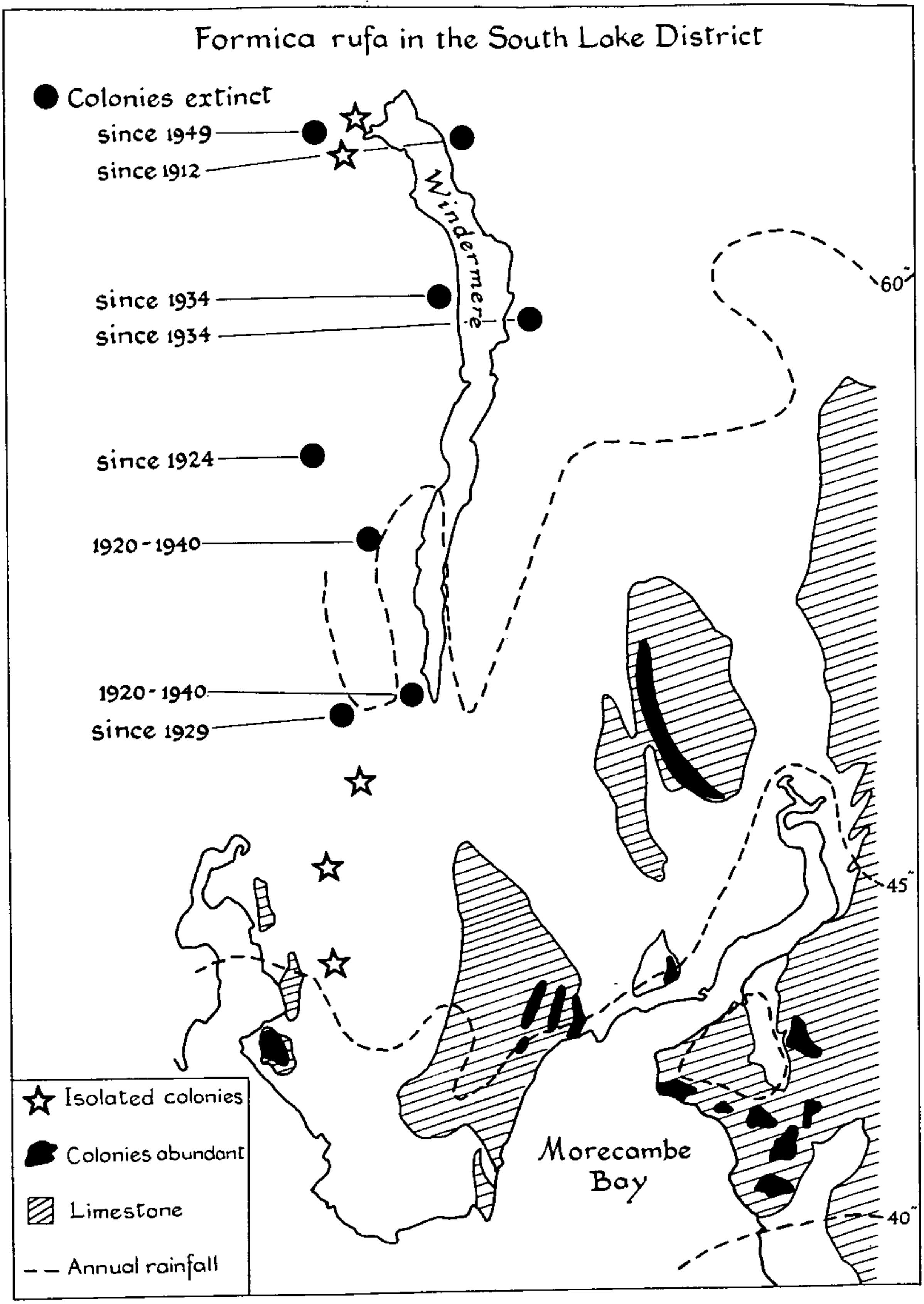
The susceptibility to extinction of species at the edge of their range contrasts with the pressure many species seem capable of withstanding near the centre of their range. The recent history of the wood ant Formica rufa near the northern end of its range in the Lake District and in South-East England provides an example.

(a) The effects of habitat disturbance on the wood ant Formica rufa on the edge and near the centre of its range.

Apart from some colonies near Keswick, F. rufa reaches the North-West limit of its distribution in Britain in the area around Grange-over-Sands and Windermere. It occurs there in abundance in woodlands on Carboniferous limestone and in a few scattered colonies on the

Distribution of
Stephonitis rhododendri in 1939
introduced from Europe
in 1901 [Fox-Wilson 1939]

Fig. 8



Formica rufa in the South Lake District
Colonies extinct
since 1949
since 1912
Windermere
since 1934
since 1934
since 1924
1920 - 1940
1920 - 1940
since 1929
60"
45"
40"
Morecambe Bay
Isolated colonies
Colonies abundant
Limestone
Annual rainfall

Fig. 9

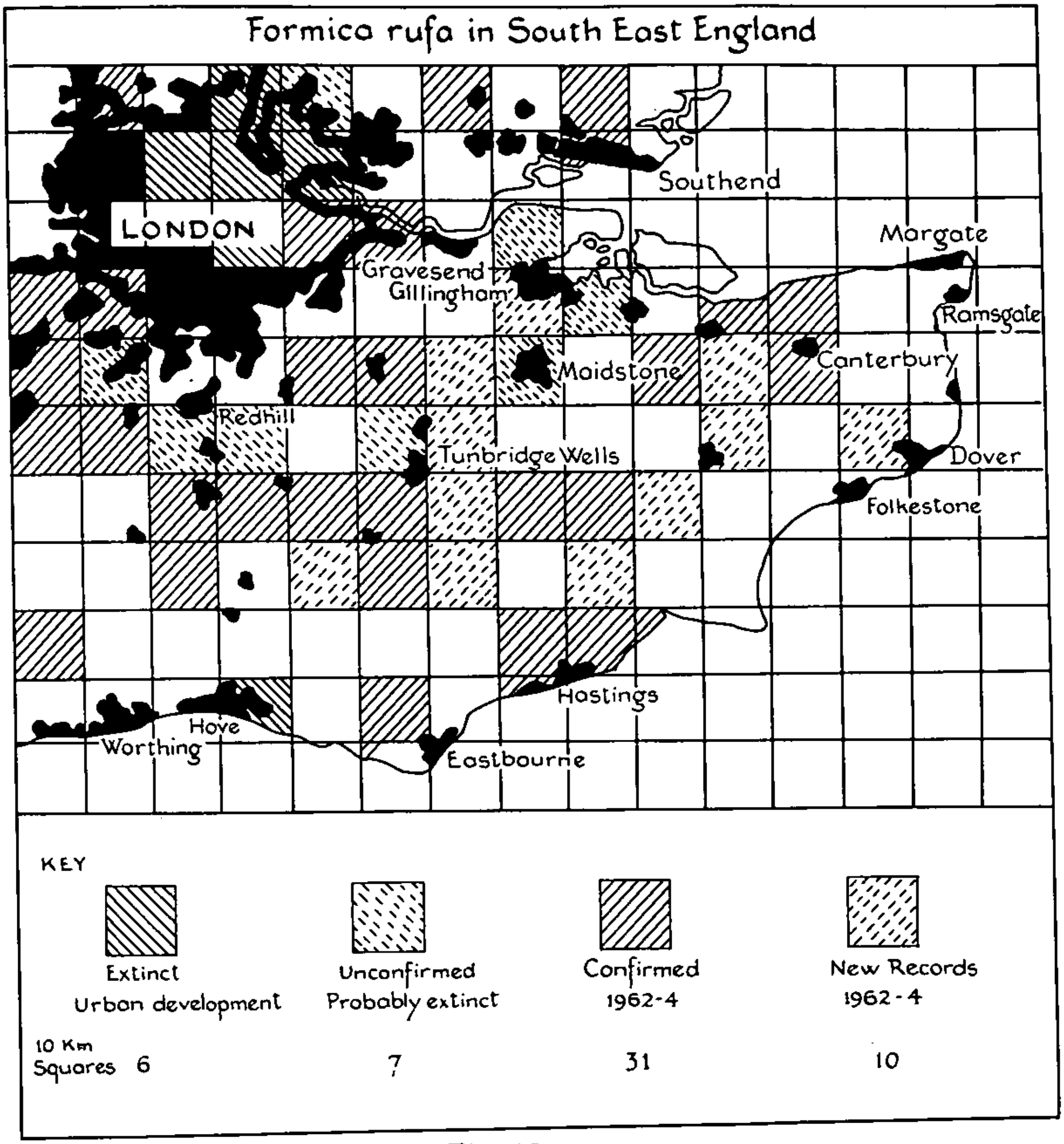
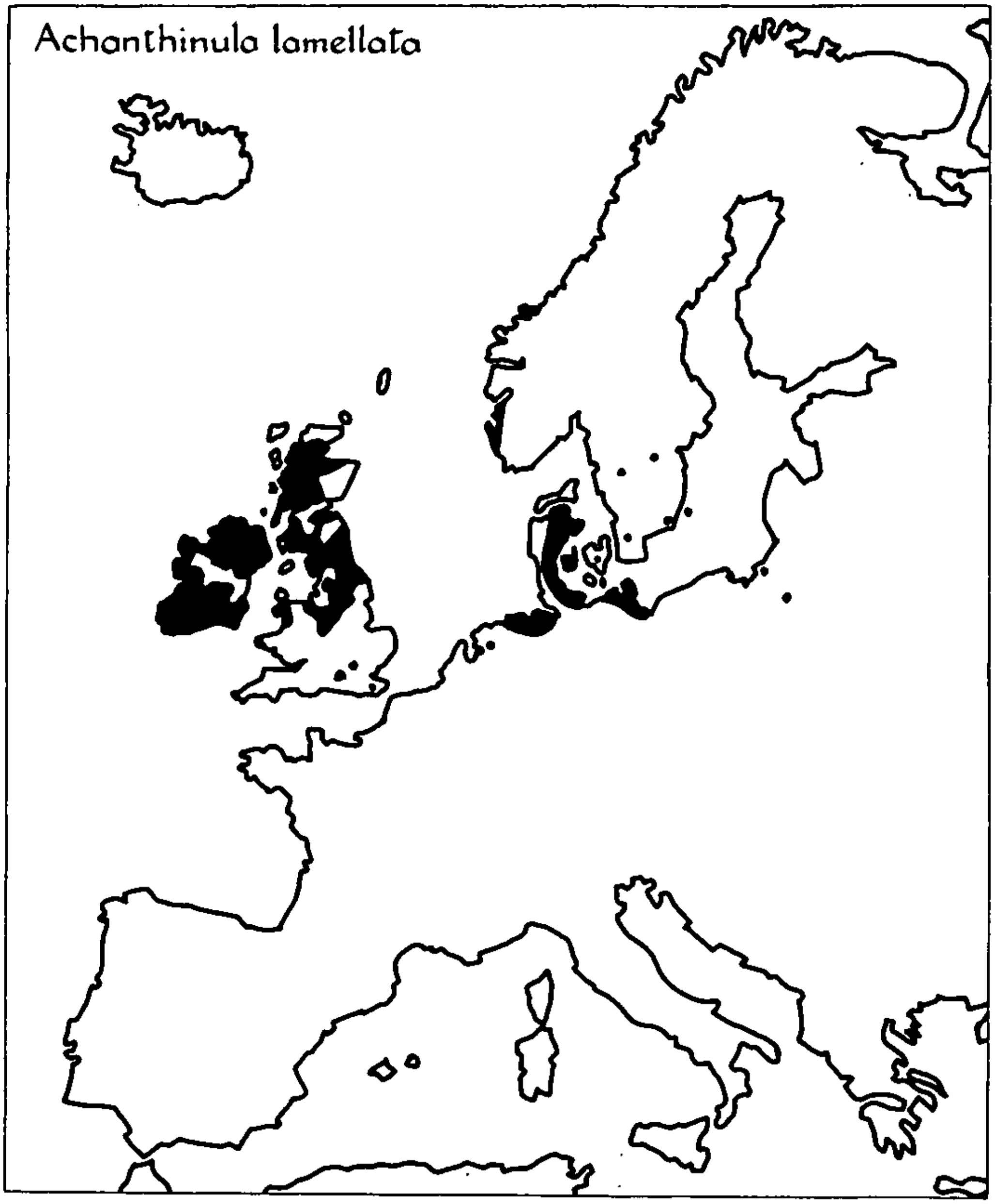

Formica rufa in South East England
LONDON
Southend
Margate
Gravesend
Gillingham
Ramsgate
Maidstone
Canterbury
Redhill
Tunbridge Wells
Dover
Folkestone
Hastings
Hove
Worthing
Eastbourne
KEY
Extinct
Urban development
Unconfirmed
Probably extinct
Confirmed
1962-4
New Records
1962-4
10 Km
Squares 6
7
31
10

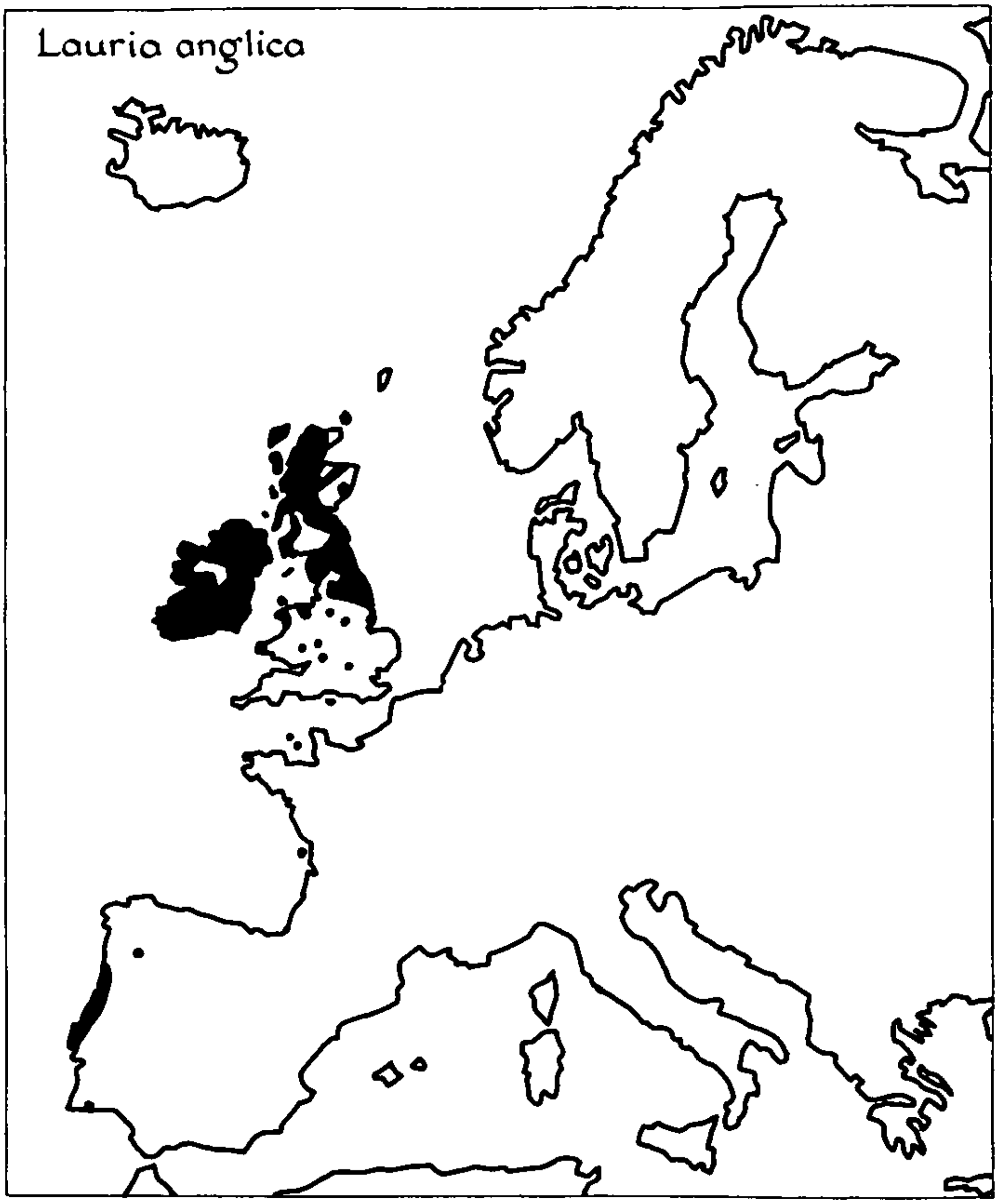
Fig. 10

Distribution of *Mollusca* as a factor in selecting areas for their conservation. (*Maps a-f*) (Maps from Kerney unpublished)



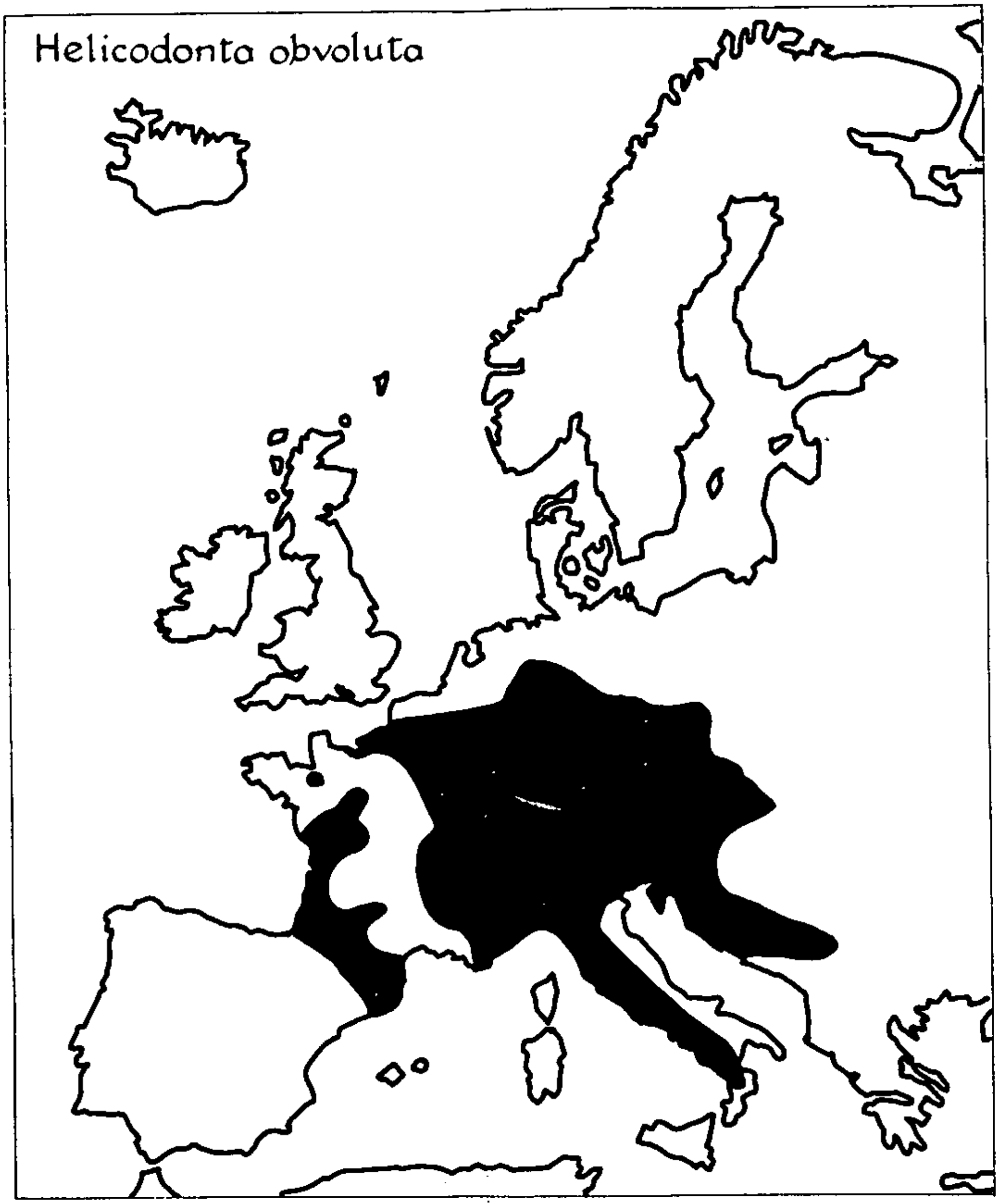
Appropriate for conservation in Britain

Fig. 11 a

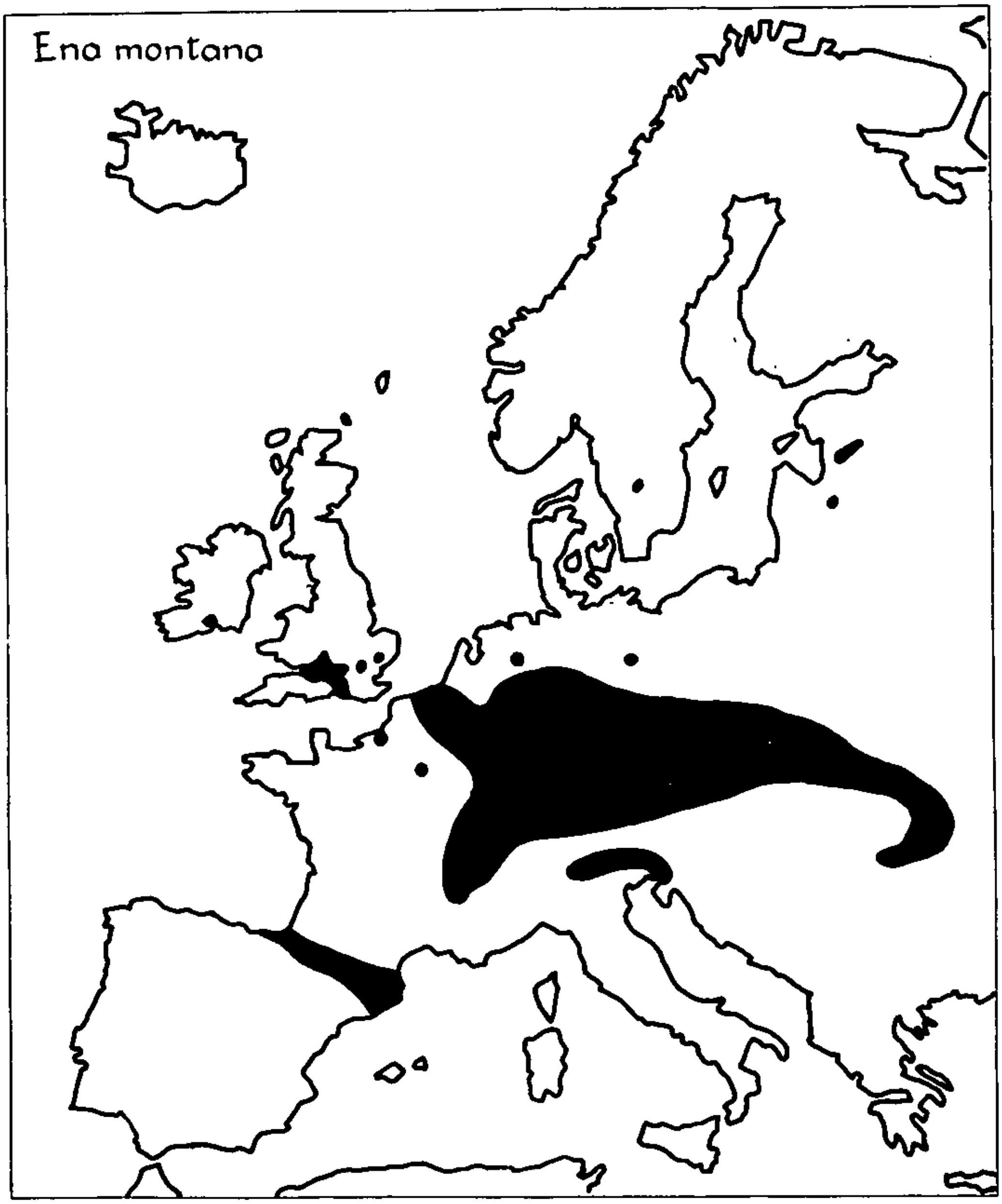


Appropriate for conservation in Britain

Fig. 11 b

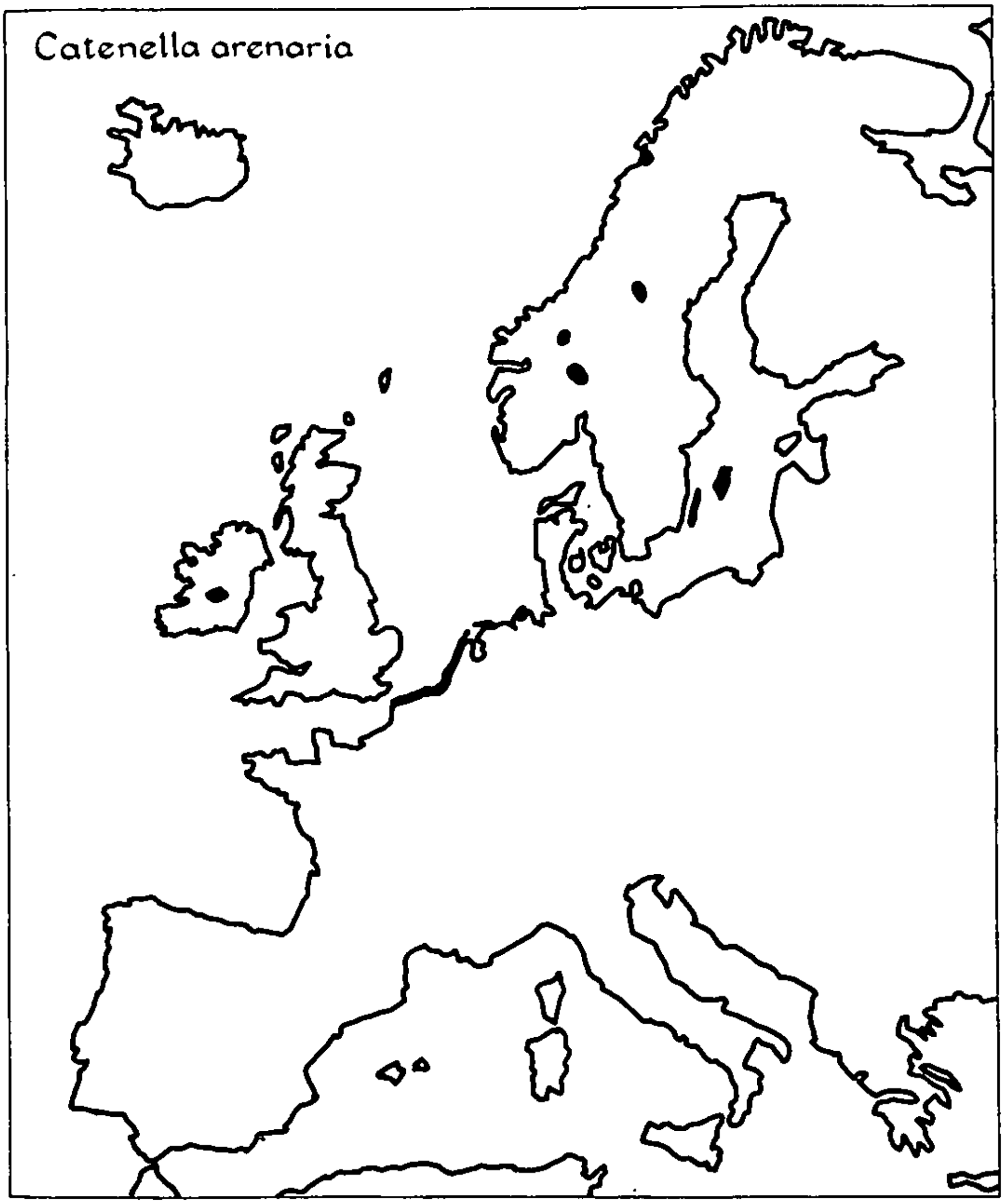


Conservation in Central Europe more appropriate
Fig. 11 c



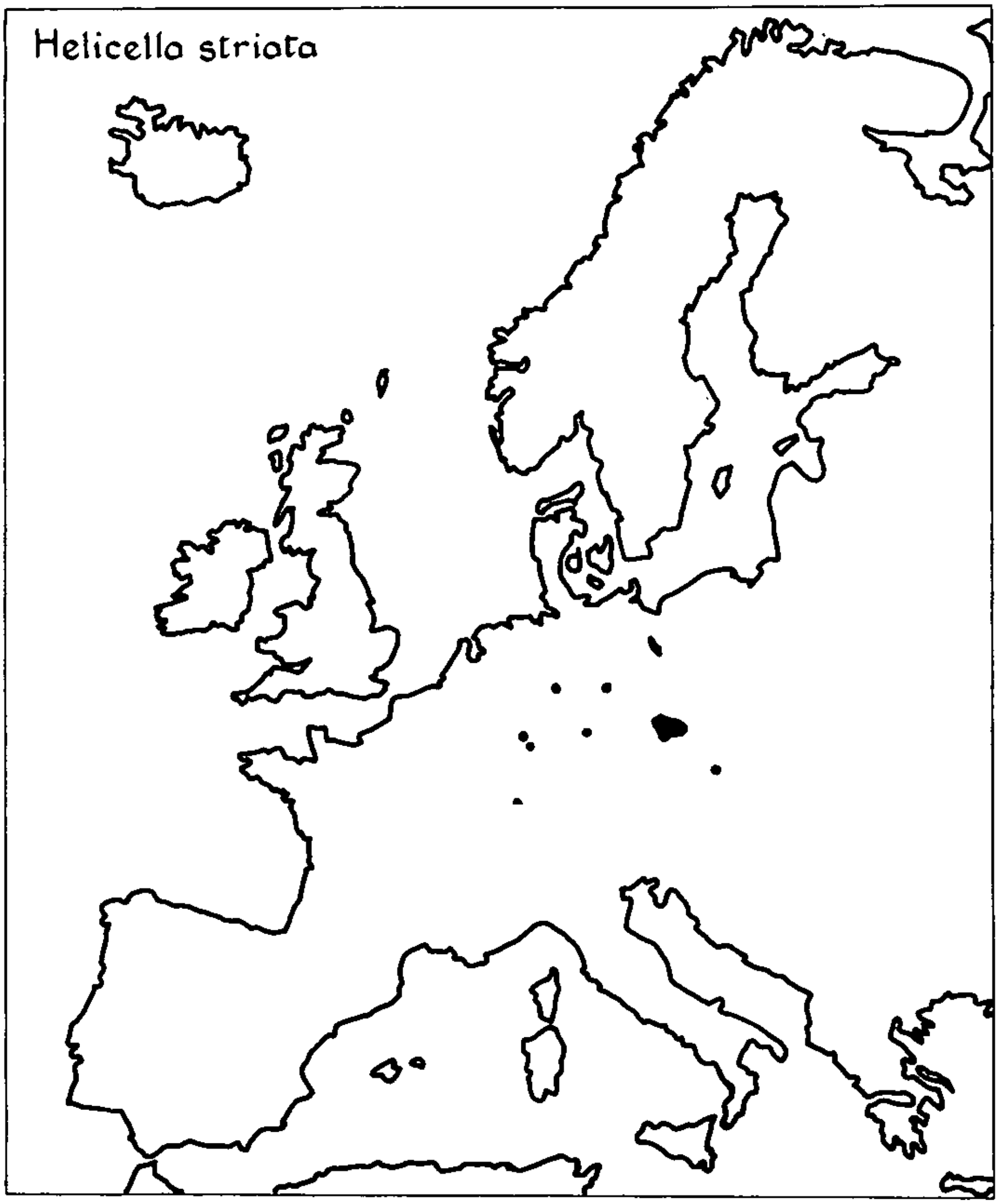
Conservation in Central Europe more appropriate

Fig. 11 d



Conservation desirable wherever possible.

Fig. 11 e



Conservation desirable wherever possible

Fig. 11 f

Silurian slates to the north (Fig.9). In the woodlands near Windermere it was however at one time more abundant and a number of formerly flourishing colonies have become extinct during the present century. The woods themselves still exist but the canopy has been broken for extraction of the larger timber during the two World Wars. With the decline in demand for native hardwoods, little has been done to restock these woods and as many are grazed there is little regeneration. On the limestone this has left large well-isolated clearings but in the Windermere area, in the woods on acid soils, the clearings have been invaded by dense growth of bracken. The extinction of the colonies on these sites has been attributed (Satchell and Collingwood 1955) to the spread of bracken through the reduction of direct insolation of the ground layer which is essential for the ants' foraging activity.

In the area of South-East England, illustrated in Fig.10, valid records of F. rufa had been made before 1960 from 44 sites. In 1960-64 these were examined by Barrett (1965). Of the older recorded sites six, five in London and one in Hove, had been built over. F. rufa was not found in a further seven sites on the outskirts of Tunbridge Wells, Maidstone, Gillingham, Reigate, Leatherhead and Woodford and these colonies too are probably extinct from urban development. In 31 ten km. squares, the continued presence of the ant was confirmed and in ten additional squares, it was recorded for the first time. F. rufa is apparently flourishing in this part of Britain, other than on sites which have been totally destroyed, and can evidently withstand the intense human pressure for which the area is notorious. Its ability to survive such pressure near the centre of its range is supported by the record (Yarrow 1934) of F. rufa from Kensington Gardens as late as 1831. The situation contrasts markedly with that in the Lake District where relatively minor disturbance of the ants' habitat has resulted in its extinction over a large area.

(b) Survival of the Aculeate Hymenoptera of Hampstead Heath. Perhaps the best documented analysis of the effect of urban pressure on an association of invertebrates is that of the aculeate Hymenoptera of Hampstead Heath by Guichard and Yarrow (1948) and Yarrow (1954). These authors listed 49 species which had been recorded in the nineteenth century but not since. Sufficient information is available on 27 of them to assess their probable significance and of these, 12 were either doubtful records, were probably vagrants or have been rediscovered. Of the other 15, 3 appear to have gone with their host plants, one with the disappearance of its nesting site and 11 parasites and predators with their insect hosts. If the 22 species unaccounted for are similarly apportioned between probably doubtful and probably reliable records, the number of species which has really disappeared in this period seems to be about 30. Added to the 150 authenicated records of the present century, this would suggest a loss of not more than about one sixth of the aculeate Hymenoptera of the Heath. The Heath of a century ago was surrounded by fields. It is now surrounded by suburbs, nowhere connected to open country. The survival of five sixths of this insect fauna under the intensity of urban pressure characterising Hampstead Heath, indicates a degree of resilience which, though never doubted by agricultural entomologists, is sometimes under-estimated by conservationists. It suggests that in the conservation of invertebrates in nature reserves, protection against human interference may be of less consequence than the proper siting of the reserve in relation to the climatic demands of the species it is desired to protect.

III CONCLUSIONS

In the present state of invertebrate conservation research, the kind of case histories cited form one of the few available sources of guidance in the formulation of an invertebrate conservation policy. They suggest the following provisional conclusions:-

(1) The invertebrate fauna of Britain is not a static entity but contains elements from diverse sources which are subject to changes in density and distribution.

(2) One cause of such changes is variation in climate and weather. Species which are on the edge of their distribution in Britain are particularly susceptible to such variation. There may be scientific grounds for conserving them if they form genetically distinct populations or non-scientific grounds in the case of 'rarities' valued by naturalists. But efforts to conserve them cannot in the long run be expected to succeed unless their habitat is sufficiently large and varied to provide refuges from unusual weather and climatic trends. Nature reserves for such species would generally need to be large, of the order of several square miles, to provide both the refuges and the continuity of habitat necessary to permit re-dispersal from them.

(3) Another cause of such changes is habitat disturbance by man. Some of the species whose existence in Britain is threatened by habitat destruction are also species at the northern end of their range. It follows that preservation of samples of their habitats as nature reserves cannot be expected to secure their protection unless the reserves are very large as indicated above. A number of fenland, heathland and chalk grassland species fall into this category.

(4) As a converse of (3), populations of species near the centre of their range generally appear remarkably resistant to human pressure short of total destruction of the habitat.

(5) The logical place to conserve any species is where conservation measures are most likely to succeed i.e. towards the centre of the species' range. This implies an international approach aimed at conserving species with, for example, a mainly Continental European distribution in Continental Europe and Mediterranean species in Mediterranean countries.

(6) In the context of such an international policy one of the special responsibilities of Britain would be the conservation of Arctic-Boreal species. It would be a practical advantage that these occur in the northern and highland areas least subject to land pressure. More could be achieved of international scientific value by concentrating on conserving these species than by attempting to preserve southern species against the odds of climate and land demand.

(7) There is a source of information on the invertebrates for which conservation measures are desirable in the taxonomists and specialists in particular invertebrate groups. Provisional lists of species of particular scientific interest, e.g. species with special evolutionary significance; with relict distributions; with special habitat requirements; with peculiar life histories - could be drawn up, group by group, by small meetings of specialists on an international basis.

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INVERTEBRATE CONSERVATION

AND

MANAGEMENT PLANS

E. Duffey

At the present time, 69 management plans have been completed by the Conservancy and several others are in the course of preparation. A recent analysis of the 550 research projects listed in these plans as "in progress" or "proposed" show that 47 are in the former group and are concerned with invertebrate investigations. Of this small total, 56% are by scientists not in the Conservancy, 31% by Conservancy scientific staff and 12% by research station staff. Only a small proportion were planned specifically in relation to management studies. A further analysis of the 47 projects in relation to (a) habitats and (b) invertebrate groups, is as follows:-

(a)

Coastal	Uplands	Mountain	Lowland Grass Heath	Wetlands	Woodland
13%	4%	2%	25%	23%	33%

(b)

Insects	Freshwater animals	Non-insect groups	Unspecified
54%	2%	24%	20%

The only conclusion which one can draw from this is that the production of ecological knowledge on invertebrates on Nature Reserves is poor and apart from some of the work at Monks Wood and Furzebrook is not orientated towards management studies.

The presentation of invertebrate material in the earlier management plans is very poor, but improved with the introduction of the use of the Chart of Animal Habitats. The Chart is slowly being accepted and is proving of value as an assessment of the potential richness of the Reserve fauna and as a basis for interpreting existing lists of species recorded. This has been done in several cases by the Conservation Research Section using old records for which ecological data was not recorded at the time. We feel that a habitat analysis is a valuable preliminary for any zoological project on a Nature Reserve whether this is a general survey or a planned experimental study of a management problem. The designation of habitat categories can be supplemented with botanical information and in some cases, this may be very detailed. Where the information on plants and animals is comprehensive, it is possible to make a useful cross-reference between the Sections on the fauna and on the vegetation. The management of a Nature Reserve for invertebrates is essentially the maintenance of habitats although not all are of equal importance. For this reason, it is important to find out as much as possible about the fauna in each habitat category.

Comprehensive faunal studies of ecologically complex Nature Reserves are a formidable problem and require the services of many specialists including staff to maintain records and collections. Of the 21,000 (approximately) species of British insects, only about 5,000 are "accessible" in the sense that there are modern or older reliable keys available. Although a few National Nature Reserves are comparatively well known, none has the detailed knowledge available for Wytham Woods, Oxford. As an example of the value of relating habitat richness to animal communities the following may be taken. Woodwalton Fen and Wicken Fen are both well known entomologically and include a habitat range from woodland, scrub, reedbed, herbaceous fen to various types of water body. Scolt Head is an extensive dune system with some shingle formation. A habitat chart was completed for each Reserve and the species totals for several important orders of invertebrates are listed below.

	Woodwalton Fen	Wicken Fen	Scolt Head Island	
	66 Habitat categories	60 Habitat categories	23 Habitat categories (above H.W.M.)	
Lepidoptera	665	737	162	* (2187)
Coleoptera	750	1075	84	(3690)
Araneae	125	190	75	(600)
Mollusca	32	50	16	(101)
Odonata	17	25	0	(45)

* Totals of species recorded in Britain.

The figures for Scolt Head are probably the most accurate because it is relatively simple ecologically and has changed little since biologists first worked there. The two fens are much more complex ecosystems, more difficult to work thoroughly and have changed considerably since records of animals were first made.

Invertebrate studies designed in relation to management problems should be carefully selected to avoid the danger of finding that one has to sort through an immense amount of material which cannot be identified without specialist help and a great deal of time using keys. Two useful methods which produce valuable results are:-

(a) the selection of a few, or perhaps only one, species of special interest which can be studied intensively in relation to habitat and the environmental factors influencing numbers and behaviour.

(b) the selection for special study of the animal community of a habitat which is of importance in management work because it is extensive, vulnerable in some way to outside influences or has been artificially maintained for a long period by some form of exploitation.

Single species studies which can be illustrated by reference to the work on the Large Copper are of special value because they demonstrate the ecological significance of certain components in the habitat in which the species lives. This opens the way to other types of management studies involving the co-operation of other disciplines. Examples of species which deserve intensive studies of this type are the Black Hairstreak butterfly which feeds on blackthorn; the Large Blue butterfly which Mr. Hunt is to tell us about; certain dragonflies which Dr. Moore has studied and numerous species which can be selected from less well known orders.

The Large Copper butterfly is particularly valuable for study because it occurs only on Woodwalton Fen and has a single foodplant, the Great Water Dock. The population of this insect (as measured by number of adults emerged) since 1953 has varied between 60 and 250, although in most years it is about 100-120. The natural distribution of the foodplant is along the edges of waterways which at Woodwalton Fen, are artificially constructed dykes. In such places, the dock grows into a large, vigorous plant. The insect does not like such plants for egg-laying; the optimum conditions for this part of the life cycle are not the same as the optimum conditions for the growth of the foodplant. The eggs are usually laid on smaller plants away from water and in surrounding vegetation which does not smother the water dock. The presence of the foodplant on its own is not enough to maintain the insect; it must be growing in a particular habitat. The identification of this habitat and the methods of preserving or recreating it is therefore the first step in ensuring the survival of the insect. This leads to a study of water table fluctuations and their control, germination conditions required by the dock seed and the factors affecting the growth of the young plants.

Another aspect of the study of this species concerns population dynamics. The eggs hatch in late summer, and after feeding for a little while, the first and second instar larvae move to the dead leaves around the base of the plant and hibernate until the following spring. During this period mortality is high and after feeding recommences in the summer the surviving larvae may be heavily parasitised by a tachinid fly Phryxe vulgaris. The conservation problem arising from this is to decide how large the population must be to avoid extinction. The number of eggs laid each year is very variable:-

	1960	1961	1962	1963
Number of eggs laid	1,500	1,700	3,800	10,900

In captivity, females can lay an average of about 350 eggs although as many as 600 have been recorded. Since 1960, the number of eggs laid per female on the Fen has averaged 72 (20.5% of average total in captivity).

The figures are as follows:-

	1960	1961	1962	1963
Average number of eggs per female on the Fen	24	68	69	126

The percentage survival of larvae after winter mortality is generally very low:-

	1960/61	1961/62	1962/63	1963/64	1964/65
Wild colony	6.4%	10.0%	3.5%	1.7%	3.1%
Caged colony	4.3%	17.1%	3.1%	1.0%	-

The traditional method of maintaining this butterfly since its introduction in 1928 is to collect the young larvae emerging in the spring and place them on foodplants in muslin cages where they are protected from predators and parasites. Since 1961 however, a population of Large Coppers has been maintained in another part of the Fen where no protection is provided. The comparative figures for survival are as follows:-

% survival of larvae after spring emergence to pupation

	1960	1961	1962	1963	1964
Wild population	-	38%	9.5%	9.0%	25.0%
Caged population	79%	77%	68.0%	82.0%	95.0%

We now have some evidence to show that, with the population at the level it has been maintained for many years, there is a strong risk of extinction if the larvae are not protected during the stage up to pupation, but we are also beginning to demonstrate that suitable habitats can be re-created in the Fen for the successful regeneration of water docks which develop into plants attractive to the egg-laying female.

Studies on the fauna of selected habitats can also be illustrated by reference to Woodwalton Fen. The Fen dykes were dug about 100 years ago for the transportation of peat. These waterways have to be cleaned out from time to time or else they soon become choked with vegetation. They form a type of water body not usually studied by freshwater biologists and because of their uniform width, depth and method of maintenance are very suitable for experimental work. Dr. Morris has been studying the development of the fauna in a newly constructed dyke and the influence on the aquatic bugs and beetles of the annual cutting of submerged and marginal vegetation in older dykes. The presence and quantity of dead plant material in the water has a significant effect on the composition and numbers of aquatic animals.

The main habitat studies of the Conservation Research Section during the last two years have been on the fauna of a type of Breck heath classified on the Animal Habitat Chart as "Open-ground formation", the vegetation being generally less than 6" in height. Many other types of vegetation can be included in this habitat category; chalk down, sand-dunes, upland pastures and some heathlands. They have the advantage for ecological studies of a simple and often uniform structure and a fauna with a limited number of species.

The main object of Breckland study is to assess the changes in the invertebrate fauna in relation to the almost complete cessation of rabbit grazing. Two study areas were chosen: (a) a thick uniform turf which has developed at Weeting Heath since myxomatosis; (b) very short vegetation, mostly lichens, mosses, small annuals, a little grass and with some bare ground and stones. Very distinct faunas can be demonstrated in these two sites and the surge of vegetation growth in recent years appears to have resulted in the loss of a number of species of animals which are more characteristic of the pre-myxomatosis Breck conditions. The material from the many samples taken is still being examined.

The second part of this work is to try to identify those components of the Breck habitat which have special significance for the survival of the more interesting species. Those parts of the habitat which have been studied are isolated grass tussocks, rabbit holes and scrapes, presence or absence of stones, presence of mobile sand, dung, isolated gorse and heather plants. The knowledge derived from this mosaic will then be compared with that obtained from the more comprehensive work on the two study areas. A few examples can be quoted from the work on Breckland spiders. Arctosa perita is a lycosid commonly found on coastal sand-dunes but on very few inland sites. On the Breck heaths, it occurs where there is exposed sand with scattered short vegetation. As soon as such areas become completely vegetated, it disappears. Two salticids, Attulus saltator and Euophrys aequipes also occur in similar habitats although the latter which is not typical of coastal areas may be found where there is no bare ground as long as the vegetation is short. Lithyphantes albomaculatus requires open sparsely vegetated habitats where there are stones, tussocks or isolated taller plants around which the web can be spun. The crab-spider Oxyptila scabricula is rarely taken away from dry heaths or dunes in this country and is often associated with rabbit holes or scrapes.

SUMMARY

(i) There is still very little known about invertebrate faunas on Nature Reserves. Much primary survey in relation to a habitat classification is required. The use of the Chart of Animal Habitats is a valuable preliminary to invertebrate studies on Nature Reserves and in ecologically complex areas, may be essential.

(ii) The large number of invertebrate species and the shortage of specialists means that management research projects must be carefully selected. Two useful methods are detailed studies on a few, or a single species, with special reference to ecological requirements in relation to the Reserve as a whole and studies on the fauna of a habitat selected because it is of special significance for conservation purposes.

(iii) The accumulation of ecological knowledge of this type for a range of habitats within for example, the Open-ground Formation, will illustrate the effects of management treatments such as grazing. It will also reveal those species which are of value as indicators of particular ecological conditions in the environment, and the pattern of animal communities in relation to the distribution of habitats should emerge.

Summary of Discussion

A member asked whether the Large Copper suffered from the same degree of parasitism in Holland as it does in this country. Dr. Duffey replied that two species of ichneumon fly seemed to be the main parasites in Holland, but the parasite of the Large Copper on Woodwalton Fen had nearly always been the tachinid fly, *Phryxe vulgaris*. Dr. Dempster said that *Phryxe vulgaris* was extremely prolific and this had been demonstrated by his work at Monks Wood where the degree of parasitism by this fly on the Small Cabbage White butterfly is of the order of 15-20%. Referring to the situation in Holland, Dr. Duffey said that the Large Copper habitat in the Dutch fens is in an area which is extensively exploited for hay and reed. The dock plants on which the eggs are laid occur in small groups, sometimes separated by considerable distances, and when surprise was expressed to the Dutch entomologists that the insect could maintain itself under such conditions, they replied that scattered small groups seemed to be characteristic of the distribution of the Large Copper. Such dispersal may reduce the incidence of parasitism. Dr. Satchell said that if the Large Copper is not subject to the same tachinid parasite in Holland, then it could be argued that we should not attempt to conserve it in this country where it is in a different environment which may be particularly unfavourable. Dr. Duffey said that the Large Copper had existed without protection on other sites in this country and gave as an example Wicken Fen, where it thrived for several years without protection until Adventurers Fen was drained.

STATUS AND CONSERVATION OF THE LARGE BLUE BUTTERFLY, MACULINEA ARION L.

O. D. Hunt

INTRODUCTION

The status in Britain of the Large Blue butterfly has declined to a point where it must be asked:-

1. Will it survive without conservation?.
2. Can it be conserved?

With this in mind the Devon Trust for Nature Conservation decided in 1962 that a survey of the status of the species in Devon and Cornwall ought to be made, especially as its breeding grounds in these two counties were now generally thought to be the only ones of consequence remaining.

The Nature Conservancy was approached and steps taken to arrange for the organisation of any survey that might eventuate. Proposals for a two-year fact-finding survey were put forward to the Conservancy by a Joint Committee on which the Naturalists' Trusts for Devon and Cornwall, the Royal Entomological Society, the Society for the Promotion of Nature Reserves and the Nature Conservancy were all represented. A grant was obtained and the survey has now been under way during the years 1963 and 1964, while further work, now in train, will be continued during 1965 if support from the Conservancy is forthcoming.

This paper is presented as a brief narrative of what has been accomplished, summarising the position in the light of the data so far available.

LIFE HISTORY

The briefest reminder of the life-history of the Large Blue will serve to show that its survival depends entirely on the maintenance of a special habitat.

For part of its larval existence, the Large Blue is parasitic on ants of the genus Myrmica; Myrmica sabuleti and M. scabrinodis being the main host species in Devon and Cornwall. The eggs are laid on the flowers of wild thyme, Thymus drucei, on which the caterpillar at first feeds exclusively. Later it is adopted by the ants and taken underground into their nests for the sake of secretions from its honey gland which the ants are able to excite. It stays in the ants' nest from autumn to spring, feeding on the ant larvae, and pupates there, the imago emerging from underground in early summer.

THE SURVEY

BASIS AND PROCEDURE

At the start of the enquiry, very little up-to-date information was available about:-

(a) the extent of the Large Blue population in Devon and Cornwall;

(b) the confines of its breeding grounds.

However, the Royal Entomological Society's file on the Large Blue was placed at our disposal, in which the most valuable items were an account of a survey of the coastal area of a part of North Devon and North Cornwall carried out in 1948 by Captain R. A. Jackson and some correspondence extending into the 1950's relating to the efforts of a Devon landowner to protect the Large Blue on his property.

For later information, we were indebted to Mr. Alan Kennard who had made observations in the field during the seasons 1961 and 1962.

Of basic importance was an intensive research into the literature relating to the Large Blue by Mr. G. M. Spooner, Secretary of the Joint Committee, who not only carried out exhaustive enquiries in tracing and evaluating references, but corresponded with authorities, examined collections and collated data from many parts of the country. Addressing himself specifically to the reasons for the decline of the Large Blue in Britain, Mr. Spooner has embodied his findings in a valuable paper on this subject published in The Entomologist for September 1963.

The first requirement of the survey was to locate and define the present breeding grounds of the Large Blue and, if possible, estimate the population remaining therein. From early in the 1963 season therefore, operations were directed to an observational survey of regions within which the butterfly was known to have occurred and to the listing, with appropriate data, of all sites where the conditions appeared to be favourable for the species in respect to:-

1. the presence of the foodplant, wild thyme;
2. the presence of <u>Myrmica</u>, of determined species;
3. the presence of shelter in the form of ground configuration and suitable vegetation.

All available help was then deployed to watch these sites for the appearance of the butterfly and compile a record of the numbers seen, while one site was selected for an attempted census by marking all specimens captured throughout the season.

RESULTS

The summer of 1963 was wet, windy and cold and the numbers of Large Blue seen were probably influenced by this as well as by the fact that the previous season, 1962, had also been a very poor year in which very few Large Blues had been reported. Out of the 34 locations where the survey had judged conditions to be suitable for the Large Blue, only 13 produced records in 1963 and the total number recorded throughout the flying period was only 85, two of the sites accounting for more than half of this total. The best site yielded only 27 so that even there the species appeared to be at a low ebb, while at most of the sites the impression was of nearness to vanishing point.

Colour marking with quick-drying cellulose paints applied as small spots on the wings was carried out in four sites, especially in one where easy access enabled frequent observation and where it was hoped to estimate the population by the capture-recapture technique. Over a period of ten days, this site yielded 23 captures and recaptures, representing a total of 12 separate individuals, figures which scarcely provide much for analysis but serve to confirm a very low status.

One interesting outcome of this experiment was to show that while the Large Blue has, in general, a sedentary habit, tending to remain throughout its lifetime within a small area, yet movements of individuals do take place over a sufficient distance to suggest that, given a good season with enough butterflies involved, travel, especially if wind-assisted, could distribute the species from one breeding centre into other suitable sites if such exist within range. What that range may be cannot be stated with any certainty: the longest travel observed in this experiment was about half a mile but this was covered so quickly with wind helping that considerably greater distances might be expected.

The breeding sites surveyed are in a series of coombes and cliff slopes along the coast, separated only by stretches where the requisite conditions for food and shelter are lacking. Marking experiments of the kind here attempted, even if insufficient for census purposes, can at least help in understanding the relation between these breeding sites as links in a related chain, and the relevance to survival of every link.

The survey in 1964 followed much the same plan but with less time given to preliminary exploration and more to census work and concentration on a selected site. Unfortunately, the site of the previous year's marking experiment which had been earmarked as suitable for some further intensive work was ruined by agricultural reclamation during the winter of 1963/64, but a successful marking experiment was carried out at the site which had been the most populous in 1963 and which proved so again in 1964. Here, though the figures in the data are not high enough to require computer analysis, some significant conclusions can be drawn.

The total of separate individuals marked at this site was 119. Of these, 44 were recovered at least once and some more than once, one being recaptured five times. Analysis of the figures indicates a total population throughout the whole of the flying season of not more than 200, a maximum daily population not exceeding 70 and an average "life" of the butterfly of 3 to 4 days. The longest "life" recorded was 9 days and many must have been very short-lived if the disappearance rate can be equated with the death rate. This however, may not be the case.

The weather was favourable in the 1964 season, with abundant sunshine, but although the total number of Large Blues recorded on all sites was double that for 1963, the number of productive sites had dropped from 13 to 10 and the concentration at the two most populous sites was far greater, yielding over 80% of the total. This apparent shrinkage of the habitat has a foreboding aspect for the future of the species, but offsetting this, there are grounds to hope for a measure of recovery, resulting from the good weather conditions of 1964. With the situation thus balanced, it is most desirable that observations shall be continued during the 1965 season on all the sites that have so far been surveyed.

During both years of this survey, not a single record of the Large Blue has been obtained from that part of the surveyed area which was the classic haunt and stronghold of the species in the early years of this century, yielding a thousand or more specimens per season to collectors. Moreover, in that part which provides its present breeding grounds, its low status points to a marked decline from that observed a decade ago, as deduced from documented records and from notes and recollections of individuals in the field during the mid-1950s.

CAUSES OF DECLINE

From the preceding, it would seem that the answer to the question "Will the species survive without conservation?" is quite probably no, while if the question be posed as "Should conservation measures be contemplated?", the answer must be emphatically yes.

Although there is evidence of the ability of the species to survive for years in small numbers in small areas, the marked trend of decline shown by this survey, of a species with a history of total disappearance from region after region of former abundance, brings us undoubtedly to a consideration of question No. 2 - "What are the requirements of conservation?"

In considering the cause of decline, the evidence accruing from the present survey gives general support to the picture presented by Spooner in the study already referred to. Briefly the factors responsible are:-

1. Heavy collecting;
2. Destruction of breeding grounds by agriculture;
3. Scrub encroachment on breeding grounds;
4. Adverse weather conditions;
5. Fire.

Human agencies such as collecting, agricultural practices, and fire, though controllable in theory, are by no means necessarily so in actuality. Of the natural agencies, scrub encroachment is amenable to a measure of control: the weather, not directly controllable, may not impossibly be circumvented.

Collecting - Spooner has adduced that the Large Blue has both survived heavy collecting and disappeared where there has been no collecting. Nevertheless, the species is exceedingly vulnerable to this factor, the incidence of which has been extreme, and when other adverse factors are operating as well, it seems highly probable that collectors may easily be responsible for the coup de grace. Of all single factors, even if not the most serious threat to survival today, it is one, the suppression of which would certainly be a potent measure of conservation.

Agriculture - Reclamation of the rough, untilled ground that the Large Blue needs for breeding has reduced its habitat and thereby lessened its chances of escaping the collector - potentially therefore, a process for rapid acceleration of decline. Except for very limited areas on walls and hedgebanks, there is no part of cultivated ground where the food plant, wild thyme, can grow.

The increased use of insecticides and herbicides may be involved in the decline of the Large Blue but no definite evidence of this has so far been discovered in the course of the survey. Crops in the area are commonly sprayed and high winds likely to cause drift are of normal occurrence. It is not impossible that the food plant has suffered from this means.

Suppression of rabbits affords another instance of a clash between the interests of agriculture and those of the Large Blue, for the survival of wild thyme is greatly helped by rabbit grazing.

Scrub encroachment - Wild thyme demands the absence of smothering vegetation and depends therefore on factors that suppress taller growth and preserve a short sward. Such factors are many, examples being erosion by wind and wind-borne agents; shallowness, elevation and sharp drainage of soil over rocks and ridges, on walls and mounds, especially ant-mounds; grazing by wild animals and farm stock; burning off in early spring (swaling). The rich growth of thyme so frequently characteristic on ant-mounds is doubtless encouraged by the periodic topping-up with soil associated with actively growing inhabited mounds. The ideal conditions for thyme growth will be those resulting from a combination of agencies acting to produce a favourable balance, sometimes comparatively stable, often more transitory as representing a passing phase - one example of which is probably to be seen in the interim period between successive swalings at suitable intervals of years, accompanied by the effects of selective grazing.

The effects of grazing will not be understood without intensive study, for which there is obvious need and ample scope. There is however, no doubt concerning one aspect of this factor, namely that the great reduction in numbers and, for a time, virtual disappearance of the rabbit following myxomatosis, has had a profoundly adverse effect on wild thyme.

8 Weather - Spooner has adduced evidence that decline of the Large Blue in some of its former haunts may to some extent by correlated with climatic fluctuations, tracing increases associated with good weather seasons as well as decreases with "bad" years, especially where these occur in succession. Decline may well be brought by such influences to a point where it only needs the intervention of some other harmful factor like excessive collecting to achieve extinction. Equally effective could be a succession of bad weather seasons following reductions in numbers of breeding areas brought about by other causes.

Fire - Two distinct sources of fire damage to the interests of the Large Blue may be cited.

The first of these is swaling, the deliberately planned burning of coarse growth in early spring in order to encourage the finer sward grasses on the rough, untilled pastureland which includes the breeding areas of the butterfly. Swaling is allowed up to the end of March, after which it is illegal. It is widely practised and is undoubtedly beneficial for the purpose for which it is intended provided it is properly controlled and the same ground is not swaled too frequently. The optimum period between successive swalings may vary according to location and climate, but in the coastal areas here under study, it is probable that three years is about the right interval. If this is correct in the economy of pasturing, it is not yet known whether the same interval serves best the requirements of the Large Blue, depending on a nice balance between a short thyme-favouring sward and the taller, sheltering growth of heather and gorse etc. Considerable further study of this is needed before any confident pronouncements can be made, but one thing that can be said is that the Large Blue has lived and thrived with swaling for as long as its history is known and can be expected to continue to do so unless changes come about in the practice or effect of swaling that are inimical to the butterfly. Deleterious results would almost certainly result from too great an area being swaled in one year, for in the year of swaling, the ground is likely to be too denuded to suit the butterfly. To have enough ground available in the right condition every season, it is essential that a substantial part of any one breeding ground shall have remained unburnt for a sufficient period - probably at least three years. Clearly therefore, the smaller the area of a breeding ground, the greater the risk of swaling being harmful and, as already noted, reduction of breeding areas by advance of reclamation, for the plough is one of the factors operating against the Large Blue. Too frequent swaling will also certainly be very harmful, but since this is likely to cause deterioration of pasture quality and arise only from bad and ignorant husbandry, it must be considered a less likely risk. Too fierce or prolonged burning can do harm by causing undesirably deep-seated damage affecting dwarf herbage.

The other fire hazard to the Large Blue is a much more serious one than swaling: it is the summer fire caused by accident or carelessness. During the swaling season, the butterfly is underground in the ants' nests where it is presumably immune from destruction by fire above ground. In the summer however, from egg-laying in June and July till it goes underground in the autumn, it is wholly vulnerable to surface fires and fire extending over a breeding area could readily cause its complete extermination on that site. Summer fires are often of great extent, not being under control from the outset like swaling, and it may be held that the disappearance of the Large Blue from some former sites has happened from this cause. The menace of summer fires, caused either by carelessness or malice - often by the sun's rays focussed through discarded bottles - is one which is worsening rapidly with expansion of the human population and its accelerating influx by motor car into coastal areas and hitherto remote wild places.

CONSERVATION

Having reviewed the causes of decline, some attempt can be made to discuss the requirements of conservation and assess the practicability of aims and methods.

Conservation measures could be aimed at:-

1. Elimination or reduction of collecting and other wanton destructive agencies.

There is little disagreement that the present low status of the Large Blue and its vulnerability render the act of collecting cabinet specimens one of wanton destruction, while even the taking of specimens to be kept alive for experimental purposes aimed at aiding conservation needs careful consideration and the strictest control. Elimination of collecting is thought to be impossible but reduction might be effected and among methods mooted are:-

(a) Enclosure

In the known breeding areas, this is not at present viewed as practicable. There is multiple ownership of the land with a negligible extent of it as yet in the hands of conserving bodies. So far as is known, only one area exists where a limited degree of enclosure might be effective and there is also a possibility of acquisition if funds were available. A public coastal footpath runs through or adjacent to the breeding grounds and the only bar to access lies in a varying degree of remoteness which is steadily becoming lessened.

(b) Policing

Patrol by wardens of the most important breeding centres could only be practicable if voluntary helpers can be found to serve and funds be made available to defray their expenses during the flying season of the butterfly. In the absence of any law prohibiting the taking of butterflies, wardens could only use persuasion, but with the co-operation of landlords and invoking the question of trespass, it is likely that such patrols could be usefully effective.

(c) Appeal

Appeal to collectors to refrain from taking the Large Blue, made to the widest possible range of entomological societies, has been suggested and put into action, not without considerable doubt as to its advisability. It has been opposed on the score that the wider the publicity given to the rarity of a species, the graver the menace from collectors, a sad reflection on the attitude of collectors in general.

2. Resistance to reclamation of breeding areas

As with the case of enclosure, withholding of reclamation projects can only be accomplished with certainty by purchase or leasing of land, though much can and has been done by cultivating contact with farmers and landowners to secure goodwill and interest in conservation. Compensation by payment for sterilisation of land may in some cases be practicable. Much will depend on the attitude and financial status of County Naturalists' Trusts.

Control of Scrub Encroachment

Planned and controlled swaling and grazing could be effective if the goodwill of farmers can be secured to co-operate with County Naturalists' Trusts or other conserving bodies. Mechanised cutting of gorse, bracken, etc., controlled to careful plan, avoiding the destruction of shelter to the extent risked by swaling, is being tried out with considerable hope of success.

4. Transplantation

The survey has shown that there are many former breeding grounds where conditions appear to be very good for re-introduction of the Large Blue. A project to achieve this is desirable and should be undertaken whenever a strong colony becomes available from which transplants can be spared.

5. Artificial or assisted rearing

Experiments so far have not encouraged the view that artificial rearing away from the natural breeding grounds is likely to result in any large numbers being raised. It is desirable however, that further experiments in assisted rearing should be carried out, especially if these could be directed to improvement of conditions in the natural breeding area by boosting the quantity of thyme and of ants of the required species, together perhaps, with some measure of enclosure to prevent escape and protect from possible destructive agencies and inclement weather.

Further investigations of certain aspects of the life history are needed, especially the incidence of cannibalism, the circumvention of which under artificial or assisted conditions, might be possible and lead to increased production. In general, greater knowledge of the life history and ecology might well lead to ways of intensive rearing in the field - in effect, to farming the species.

Summary of Discussion

The main point raised in discussion was whether the decline in the population of the Large Blue in Britain was paralleled by a disappearance, or change in the nature, of the most favoured habitat. Mr. Hunt pointed out that there exist at the present time, sites which appear ideal for the insect but which are not populated. He also thought that in some instances, colonies of the Large Blue had been destroyed by bad seasons or temporary changes in the habitat, but when the habitat and weather became favourable again, there were no insects available nearby for recolonisation.

Dr. Moore said that two notable land-use changes occurred in the years after the last war which had very significant effects on the numbers and distribution of the Large Blue. The range of the insect was mainly along the coast where there were extensive areas of rough cattle-grazed grasslands with many ant-hills and a great deal of thyme. After the war, it became profitable to plough up these grasslands with the aid of Ministry of Agriculture grants and many Large Blue sites disappeared. Surviving coastal grasslands were fenced off in many cases, so that scrub growth was able to spread in the absence of cattle-grazing, aided also by the disappearance of the rabbit after myxomatosis. He believed that in such areas, the changes were reversible if money could be found to manage them effectively.

THE CONSERVATION OF DRAGONFLIES IN BRITAIN

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SUMMARY

1. Dragonflies are at the edge of their range in Britain. Most of the forty-three species are highly adaptable and do not have exacting ecological preferences. Only two are in danger of extinction but several others are very local and could become threatened.

2. Owing to destruction of habitat and increased pollution, dragonflies are probably becoming much rarer in lowland Britain and so active conservation of formerly abundant species is becoming necessary.

3. Enough is known about the requirements of dragonflies to make active conservation measures easy. The immediate need is for the application of existing knowledge rather than for further research. It is suggested that derelict ponds in National Nature Reserves should be made suitable for dragonflies and other aquatic animals by clearing surrounding woody growth especially on the south side of the ponds, and new ponds should be dug in reserves which do not possess them. Experience on National Nature Reserves and elsewhere shows that such measures can be highly successful.

4. The method of selecting a wide range of habitats in National Nature Reserves has resulted in the "accidental" protection of at least 75% of the British dragonfly fauna in them. Rare species are given some protection by the S.S.S.I. procedure. The degree of protection should be increased by carrying out the measures suggested in 3 above, and some special measures should be taken in the case of two or three very rare species.

INTRODUCTION

The Odonata are a small order - of the 5,000 or so living species, only forty-three occur in Britain and of these three are only occasional migrants and do not maintain permanent populations. One species (Coenagrion scitulum) was discovered in 1946 but was apparently exterminated by the great sea floods of 1953. The forty-three species belong to nine families, and the British fauna is fairly representative of the world fauna.

As with butterflies the distribution of British dragonflies is tolerably well known and interest in the group extends beyond that of specialists - though not to the extent that reserves are set up expressly to protect them.

Dragonflies are essentially tropical; the order is at the edge of its range in Britain. This is well illustrated by the fact that while thirty-two species breed in Hampshire, only one occurs in the Shetlands. Most British species are tough and adaptable, and are not tied to very exacting ecological conditions, therefore they are potentially easy to conserve. Their conservation has been briefly discussed by Moore in Corbet et al 1960.

THE NEED FOR CONSERVATION

None of our species is endemic and so there is no special responsiblity to conserve British species. A possible exception is <u>Oxygastra curtisii</u> which is a rare species from the world point of view. By virtue of their size, dragonflies provide special opportunities for ecological and ethological study and are of educational and aesthetic value, and so are worthy of special conservation measures.

Until recently, suitable habitats for most species were abundant and conservation measures were not urgent. But post-war developments in farming now threaten breeding areas on a large scale throughout lowland Britain. The principal threats are as follows:-

1. Greatly increased efficiency in draining due to widespread use of mechanical equipment. This means that many ditches and ponds which used to contain permanent water are now only temporary and so are useless for dragonflies. Many other ditches still contain permanent water, but their rate of flow varies much more than in the past - from nil to a fast torrent. These streams are unsuitable for all British species, which are either adapted to live in fast-flowing water or to slow-moving and static water, but never to both.

   Modern mechanical equipment, improved methods of making poor land productive, and Government grants have increased land reclamation, particularly of lowland heaths (Moore 1962), and of small areas of marshy land.

   The loss of farm ponds due to changes from mixed to purely arable farming, and the provision of piped water.

   In recent years, pollution by pesticides has been added to that of industrial wastes, detergents and sewage. Particularly hazardous are the organochlorine insecticides which are now universally distributed in British river systems (Moore and Walker, 1964 and unpublished). The use of aquatic herbicides is increasing. This, like mechanical treatment, alters the habitat by killing many aquatic plants and by encouraging the development of resistant species. These often have to be treated later by more toxic herbicides. In general aquatic herbicides in use today are relatively non-toxic to insects; nevertheless, large-scale destruction of aquatic weed may result in de-oxygenation of the water to an extent which is likely to be harmful to aquatic insects like dragonflies which cannot tolerate very low oxygen tensions.

No systematic work has been done to evaluate the effects of the factors mentioned above, but the general impression that dragonflies in cultivated lowland Britain (e.g. the Fens and Romney Marsh) are much rarer than they were twenty-five years ago, is shared by many observers. Since the situation is unlikely to improve there is a good case for taking active measures towards conserving British dragonflies.

The Nature Conservancy's policy by which its National Nature Reserves are obtained to cover a wide range of habitats, has led to the protection of many freshwater ponds and streams, both by design and accident. And while no reserve boundary has been drawn specifically to protect a special dragonfly breeding area, at least thirty of the forty breeding species occur in National Nature Reserves (see appendix). Five S.S.S.Is. have been designated to protect rare species of dragonflies; and National Nature Reserves and S.S.S.Is. together give some sort of protection to practically all the British species of Odonata. Nevertheless, many of the protected populations are very small and might well not survive if neighbouring breeding places outside them were destroyed. Therefore, it is desirable to increase the number of dragonfly breeding places within existing reserves.

MEASURES TO INCREASE DRAGONFLY POPULATIONS IN RESERVES

Since most dragonfly species are fairly catholic in their requirements, these can be provided relatively easily. The following generalisations about their requirements must be borne in mind:-

1. All species require permanent water.
2. Thirty-five of the British species are found in ponds or slow-moving rivers or both. Only five (*Agrion virgo*, *Platycnemis pennipes*, *Gomphus vulgatissimus*, *Cordulegaster boltonii*, *Oxygastra curtisii*) are confined to flowing water.

Thirty-three to thirty-four species are found in neutral or alkaline waters; most of them will tolerate acid conditions. Only six or seven species (Coenagrion mercuriale, Ceriagrion tenellum, Aeshna caerulea, Orthetrum coerulescens, Leucorrhinia dubia, Sympetrum danae and perhaps Ischnura pumilio) are confined to acid water.

All species are absent from shaded ponds in woods. The extent to which this is due to de-oxygenation of the water resulting from bacterial activity on dead leaves or to the lack of plants and associated animals dependent on them is not known.

5. All species are territorial; as a result population density of adult males is low and dispersal is generally efficient. On the other hand, local populations of rare species are vulnerable to overcollecting, since it is quite possible to collect out the whole male population at one site after the main dispersal has occurred.

6. A few species are known to have special requirements:- Coenagrion armatum is apparently dependent on frogbit (Hydrocharis morsus-ranae L.); Erythromma najas is dependent on water lilies and/or Potamogeton spp.; Sympetrum sanguineum is probably dependent on Typha latifolia and/or Equisetum spp.

For most species a small unshaded pond surrounded by aquatic vegetation will provide a suitable habitat. Recent studies (Moore 1964 and unpublished) show that the creation of permanent ponds leads rapidly to colonisation. For example, bomb holes made in the 1939-45 war on heathland of the Arne S.S.S.I. supported fifteen species of dragonfly by 1954. Twelve species of dragonfly were seen at twenty ponds dug for experiments on aquatic herbicides at Woodwalton Fen N.N.R. only three years after digging. Felling trees around a shaded pond at Ham Street Woods N.N.R., which hitherto supported no dragonflies, resulted in it being colonised by seven species the following summer.

Most reserves contain ponds, but many, especially those in woodland reserves, have become so overgrown that they support few or no dragonflies. By felling trees round such ponds and thereby letting in the light and reducing the leaf fall into them, woodland ponds can be made suitable for dragonflies and other aquatic animals. It is particularly important to fell trees on the southern edge of the pond since these provide most of the shade.

It is suggested that, unless there are specific reasons against it, all ponds on National Nature Reserves should be cleared in this way, and ponds should be dug on those reserves which do not yet possess them. By this means, the numbers of common dragonflies and numerous other aquatic species would be greatly increased on National Nature Reserves. About twenty-two species of dragonfly would be helped in this way.

SPECIAL MEASURES FOR CONSERVING RARE SPECIES

At present special conservation measures are only required for a few species:-

1. Oxygastra curtisii - this species is confined to Spain, the South of France and one or two rivers in southern England. Its most famous British site is an S.S.S.I. but accidental pollution of the river in which it breeds could easily exterminate it. Since the site is of great general zoological interest, consideration should be given to making it a National or Local Nature Reserve.

2. Coenagrion armatum - in Britain this species is confined to one site, which is an S.S.S.I. The habitat may have to be maintained artificially if the species is to survive.

   Coenagrion hastulatum - this species is confined to a few small lochs in the Highlands of Scotland. At present these do not appear to be threatened but a watch should be kept on the species.

   Ischnura pumilio, Aeshna isoceles, Aeshna caerulea, Coenagrion mercuriale, Somatochlora metallica, Leucorrhinia dubia - all occur at several sites but some of the best ones have been lost since the war and active protection may become necessary. Several of the sites are scheduled as S.S.S.Is.

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APPENDIX

Species (43)	Status	Present in N.N.Rs	Species protected specifically on S.S.S.Is.	Confined to flowing water
Gomphus vulgatissimus	2	?		x
Cordulegaster boltonii	1	x		x
Brachytron pratense	1	x		
Aeshna cyanea	1	x		
Aeshna juncea	1	x		
Aeshna grandis	1	x		
Aeshna caerulea	2	x		
Aeshna mixta	1	x		
Aeshna isosceles	3	x		
Anax imperator	1	x		
Cordulia linaenea	1	x		
Somatochlora metallica	2	?		
Somatochlora arctica	2	x		
Oxygastra curtisii	3			
Libellula quadrimaculata	1	x		
Libellula depressa	1	x		
Libellula fulva	2	x		
Orthetrum coerulescens	1	x		
Orthetrum cancellatum	1	x		
Sympetrum striolatum	1	x		
Sympetrum nigrescens	1	x		
Sympetrum vulgatum	M			
Sympetrum fonscolombei	M	(x)		
Sympetrum flaveolum	M	(x)		
Sympetrum sanguineum	1	x		
Sympetrum danae (=scoticum)	1	x		
Leucorrhinia dubia	2	?		
Agrion virgo	1	x		x
Agrion splendens	1	x		G
Lestes sponsa	1	x		
Lestes dryas	2	?	(x)	
Platycnemis pennipes	1			
Pyrrhosoma nymphula	1	x		
Ischnura elegans	1	x		
Ischnura pumilio	3	?		
Enallagma cyathigerum	1	x		
Coenagrion puella	1	x		
Coenagrion pulchellum	1	?		
Coenagrion mercuriale	2	x		
Coenagrion hastulatum	3			
Coenagrion armatum	3			
Erythromma najas	1	x		
Ceriagrion tenellum	1	x		
Totals:	43	30 ± 6		4 ± 2

1. Wide distribution in suitable habitats	27
2. Confined to local areas	8
3. Very local	5
M. Migrants	3
G. Generally found in flowing waters	

Summary of discussion

Dr. Mellanby said that there had been a great increase in recent years in the area of water in this country. He wondered how important gravel pits and reservoirs were for the conservation of dragonflies, now that these habitats had become more numerous.

Dr. Moore said that the interest of reservoirs for dragonflies was slight in the first few years, but they can become colonised very quickly. If there was a great deal of fluctuation in the water table, then only certain species of dragonflies can adapt themselves to these conditions. Gravel pits tend to get polluted by refuse, but sometimes they can be of very considerable interest.

Mr. Elton enquired what sort of interaction there was between dragonflies. Do they for instance, establish territories? Is there interference between species, and have dragonflies attempted to pair with the wrong species?

In reply, Dr. Moore said that there was a great deal of interspecific fighting. In the cases where two dragonflies of a different type fought, the larger usually won. The female lays her eggs when the male is not present so that they are not generally affected by interspecific strife. Mr. Skellam referred to Dr. Moore's statement that of forty species of dragonflies in Britain, twenty-eight occur in National Nature Reserves, and that five Sites of Special Scientific Interest had been established partly because there was a dragonfly interest. Mr. Skellam asked how many extra species have been added to the twenty-eight by establishing S.S.S.Is. In reply, Dr. Moore said about three.

BASIC ECOLOGICAL KNOWLEDGE REQUIRED FOR INVERTEBRATE CONSERVATION

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All ecologists would doubtless agree that the more we know about the mechanisms of survival and maintenance of populations of animals in the field, the more intelligently and more surely shall we be able to modify the environment in favour of species we wish to encourage and also to modify it to the detriment of species we wish to discourage. Both these aspects should, in my opinion, be kept in mind when we are thinking of conservation procedures and of the theoretical basis of conservation - particularly so with regard to the conservation of invertebrates because there are so many species and so many interactions and kinds of interaction among them. It is therefore important to think of the conservation of invertebrates in terms of the maintenance of variety of species in any one place or area. In saying this, I am not thereby denying the importance of conserving some outstanding rare species on aesthetic or educational grounds or because of some special scientific interest as for instance, the Large Copper butterfly which exists as a small local population in Woodwalton Fen. As Dr. Duffey has indicated in his contribution to this Symposium, the eggs and larvae of this butterfly may easily be counted and the adults marked for census movement and longevity estimates. Here is an almost unique opportunity for studying in very great detail the population dynamics of a very rare species near the edge of its range. Such a study would have undoubted value in deciding conservation procedure.

With regard now to the conservation of variety of species, the most important basic information required is concerned with the number of herbivorous species that can exist in a given area. I wish to point to two lines of approach. The second has a much greater theoretical content than the first. Both have undoubtedly important practical applications.

The first I shall deal with briefly, although it is the kind of knowledge on which probably the great majority of conservation programmes for invertebrates will be based in practice. If we know enough about the correlation between occurrences of species of herbivores and the occurrences of plant species or of associations of plant species, then we can plan management of the habitat to encourage the maintenance of the maximum number of animal species. This may be illustrated by reference to Table I which indicates the relation between density of each of the three psocid species and plant association, e.g. the 6 tree species named together with the epiphytes they carry; these psocids feed upon the epiphytes but their densities are not determined entirely by the amount of food on each kind of tree. We see how restricted is Elipsocus mclachlani compared with the other two species. E. mclachlani is of special interest as one of the few lichenophilous psocids in this country and among these, it is of special interest as being only imperfectly adapted to a lichen diet. It is much more numerous on the dead larch branches on the tree than on the living ones. The Ha Mire plantation on the east shore of Malham Tarn is an ideal habitat for this species, the populations being much denser here than anywhere else in the Pennines.

Table 1

Density indices of three Elipsocus species on six tree species in the wooded areas around Malham Tarn, September 1952

No. of trees sampled (= no. of samples)	Species of tree	westwoodi		mclachlani		hyalinus		Total Elipsocus	
		Tot. No.	Av. Sam.	Tot. No.	Av. Sam.	Tot. No.	Av. Sam.	Tot. No.	Av. Sam.
23	Hawthorn	137	5.96	15	0.65	21	0.91	173	7.52
34	Beech	114	3.35	3	0.09	30	0.88	147	4.32
20	Sallow..	67	3.35	5	0.25	96	4.80	168	8.40
42	Larch (dead branches)	89	2.12	108	2.57	98	2.33	295	7.02
20	Spruce..	15	0.75	6	0.30	74[1])	3.70	95	4.75
20	Yew	30	1.50	3	0.15	46[2])	2.30	79	3.95

1) includes 26 from one sample; 31 from another.

2) includes 38 from two samples.

Table 2

The Relative Abundance of Psocid Species on Larch in late Summer

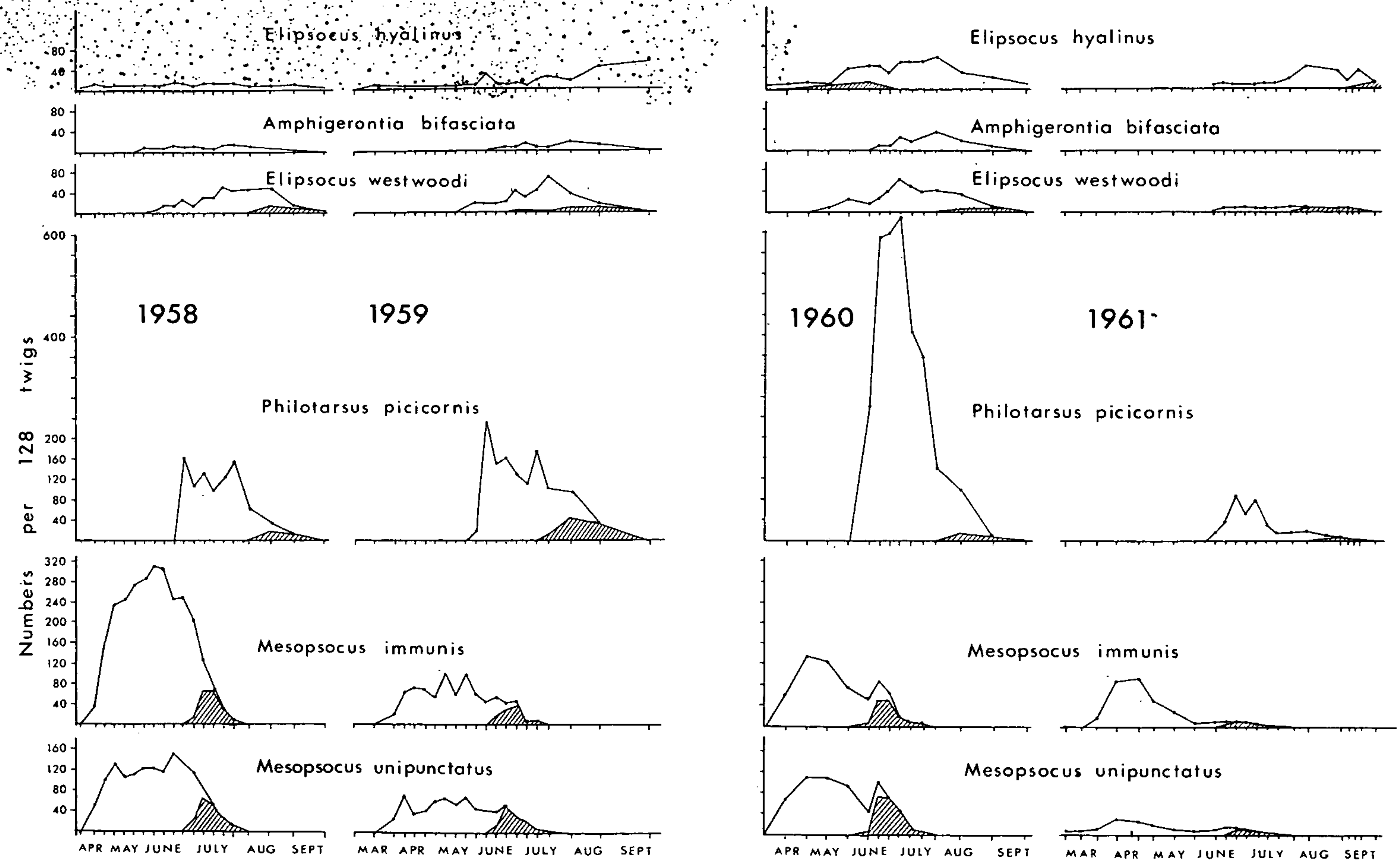
The figures show total captures from twenty-four localities, 8th August - 24th September 1954. Equal numbers of samples were taken from living and from dead branches.

	Numbers captured from		Total capture on larch	Percentage of total psocid capture
	Living twigs	Dead twigs		
Philotarsus picicornis	6,356	4,274	10,630	26.8
Reuterella helvimacula	406	9,394	9,800	24.7
Elipsocus westwoodi	5,462	824	6,286	15.8
Amphigerontia bifasciata	1,211	4,510	5,721	14.4
Elipsocus mclachlani	77	2,722	2,799	7.0
E. hyalinus	472	1,664	2,136	5.4
Amphigerontia contaminata	585	158	743	1.9
Mesopsocus unipunctatus	112	55	167	0.4
M. immunis	52	40	92	0.2
Fourteen other species *	991	348	1,339	3.4
Total:	15,724	23,989	39,713	100.0

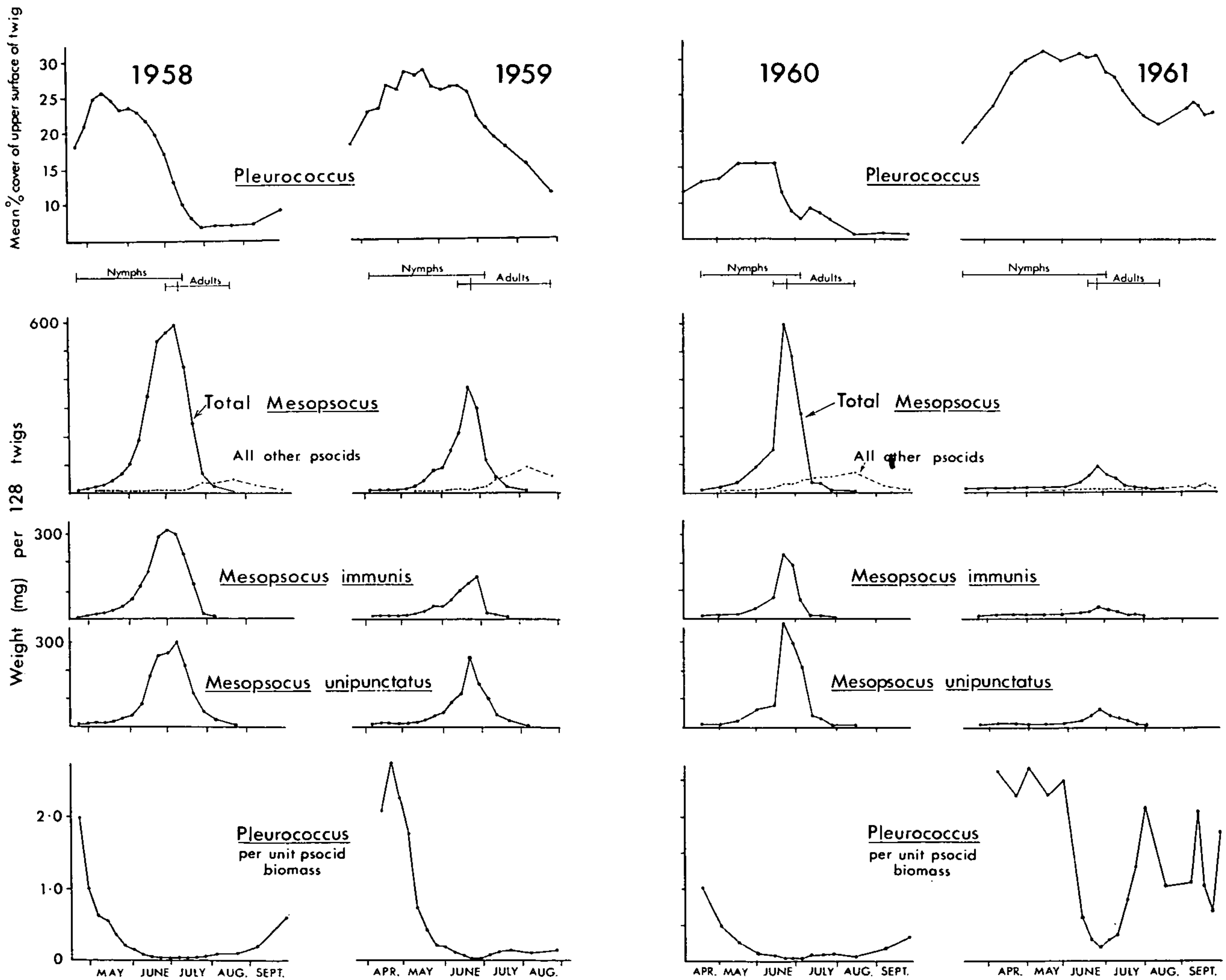
* Three Peripsocus spp., 792 individuals; Cerobasis guestifalica 269; Stenopsocus immaculatus 151; Metylophorus nebulosus 35; Psococerastis gibbosa 29; Trichadenotecnum sexpunctatum 15; Lachesilla pedicularia 12; Cuneopalpus cyanops 8; Caecilius burmeisteri 7; Loensia variegata 3; L. fasciata 3; Graphopsocus cruciatus 1; and 14 unidentified nymphs.

.... Brashing the trees would clearly reduce the population enormously. With facts such as these, one could easily set out a woodland management procedure designed to allow the densest population of mclachlani to exist. Eventually of course, a management programme for any one area would be designed with reference to a large number of species. Compromises would inevitably be necessary and some species would no doubt be considered to merit more attention than others.

This kind of information - involving the recording of densities at different sites with reference to different food or substrate resources - is the kind one would collect first of all for most invertebrates. It is a natural starting point. It is not very deep knowledge but it is extremely useful for conservation purposes.....



Elipsocus hyalinus
Amphigerontia bifasciata
Elipsocus westwoodi
1958
1959
1960
1961
Philotarsus picicornis
Mesopsocus immunis
Mesopsocus unipunctatus
Numbers per 128 twigs
APR MAY JUNE JULY AUG SEPT
MAR APR MAY JUNE JULY AUG SEPT


1958
1959
1960
1961
Mean % cover of upper surface of twig
30
25
20
15
10
Pleurococcus
Pleurococcus
Nymphs
Adults
Nymphs
Adults
Nymphs
Adults
Nymphs
Adults
600
Total Mesopsocus
All other psocids
Total Mesopsocus
All other psocids
Weight (mg) per 128 twigs
300
Mesopsocus immunis
Mesopsocus immunis
300
Mesopsocus unipunctatus
Mesopsocus unipunctatus
2·0
1·0
0
Pleurococcus
per unit psocid
biomass
Pleurococcus
per unit psocid
biomass
MAY JUNE JULY AUG. SEPT.
APR. MAY JUNE JULY AUG.
APR. MAY JUNE JULY AUG. SEPT.
APR. MAY JUNE JULY AUG. SEPT.

The second line of approach follows from the first. It is the consideration of a more fundamental problem: given now only one food resource, what conditions allow for its exploitation by the greatest number of species of herbivores? Let me develop this with reference to some typical woodland insects, the Psocoptera. These animals are very common in upland areas in Britain. On the bark of larch trees, they can be as abundant as are the big herbivorous mammals on the plains in Africa. Kendeigh (1961) gives figures ranging from 0.18 to 8.34 g./m.^{2} for the biomass of grassland herbivores in Africa and North America and we have estimated the weight of the population of two Mesopsocus species on a complete larch tree at Harrogate at the time of peak biomass as 1.18 g./m^2. of bark surface.

Table 2 gives a list of all psocid species occurring on larch trees in Yorkshire with their relative abundance in late summer. There are two abundant lichenophilous species and seven abundant species exploiting the Pleurococcus-fungal spore mixture present on the bark. Table 3 indicates the groups of closely related species which occur on larch. Except for the two Mesopsocus species, the members of each pair show a pronounced difference in habitat on a single larch tree. Figure 1 shows the change in numbers of individuals of all the six common Pleurococcus-eating species of psocid occurring together on the terminal two feet of the living larch branches in a plantation at Harrogate over four years. Elipsocus hyalinus and Amphigerontia bifasciata occur more abundantly on the dead branches than on these living branches. Elipsocus westwoodi occurs more abundantly on the living than on the dead branches. Philotarsus picicornis and the two Mesopsocus species are as abundant on the dead branches as on the living ones. These three commonest species show therefore the closest similarity in habitat requirement and all are exploiting the same food resource. In Figure 2, the numbers are converted into biomass, and the change in abundance of food is also indicated. The mixed species populations of Mesopsocus exert an appreciable effect on food level on these twigs. They take the food early in the season, and the remaining four later summer species together account for only a relatively small biomass and take much less food than do the Mesopsocus.

On these larch trees then, we have a great diversity of herbivorous species living together and eating the same food. There is now plenty of evidence to show that in a closed homogenous environment, two species cannot co-exist if they require the same resource. In a purely theoretical way, this was expressed in the Lotka-Volterra equations of interaction between two non-predators. Empirically, it has been demonstrated by much laboratory work - particularly Park's work (1956) on mixed Tribolium confusum and castaneum populations.

Table 3

Food resources and habitats of five groups of closely-related psocid species on Larch in Yorkshire

	FOOD	SPECIES	HABITAT Proportions of population on living twigs	dead twigs
1.[x]	Pleurococcus	Elipsocus westwoodi	90	10
	Lichen	Elipsocus mclachlani	3	97
2.[xx]	Pleurococcus	Elipsocus westwoodi	84	16
	Pleurococcus with some lichen	Elipsocus hyalinus	21	79
3.	Pleurococcus	Amphigerontia bifasciata	21	79
	Pleurococcus	Amphigerontia contaminata	79	21
4.	Pleurococcus	Peripsocus phaeopterus	93	7
	Pleurococcus	Peripsocus didymus	14	86
5.	Pleurococcus	Mesopsocus immunis	34	66
	Pleurococcus	Mesopsocus unipunctatus	49	51

x - above 600 feet above sea level;
xx - below 600 feet above sea level.

The possibilities of reducing or obviating the results of competition between two such species by introducing environmental heterogeneity are several:-

1. Co-existence of potentially competing species. Two species requiring the same food resources may co-exist in a stable and permanent way provided that the two populations are separately controlled, each by its own density dependent factor, at a level below that which would result in food shortage.

Co-existence of competing species. Species competing for food (i.e. the exploitation type of competition) may nevertheless co-exist provided that there exists a balance of advantages:-

(a) in time. As Park has shown, the competitive prowess of two species may be reversed by change of climatic environment. An environment whose climate changes in a periodic/

way with the appropriate frequency about an appropriate mean value may then allow prolonged co-existence of two competing species whose fluctuations would be out of phase. On the basis of what is now known about mixed species populations of Tribolium, this system could easily be engineered in the laboratory. In the field, seasonal changes in frequency of the chromosome types "Standard" and "Chiricahua" in Drosophila at Piñon Flats in California (Dobzhansky, 1943) approaches this system most closely.

(b) in space. Co-existence is possible provided that one species is favoured (or has a refuge) in one part of the habitat and the other species in another part. Movement from these refuges would produce a zone of co-existence which would be stable so long as the refuges remained invidable.

(c) Skellam's model of two hypothetical plant species (1951) incorporates a balance of advantages. The environment is conceived as carrying a certain number of sites suitable for the growth of seeds of species A and B. If seeds of the two species fall at the same place, A wins because it grows more quickly. Both plants are mortal however, so releasing vacant places and species B disperses its seeds more widely than does species A so that there will always be some sites reached first by B in which it can then maintain its position.

(d) A common enemy (parasite or predator) could act as a stabilizer to the populations of two competing species provided that it is habit-forming with respect to preference for prey species, i.e. it comes to prefer whichever species happens to be the commoner one.

(a) We can conceive an extension to Park's Tribolium model. Park found that alternative outcomes were possible from the struggle for existence in replicate mixed species populations of Tribolium under identical climatic conditions. By allowing a limited migration between replicate vials, co-existence would be greatly prolonged, although it would not be stable.

(b) This is not far removed from the transient co-existence of two competing species - one of which is moving towards extinction.

These ideas are hypotheses or a priori models which are available to the field ecologist trying to interpret what exactly is happening in any given situation in the field. In order to decide which model or combination of models is appropriate, the field data required must relate to changes in time. I will now illustrate this by brief reference to a study of the population dynamics of two co-existing Mesopsocus species on larch trees - a study conceived in part as an attempt to utilize the conceptual schemes arrived at from laboratory studies of mixed species populations. The final interpretation is summarized by model 1 above.

In a plantation at Harrogate, two Mesopsocus species, M. immunis and M. unipunctatus, feed on the same food and live together on the same trees at the same time. The eggs and each of the six nymphal instars can be identified to species. Weekly sampling from the terminal two-foot region of living branches in 8 blocks of trees provided the observational data and the remarks made below all apply to the population in this sampled zone of the tree.

Figure 3 gives a quantitative picture of the life history of the two species in 1958 and the flight period of the mymarid Alaptus fusculus, which parasitizes the eggs of both these Mesopsocus species. Another parasite, a braconid, attacks the 5th - 6th instar nymphs of both these species. From this information, life tables of M. immunis, M. unipunctatus and of the mymarid can be constructed. Table 4 shows the life table for M. immunis. From these life tables and a further analysis of the results on which the life tables were based, we can construct an empirical mathematical model. Figure 4 indicates the model qualitatively and Table 5 gives the parameters of this model. The Mesopsocus life cycle is divided into 8 stages and the quantitative expressions describing these stages fall into three types:-

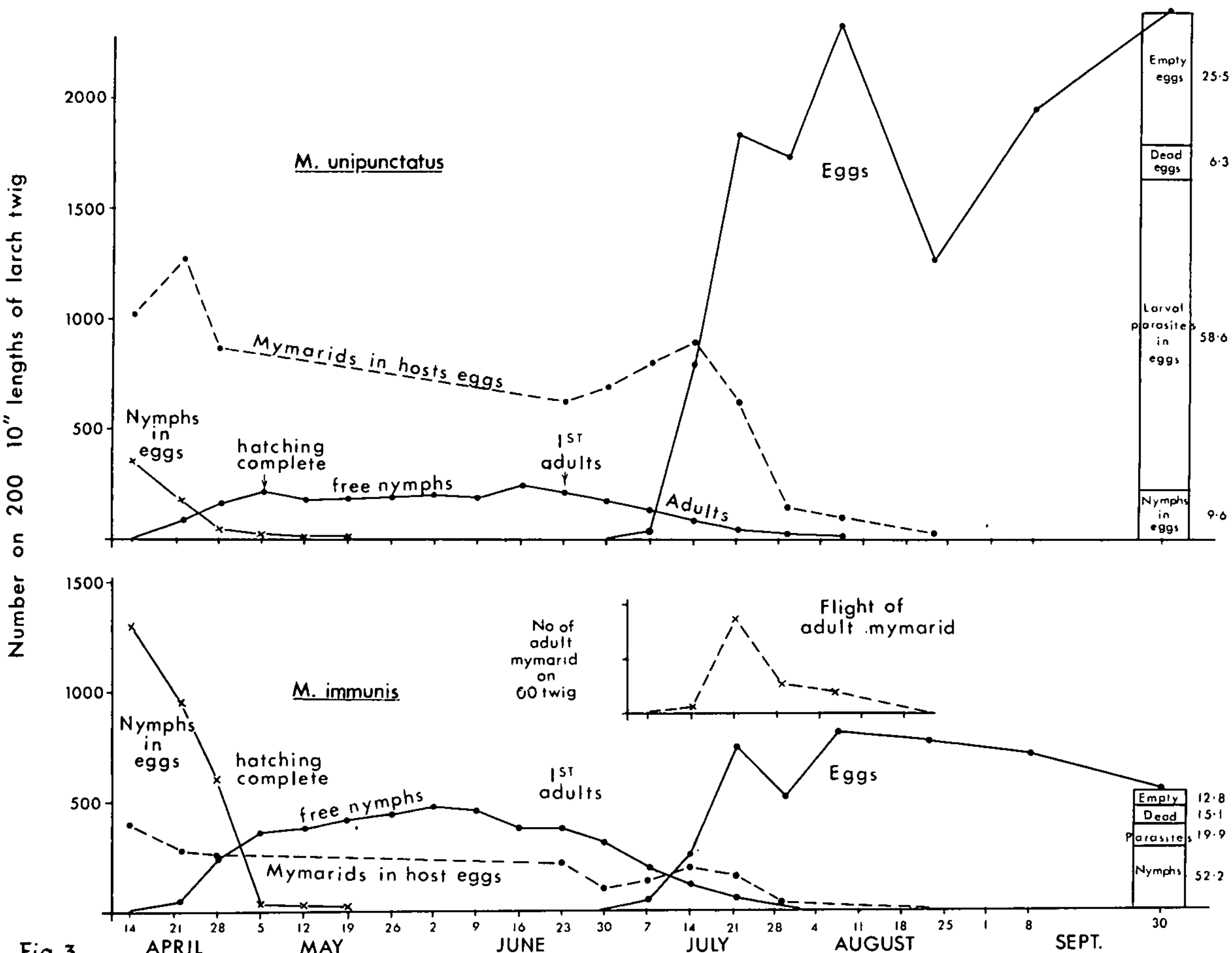
(a) mean survivorship values for stages 1, 3, 4, 5. This is the equivalent of simplifying our model by regarding mortalities in these stages as constant. It is also the expression of inadequacy of the model, which could be improved by incorporating, in place of these survivorships, equations describing the relationship between survivorship and either climate or animal and plant enemies or both.

(b) the use of the Nicholsonian host-parasite equation for stages 2 and 6, an equation which is itself an a priori model.

(c) for stages 7 and 8, empirically determined relationships between numbers of females at the beginning (N_o) and at the end (N_1) of the preoviposition period and between N_1 and the number of eggs laid. Both these equations for each species describe equilibrating, i.e. density governing processes.

When this model is worked out (Fig. 5) from arbitrary initial densities, the numbers of the four species reach equilibrium values close to the density levels recorded in the field.

This kind of empirical model cannot immediately be translated into a conservation programme, but it can point the way with reference to these particular species and it can do this in two ways:-



Number on 200 10" lengths of larch twig
2000
1500
1000
500
M. unipunctatus
Mymarids in hosts eggs
Nymphs in eggs
hatching complete
free nymphs
1ST adults
Adults
Eggs
Empty eggs 25·5
Dead eggs 6·3
Larval parasites in eggs 58·6
Nymphs in eggs 9·6
1500
1000
500
M. immunis
Nymphs in eggs
hatching complete
free nymphs
Mymarids in host eggs
1ST adults
Eggs
No of adult mymarid on 60 twig
Flight of adult mymarid
Empty 12·8
Dead 15·1
Parasites 19·9
Nymphs 52·2
14 21 28 5 12 19 26 2 9 16 23 30 7 14 21 28 4 11 18 25 1 8 30
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.

Fig. 3

Life History of two *Mesopsocus* species and their parasites

	EACH *MESOPSOCUS* SPECIES	MYMARID	BRACONID
	Egg Mortality		
	fungal attack		
AUG.	mymarid attack ← $u = u'e^{-ap}$	adults	
SEPT.	sucking predator	loss of larvae by sucking predator and	
OCT. - APRIL	winter loss of egg batches from twigs	by winter loss of host eggs	
	Nymphal Losses		
MAY	bird predation	$u = u'e^{-ap}$	
JUNE	braconid attack ←	(pupae)	adults
	Adults		
	mortality and migration during preoviposition period	$N_o - N_1$	(larvae pupate in soil)
JULY	Egg-laying	N_1-Eggs	

Figure 4

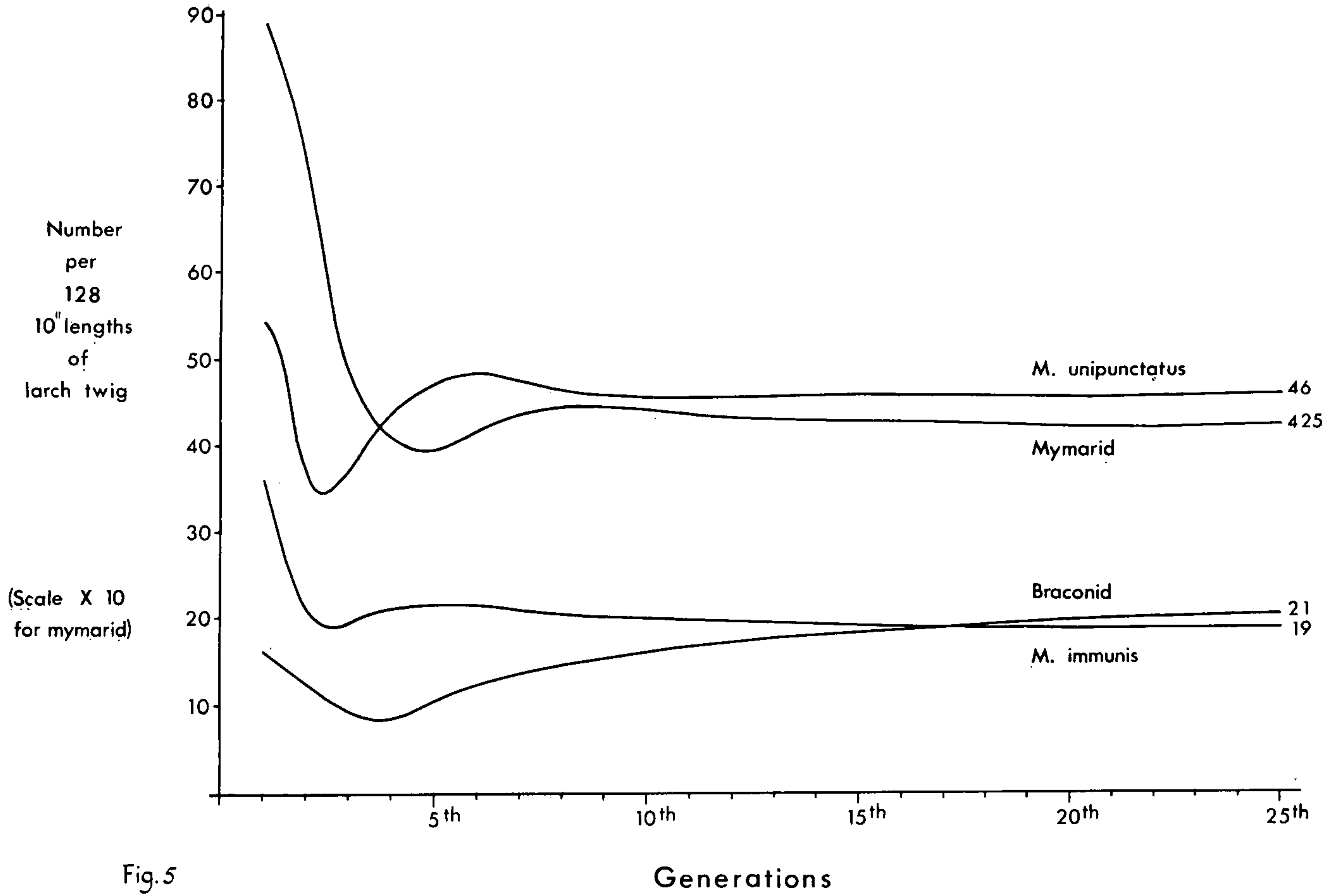

Number
per
128
10" lengths
of
larch twig
(Scale X 10
for mymarid)
90
80
70
60
50
40
30
20
10
M. unipunctatus
46
425
Mymarid
Braconid
21
19
M. immunis
5th
10th
15th
20th
25th
Generations
Fig. 5

Table 4

Mortality and Natality Budget for Mesopsocus immunis 1958-61 at Harrogate

Stage	Period (x)	Approx. duration in weeks	Factors	1957 - 58			1958 - 59			1959 - 60			1960 - 61			1961 - 62		
				Nos. surviv'g at begin. of x l_x	Nos. dying during x d_x	Percentage loss $100q_x$	l_x	d_x	$100q_x$	l_x	d_x	$100q_x$	l_x	d_x	$100q_x$	l_x	d_x	$100q_x$
EGG	From completion of egg-laying to onset of winter	9	Mymarid attack Fungal attack & dead eggs Predators producing empty eggs Total	1183	253 35 61 349	21 3 5 29	475	94 72 61 227	20 15 13 48	647	113 55 58 226	17 9 9 35	378	82 65 45 192	22 17 12 51	134	21 22 10 53	16 16 7 39
	Winter	26	Loss of egg batches	-	-	-	248	72	29	421	191	45	186	78	42	81		
NYMPH	From beginning of hatching to braconid attack on 6th instar	11	Predators	834	764	92	176	131	74	230	161	70	108	97	90			
	From beginning of braconid attack to peak adult incidence	2	Braconid attacking 5th and 6th instars	70	6	7	45	7	15	69	17	25	11	2	18			
ADULT	From peak incidence of adults to completion of egg laying	4	Predation of adults and their oviposition	64	-411	-642	38	-609	-1603	52	-326	9	-125	-1389				
			Total eggs	475			647			378		134						

Table 5

THE PARAMETERS OF THE MODEL (NUMBERS PER 16 TWIG SAMPLE UNIT)

	Period			Factor	Parameter	M. immunis	M. unipunctatus
1.	Eggs laid	→	Eggs available to mymarid	Fungal attack	Survivorship (n = 5)	0.879	0.955
	Eggs available (u')	→	Eggs surviving (u)	Mymarid attack	Area of discovery (a)(n = 4)	0.003096	0.01656
.	Eggs surviving mymarid attack	→	Nymphs within eggs at beginning of winter	Attack by sucking predator	Survivorship (n = 4)	0.879	0.776
.	Nymphs within eggs at onset of winter	→	Nymphs ready to hatch in spring	Winter loss of egg batches from twigs	Survivorship (n = 3)	0.612	0.974
.	Nymphs ready to hatch from eggs in spring	→	5th-6th instar nymphs available to braconid	Predation by birds and lacewings	Survivorship (n = 4)	0.185	0.267
6.	6th instars available (u')	→	6th instars surviving (u)	Braconid attack	Area of discovery (a)(n = 3)	0.1807	0.0653
	6th instars surviving	→	♀ 6th instar nymphs (N_o)	-	Sex ratio (♀:total)	0.597	0.506
.	N_o	→	Females at end of pre-oviposition period (N_1)	Mortality + Migration	Regressions below		
8.	N_1	→	Eggs laid	Oviposition	Regressions below		
				PARASITES:-			
	Mymarids produced by oviposition in host eggs	→	Mymarids attacking the following year (p)	Mortality of host eggs: from sucking predator	Survivorship	0.879	0.776
				and by winter loss of host egg batches	Survivorship	0.612	0.974
	Braconids produced	→	Braconids attacking the following year (p)	-	Survivorship	1.0	1.0

EQUATIONS USED:-

		M. immunis	M. unipunctatus
7.	Period $N_o \rightarrow N_1$	$\log_e N_1 = 0.809 + 0.364 \log_e N_o$	$\log_e N_1 = 1.323 + 0.305 \log_e N_o$
8.	Period $N_1 \rightarrow$ Eggs	$\text{eggs} = 16.16 + 28.38 \log_e N_1$	$\log_e \text{eggs} = 3.564 + 0.694 \log_e N_1$
2+6	Parasite attack	$u = u'e^{-ap}$	

it helps us to explore species interaction in a speculative way in so far as the model is greatly simplified and random variables are excluded;

it can be elaborated by substituting, for the constant survivorship terms, equations relating mortality (or migration) with other animals or with climatic factors, e.g. nymphal mortality can be related to lacewing and bird numbers and for the adult period the regressions cited can incorporate temperature as a significant additional term. This would give us some predictions of the consequences of changes in climate or of other animals.

Finally I should like to end my talk with a synthesis of the main points I have just discussed and a comment upon the relation of basic ecological ideas to conservation, (see Fig. 6). I have mentioned some of the a priori models conceived in a purely theoretical way independently of considerations of the properties of particular species of animals or plants. These, historically speaking, are gradually tested against our ecological experience at the various levels of complexity - initially with the simplest animals in the simplest and most highly controlled laboratory situations (e.g. Park's Tribolium cultures). These laboratory investigations themselves result in models, simple empirical models, which the field ecologist can use, and test, with reference to natural populations of animals in uncontrolled or largely uncontrolled environments. These field studies, as for instance, in the case of our own work on Mesopsocus, can also result in simple empirical models, which give us a little further insight into the mode of working of that much more complex entity - the whole biotic community in any one region. This summarizes the structure of research in population ecology. In long term view, it should impinge to an important degree, upon the ways in which conservation is viewed and the way conservation programmes are developed. In short term view, the kind of information I indicated in my first line of approach will provide the most valuable information for developing management plans to conserve specified invertebrate animals.

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SOURCE OF TABLES AND FIGURES

Table 1 from Broadhead & Thornton, 1955; Table 2 from Broadhead, 1958; Table 3 in part from Broadhead, 1958 and Broadhead & Datta, 1960; Tables 4 and 5 and Figures 1 - 3 and 5 from Broadhead and Wapshere (unpublished).

FIGURE 6

CONSERVATION IN RELATION TO BASIC ECOLOGICAL IDEAS

A LONG-TERM VIEW

towards higher grades of abstraction

the direction of our understanding

The structure of research in population ecology

the ideas expressed in these *a priori* models

are successively tested against our ecological experience at these successively more complex levels

a priori models

laboratory empirical models

field empirical models

practical conservation programmes

all these are our practical starting points

Its long term influence on conservation theory and practice

the ideas and wisdom implicit in traditional lore etc. made explicit and further elaborate, i.e. the utilisation of developing population-ecological theory for conservation practice.

the scientific development -

The starting point historically of The Nature Conservancy i.e. the declaration of Nature Reserves and thereby conservation achieved by executive and political action

basis of selection:-
traditional lore
intuitive procedure

WHY WE NEED INVERTEBRATE SURVEYS

M. G. Morris

This Symposium is taking at its starting point, the idea that populations of invertebrates should be conserved, although exactly what this implies may mean different things to different people. Theme III is concerned with the place of surveys in the conservation of invertebrate populations. It deals with one sort of knowledge such as was mentioned by Dr. Broadhead. I should like to take this opportunity of acknowledging the help I have had from Mr. G. E. Woodroffe, who unfortunately cannot be here today, in formulating some of the ideas on the need for surveys which I shall put forward. Inevitably, there will be some repetition in what I have to say, but perhaps this will be no bad thing.

A good deal is known about what species of invertebrates (mesofauna at least) occur in this country, although on many aspects of invertebrate ecology, we know next to nothing. In terms of species we have some idea of what we want to conserve. But it is obviously impossible, as well as undesirable, to approach the conservation of invertebrates generally from the standpoint of individual species. The exceptions to this are special, and atypical, cases. As a background to the reasons why we need surveys, we must look briefly at some attitudes to the conservation of invertebrate populations which are current.

Most of us would agree that the maintenance of places where animals live is the most urgent need in the conservation of terrestrial and freshwater invertebrates. It is customary to call different sorts of places where animals are found 'habitats', though this is using the term 'habitat' loosely. However, "conservation of the habitat" is a useful basic idea even if it is also rather much of a cliché. One of the advantages of approaching conservation of invertebrates by way of habitats rather than species is that one can readily introduce the concept of communities, particularly when using habitat in its broad sense. Unfortunately, very little work has been done on the conservation of communities because they need intensive study in themselves and also because their groupings cut across systematic groupings. We must be clear than an association of animals found in one sort of place does not necessarily constitute a community. However little we know about a community, we can presuppose that it is characteristic of a particular sort of countryside, or 'habitat' and 'habitats' are things we can all recognise. In practice, the 'habitats' we can do most to protect or conserve are those which occur together in special areas which are, of course, Nature Reserves of various sorts. Nature Reserves are important as areas containing animal habitats for two good reasons:-

1. They may reasonably be expected to contain interesting and important populations of animals.

2. They are not only protected physically, but they are managed to a greater or lesser extent. Management either maintains them in an ecologically desirable state, or converts them to this condition. In many Reserves, management for diversity of habitat types is an important object of management.

Most Reserves have been selected on the basis of their cover of vegetation, though this is not the case with geological Reserves, with which we are not concerned. This illustrates a familiar attitude to the conservation of invertebrates, that if one looks after the vegetation and flora, the invertebrates will look after themselves. One of the dangers of this as a principle is the sense of false security it gives. It encourages the maintaining of ignorance about invertebrates. After fifteen years of existence, the Conservancy should have a more positive attitude to invertebrate conservation than this. However, the principle, if there is nothing better to go on, is a reasonable one.

Through the willing help of Regional Officers and their staff, I have been able to analyse the records of butterflies from 125 statutory Nature Reserves (N.N.Rs., F.N.Rs. and L.N.Rs.). It is only with butterflies that we have sufficient records to analyse the representation of species on Reserves; this point in itself is of note. Butterflies are of course, atypical invertebrates for this very reason. Also, some Reserves have been selected partly because of their entomological interest in which butterflies figure very highly. Buterfly species have undergone countrywide fluctuations in numbers of great magnitude in the last few years and many of the records I have may be out of date; those of certain species from Monks Wood certainly are. Nevertheless, the information about butterflies from these Reserves may be of interest.

Only three species (Glanville Fritillary, Large Blue and Lulworth Skipper) have not been found on one or other of these Reserves. As far as conservation of the species is concerned, you will remember from Mr. Hunt's talk that special measures have been taken to conserve the Large Blue. Some other local species of butterfly are very well represented on our Reserves, such as the Swallowtail, Black Hairstreak and Chequered Skipper. Species recorded from only one Reserve, or which are represented by a few old records include the Scotch Argus, Purple Emperor, Heath Fritillary, Adonis Blue and Silver-spotted Skipper. The Adonis Blue is undergoing a period of decline generally while the Heath Fritillary is scarce, to say the least, in Blean Woods in which it was formerly abundant (incidentally the return from Blean Woods was a 'nil' one).

At the other end of the scale, the Meadow Brown has been recorded from 63 of these Reserves, and other common species from nearly as many. 43 Reserves have no records at all, though these include such places as Noss, Swanscombe Skull Site and Wren's Nest. A further 17 Reserves have a known butterfly fauna of 5 species each or fewer. A few of these may have a butterfly fauna actually poor in species but most are just under-recorded.

I hope this digression will show how ignorant we are about what butterflies occur on our Reserves, although I must admit that before this survey of the records, I thought we were much more ignorant that I find that we are. But if this is the case with butterflies, you can imagine what it is like for less popular groups of invertebrates, and on less important Reserves.

There are two clichés which are applied to Nature Reserves to describe their function - "living museums" and "open-air laboratories". I presume that a museum is a place where one goes to see something, that is, that the museum exists for the edification and amusement of people and not for the sake of the exhibits. I also presume that one of the important things that a curator of a museum must do is to know what is in his museum and to issue catalogues. In the case of a living museum, we are of course, dealing with an immensely complex and above all, dynamic, collection, the entities of which can be considered at several levels. But that is no excuse for not beginning to catalogue what is in our museums (Reserves).

Nature Reserves are also 'open-air laboratories', but only a few of them are getting used as such for research on invertebrates. The research done in Reserves can be usefully divided into two kinds. There is conservation research, that is, research designed to find out what sorts of management can be used in Reserves for the conservation of plants and animals, considered as species populations or communities as the need may be. And there is basic ecological research which is designed to find out about ecological processes and the flow of energy within the ecosystem. There may be some disagreement about who are the right people to do these different, but related, kinds of research. Personally, I would regard the former as being the special concern of the Conservancy, while the latter might be done mainly by Universities.

In 1954, Elton and Miller published a paper which has had considerable influence on the thinking of animal ecologists, both within and outside the Conservancy. Quite early in their paper, the authors discuss the ecological survey of animals and they distinguish three levels of survey.

1. Species lists, life histories, habits, tolerance limits; qualitative and simple quantitative studies. It is this sort of survey to which I will be referring most frequently later.

2. Quantitative studies, population processes, balance and inter-action of populations.

3. Energy flow within the ecosystem.

It can readily be seen that Elton and Miller's three levels of survey correspond roughly to the catalogue or inventory, conservation research and research on ecological processes respectively. At the highest level, there is little difference between survey and research (after all, at all levels, survey is a type of research). At the lower levels, 'survey' has an extensive connotation, 'research' an intensive one.

Elton and Miller's type 3 survey is one of the most difficult, comprehensive and long-drawn-out kinds of research. It is continuing, i.e. it is done over a long period of time. There are no signs that the Conservancy will do a survey of this type, such as the Wytham survey in the near future, nor is there any likelihood that one will be done by any other body. This type of survey will always be very rare.

Type 2 surveys are of the sort which the Conservancy can, and does, undertake, although those that have been done have not been as comprehensive as is desirable. This type and the type 3 survey, are of the sort that is best done by staff working full-time on them. Experts working as amateurs will be expected to play only a minor role in these surveys.

Type 1 surveys (species lists etc.) are appropriately done by experts working as amateurs (this includes professional and amateur zoologists who are doing something which is not part of their professional work). The prototype of this sort of survey is the survey of Wicken Fen (Gardiner, J. S. (Edit.), 1923 seg, The Natural History of Wicken Fen). Mr. Steel will tell us how some of the surveys now being done grew out of the survey of Spurn Head.

In the past, the Conservancy has given little thought to the organisation and control of people taking part in surveys of this sort. Unlike the general collector, the surveyor is willing to conform to a defined system of recording. This being so, it is the more important that the Conservancy should give positive help to its surveyors. Some points here are:-

1. Geological and plant surveys should precede zoological surveys and the results should be available to surveyors. Both vegetation surveys and lists of plant species are important to the surveyor.

2. A simple and generalised system of recording of habitat types, based on the plant survey, should be made available for the surveyors to conform to.

3. An agreed system of definitions of terms of distribution and abundance should be used, with the emphasis on objectivity e.g. "two specimens only" is to be preferred to "rare".

4. There should be a clear policy regarding voucher collections.

I have referred to type 1 surveys as being of the catalogue or inventory type. In the present state of knowledge about the conservation of invertebrates however, I suggest that they are more valuable than that, as they provide the essential information about what species we should like to conserve. In the absence of very many type 2 surveys, the best that can be done about conservation of invertebrates in many Reserves is to relate intelligently species lists to biological data about the species. I am sure that this is one of the tasks that should be done by staff of the Conservancy. At the same time, it should be thoroughly realised that this sort of extrapolation from species lists is a very inferior alternative to a comprehensive survey at level 2, in which surveys of communities would be included.

An important aspect of surveys which will be of increasing importance is the comparison of Reserves, particularly within broad types e.g. woods, sand-dune systems, heaths. Comparisons of this sort may highlight differences between Reserves that are not apparent at first sight. And these differences may be of importance in managing Reserves for diversity of habitat types.

Comparison of Reserves, in space, is important but equally or more so is the comparison of surveys done at different times at the species list level. This is particularly true where active management is taking place in a Reserve. An example of the very few surveys of this type is that of Coleoptera done at Woodwalton Fen by Buck (1962), which included the water beetles. Balfour-Browne's earlier survey (1951) of the aquatic Coleoptera of this Reserve included records dating from 1910-1930 and, not surprisingly, he recorded more species than Buck. However, a remarkable absence from his list was Acilius sulcatus, a species recorded as abundant by Buck and which now occurs in numbers in the Fen. The fact that Balfour-Browne did not record such an obvious species is surely evidence of a marked change in the nature of the water bodies at Woodwalton Fen.

I have considered so far surveys of invertebrates on Nature Reserves. I am not going to consider large-scale surveys of animals over the country as a whole, although I should mention the Biological Records Centre at this Station where Dr. Perring is interested in distributional data for some groups of invertebrates over the whole of the British Isles. Nevertheless, the survey of areas which are not Nature Reserves is of some importance. I believe that it is of little use knowing what we have in Reserves if we do not know the context of these records i.e. we do not know what animals are to be found outside Reserves. Fortunately, we have a good deal of information of this sort at the species list level in the form of county and 'area' lists of invertebrates. In the future, there may be a strong case for surveys of areas outside Reserves and other protected areas to see what has happened to these areas which have not been conserved. I imagine this links in with what Dr. Satchell has said.

SUMMARY

There are three levels of ecological survey of invertebrates, each of which is of importance to the Conservancy.

Surveys of energy flow within the ecosystem are unlikely to be undertaken except in a very few cases.

Surveys of population processes, balance, interaction of populations are likely to be done by Conservancy staff to answer problems of conservation research.

Surveys at the species list and life history level are being undertaken by experts working as amateurs. Not only do such surveys give the Conservancy catalogues of the invertebrates in National Nature Reserves, but they give the only information, in most cases, from which management can be planned and done in the Reserves. Such surveys can also give information on the relative richness of Reserves of similar type and on the possible diversification of habitats.

ORGANIZATION AND PRACTICE OF INTENSIVE SURVEYS

W. O. Steel

As is now perhaps well known, the Shell Company have made available to the Nature Conservancy, an annual sum of money to be used for entomological surveys and my talk deals with problems associated with the planning of these. Some of the points dealt with are applicable to entomological surveys in general but the main concern is with intensive surveys of the type done on Rhum between 1960 and 1963. These surveys are undertaken by entomologists who are not on the Conservancy's staff working for a fortnight or so annually over a number of years in a Reserve out of easy reach of their homes or laboratories. The object of such surveys is simply to find out what is there and where it occurs i.e. to provide an inventory of the insects present together with as much information on their biology, distribution and abundance as can be collected in the time available. For obvious reasons, no quantitative data can be given and the surveys cannot be considered in any way ecological. They may well however serve as bases for future ecological work in the areas concerned.

Having defined the aims of such surveys, it must be decided how they may best be done and here two main methods must be considered. The first, which may conveniently be referred to as the 'bulk' method consists of collecting as many insects as possible using all available means, i.e. beating, sweeping, trapping, soil extractions etc. The material collected is killed and simply bulked in tubes or papers without any examination or selection, except perhaps for size to make packing easier. This method is widely used by expeditions to the Tropics and elsewhere. It is in fact, the only method which can be used in such places where the fauna is very poorly known and it would be time-consuming and pointless to try and identify the insects on the spot. Also in such expeditions, as much as possible must be collected in a short time and the number of collectors is limited. The advantages of the method are that more or less anyone who can recognise insects can be employed for collecting; all orders of insects are covered and no great demands are made on the Survey headquarters, a tent being sufficient. No literature or equipment, other than collecting equipment, is necessary. The disadvantages are that much unnecessary material is collected, some species can be overlooked because they are not specially searched for, there is a danger of destroying habitats by the collecting methods, and a great deal of time has to be spent after the survey in sorting and mounting the material and getting it identified.

Using the second method, which here can well be called the 'selective' method, insects are collected by specialists, each working on his own particular group. The specimens are sorted and identified at the Survey headquarters and the various species present gradually become known. This means that as time goes by, more and more species can be identified in the field and therefore the number of species actually collected becomes progressively smaller. The advantages of this 'selective' method are that relatively few specimens are taken and the chances of any species being overlooked are very much less - it has repeatedly been shown that specialized collecting of a particular group produces more species of this group than does general collecting. Also, any species which are of interest from the biological or distributional point of view are recognized and can be specially searched for or studied. The disadvantages of the method are that specialists must be employed for the survey so that only a part of the insect fauna will normally be dealt with, and provision must be made at the Survey headquarters for identification work using microscopes.

With certain exceptions, the insect fauna of Great Britain is well enough known for surveys of the 'selective' type to be undertaken and the survey sub-committee (of the Nature Conservancy's Entomological Liaison Committee) believes that this method should be used whenever possible. This will, it is hoped, help to guard against overcollecting and above all, against what is probably the greatest danger in entomological surveys, the destruction or alteration of habitats. 'Habitat' as used here means the particular breeding environments of various insects or groups of insects. Not all of these are easily damaged by collecting activities, but some such as dead trees, isolated patches of vegetation or moss on mountain tops can be destroyed or considerably altered in character through thoughtless collecting. This may make it difficult for some species to survive in the Reserve, particularly if it is a small one. 'Selective' surveys have already been satisfactorily carried out at Spurn Head, Malham Tarn and Inverpolly, in addition to Rhum, and they enable the greatest possible use to be made of the time available - collecting can be done during the day and identification and other indoor work in the evenings or in bad weather.

At the present, the main obstacle to the carrying out of surveys is not lack of money but the difficulty in finding personnel to undertake work of the type required. Because the Nature Conservancy is interested in having a certain area surveyed, it does not follow necessarily that the area is of any great interest entomologically, i.e. the number of 'rare' or 'local' species may be very small. On the other hand, many entomologists are primarily collectors whose main interest is the acquisition of as many species as possible. They collect, and perhaps record, only species which are new to them or of which they have not a full series and ignore the rest. This explains why it is often so difficult to obtain accurate information on the distribution of common insects. Such entomologists are obviously unsuitable for survey work, which requires people who, besides being reliable in their identifications, must be prepared to spend several weeks collecting without necessarily seeing any species of particular interest to them. Another qualification which is desirable, though perhaps not essential, is a knowledge of the larval stages of the insects on which they are working. As the survey areas are normally visited for some eight to ten weeks, in the case of the Rhum survey between early June and early September, there is no guarantee that all the insects present will be in the adult stage during the survey. The ability to identify larvae may therefore add to the completeness of the list. It also gives an idea of the type of habitat in which the various species are breeding. The apparent shortage of such entomologists may make some people feel that there is a good case for recruiting less experienced people and being less selective in collecting. If this is done however, another problem will have to be faced, that of getting the material identified. This in itself, can be just as difficult as obtaining specialists to undertake the survey.

The accommodation and facilities available in the area concerned must of course, be considered before a survey can be arranged. Sleeping accommodation in or near some of the remoter Reserves, such as Inverpolly, is very limited and unless it can be augmented considerably, limits the number of people that can take part. The suggestion is made here that perhaps the Conservancy could obtain a caravan to increase the accommodation in such Reserves as and when required. In addition to sleeping accommodation, some form of 'workroom' is necessary where microscopes can be used. This need not be very elaborate but an electricity supply is essential. Although a survey was carried out in the Ainsdale area using caravans without electricity, a great deal of time was wasted because of inadequate lighting. Microscopes could be provided by the Conservancy but it is perhaps more practicable for the survey party to provide their own. There is no danger of loss here as insurance policies which cover all the risks likely to be encountered, can be obtained very cheaply.

It is desirable that the party themselves should not have to cook meals. Experience on Rhum showed that the preparation of meals takes up a great deal of time which could otherwise be used for collecting, more in fact, than might be expected. The saving of time on the last visit to the island when all meals were provided by the Conservancy staff, was very noticeable.

Some form of transport is also desirable to save time in getting from place to place, particularly in large Reserves. In the past, the transport provided for the staff of the Reserve has been used when available and this arrangement has proved to be satisfactory.

Much has been said here regarding the need for specialists for collecting and identification and it may be of interest to non-entomologists to have a rough idea of the number of species involved and the taxonomic state of the various Insect Orders. This is shown in the accompanying tables and gives an idea of the identification problems involved. It must be emphasized that although in many cases it is stated that adequate keys are available, a certain amount of experience, sometimes a large amount, is necessary before these can be used satisfactorily. Even then, named specimens may be needed for comparison before a correct identification can be obtained. Only rarely can a person with little or no knowledge of the subject simply read through a key and identify species.

Table I

Approximate number of British species in the various Insect Orders (excluding parasites of animals and birds)

Apterygote Orders	300
Ephemeroptera	46
Odonata	45
Plecoptera	34
Orthoptera	30
Dermaptera	7
Dictyoptera	8
Psocoptera	70
Hemiptera	1,630
Thysanoptera	160
Neuroptera	60
Mecoptera	4
Trichoptera	192
Lepidoptera	2,200
Coleoptera	3,720
Hymenoptera	6,230
Diptera	5,200
Approximate total:	20,000

Table II

Taxonomic Status of the British Insect Fauna (excluding parasites of animals and birds)

Apterygote Orders - soil living species requiring specialized collecting methods. Not many workers; literature more or less adequate, largely published abroad but in English.

Ephemeroptera, Odonata, Plecoptera - adequate keys available to adults and larvae.

Orthoptera, Dermaptera, Dictyoptera - adequate keys to adults but not to larvae.

Psocoptera - very few workers. French work available on adults and R.Ent.Soc.Handbook in preparation; little published on larvae.

Hemiptera:

Heteroptera - good keys available to adults; no comprehensive key to larvae but at least one person working on these.

Homoptera Auchenorhyncha (leafhoppers) - very few workers; two R.Ent.Soc.Handbooks available, third and final one in preparation. Little known about larvae.

Homoptera Sterorhyncha (aphids, scale insects, whiteflies) - no comprehensive keys, but keys available to some groups. Little known about larvae.

Thysanoptera - very few workers, partial key available. R.Ent.Soc. Handbook in preparation.

Neuroptera, Mecoptera - keys available to larvae and adults.

Trichoptera - several workers, particularly on larvae. British keys to adults out of date but more recent continental keys available. A number of scattered papers on larvae with some keys.

Lepidoptera - adult macros well known; work necessary on micros. Larvae not well known and much work needed, some (continental) keys available.

Coleoptera - adequate keys available to adults of most families and to a few larvae. Interest in larvae on the increase.

Hymenoptera:

Symphyta - adults covered by R.Ent.Soc.Handbooks, at least one fairly comprehensive key to larvae.

Parasitica - a number of people now working on these but a great deal still to be done. At present only a small percentage of some families can be identified and major revisional work is necessary.

Aculeata - reasonably well known and keys available.

Diptera - several workers, some families well known but others much less so and requiring further work. One family, Cecidomyiidae very poorly worked.

Summary of Discussion following papers by Dr. Morris and Mr. Steel

The question of habitat analysis prior to survey was raised. Some Symposium members emphasised the value of this while others thought that it assumed information which the survey was designed to gather. It was pointed out that the recording of information on habitats during a survey could result in a poorer species list being obtained. It was also emphasised that the places where animals are found are not their complete habitats and the importance of larval examination was mentioned in this context. The value of knowing how many specimens of one species must be observed to determine its habitat was also mentioned.

It was agreed that the relative importance to be given to the inventory and ecological types of survey depended on the time and specialists available while the surveys were being done.

SOME FEATURES OF CONSERVATION INTEREST ARISING FROM SURVEYS

A. M. Massee

Introduction

Many of the woodlands in South-East England consist of a variety of trees, of which the introduced sweet chestnut is the predominant species. Other trees commonly growing in these woodlands are oak, hazel, birch, aspen, hawthorn, maple, hornbeam and less commonly, whitethorn, elder and crab apple. Formerly, oak formed the canopy in these woodlands, but the advent of the Second World War combined with the shortage of timber, resulted in most of the oaks being felled.

The trees in these woodlands are grown for periodic cutting or coppicing. The woods are divided into cants, and once in every twelve years or so, each cant is clear-felled. There is a steady demand for the 'bats' and spiles made from sweet chestnut trees. The large chestnut 'bats' form the main framework supports erected in wirework structure used in hop gardens today. The smaller chestnut 'bats' are split and made into spiles and are used for fencing agricultural properties and housing estates. The flora of the newly coppiced part of the woodland may be very rich; such plants as bluebell, primrose, wood anemone and dogs mercury may carpet the floor and in addition, the cuckoo flower, wild strawberry, cow-wheat, golden rod and foxglove often grow freely for two or three years until the vigorous new growths of the sweet chestnut and other trees 'house in' the ground flora, which gradually dies out.

Two examples of woodlands that receive the coppice treatment are the National Nature Reserves of Ham Street Woods and Blean Woods, Kent.

These coppiced woodlands also support a large number of insects of various orders, examples of which will now be discussed in some detail.

The Conservation of Coleoptera, Hemiptera-Heteroptera, Lepidoptera and other insects in woodlands under coppice management.

A very rich insect fauna can be maintained in coppiced woodlands every year provided a reasonable acreage is cut down each winter. This type of management will ensure that trees of all ages from one to twelve years, will always be available to provide the needs of a wide range of insects associated with this kind of habitat. In addition, it is essential to leave a small acreage of trees to mature without cutting, so that the species associated with the older trees will be catered for.

Aspen Coppice

Large areas of young aspen can readily be established when the tree is under coppice management. The metallic, green weevil Byctiscus populi (L.) prefers the young saplings of from one to four years old, and these should always be available to supply the needs of this weevil. The female rolls the edge of the leaf inwards into the shape of a cigarette, and in this dwelling, the eggs are laid. The various stages of the larvae are completed within the rolled leaves, and later on, the adults emerge and feed on the foliage. In rare cases, two or more leaves may be rolled together by the weevil, but this is exceptional. Rutidosoma globulus (Herbst.) is another very local weevil that feeds on aspen leaves of this age group, although it occasionally occurs on willow and poplar also. Aspen from five to ten years old meets the requirements of the three species of the genus Zeugophora (Chrysomelidae) and the larva of the Sallow Kitten Harpyia furcula Clerck. Chrysomelá tremulae F. and its larva are more partial to the young leaves towards the tips of the shoots. The Mirid plant bugs, Brachyarthrum limitatum Fieber and Neomecomma bilineatus (Fallen) inhabit aspen of all ages. The older catkin-bearing aspens provide a suitable habitat for weevils of the genus Dorytomus and the gall-forming longhorn beetle, Saperda populnea (L.). Luperus flavipes (L.) (Chrysomelidae) also inhabits the older trees.

Hazel Coppice

Hazel is the host plant of a wide range of insects, and the fauna varies according to the age group of the trees, in a manner similar to aspen and birch. The young bushes and those up to five years are selected by the metallic green weevil, Byctiscus betulae (L.) and the bright blue variety, cuprinus (Sy.). The life-cycle of this species follows the same pattern as B. populi on aspen. Three very local Chrysomelid beetles, Cryptocephalus coryli (L.), C. sexpunctatus (L.) and C. bipunctatus (L.) are also associated with young bushes, upon which the adults feed and mate. When ready to oviposit, the females move off to much older hazel bushes that support epiphytic plants, mosses and the unicellular green alga, Pleurococcus sp. upon which the casebearing larvae feed. The case is formed of cast skins, excrement and traces of hazel bark. The bushes in the age group five to ten years attract the conspicuous red weevil, Apoderus coryli (L.) and several species of Mirid bugs including Phylus coryli (L.) and Psallus perrisi

(Mulsant and Rey), the latter being normally associated with oak. The older catkin-bearing bushes attract the Pentatomid bug, Palomena prasina (L.) which is confined to fruiting bushes. The partially predacious Mirid bug, Malacocoris chlorizans (Panzer) is especially attached to hazel, but will move to other plants in search of its prey. This is an interesting species that lays its eggs on the shoots near the axil of the buds and they are never inserted into the tissue of the shoots, as is the habit of most species of Mirid bugs. The Eriophyid mite, Phytoptus avellanae Nal. occurs on hazel of all ages, and it is abundant throughout the British Isles. The microscopic mites feed within the buds, which eventually swell considerably and are commonly referred to as 'Big Buds'. The mites also cause a malformation of the female flowers and prevent the fruits setting.

Birch Coppice

Many species of insects are associated with birch, and most of them can be maintained in coppice woodlands provided bushes of various ages are available as food for the herbivorous insects. The Chrysomelid beetle, Cryptocephalus punctiger Payk. is one of the most interesting birch insects noted in the south-east of England. It is a very local and uncommon species that has persisted on a few young birch trees in one corner of Darenth Wood, Kent for the last fifty years. Birch is one of the commonest trees scattered over the hundreds of acres of the wood, and yet this beetle confines itself to one small area, and never seems to extend its range. The adult feeds on the foliage of very young bushes and has not been found on older bushes in the vicinity. In order to have a number of bushes in a suitable condition for the beetle to feed upon, a number of bushes have been cut down most seasons to ensure a constant supply of young growths. Is it too much to hope that this simple method of conservation has partly accounted for this beetle remaining in the same locality for so many years?! As with other species of the genus, C. punctiger disperses to very old birches supporting epiphetic plants, mosses, etc., on the bark where this case-bearing larva feeds. When fully fed, the larva moves on to grasses under the trees and pupation takes place on the grass stems. The black weevil, Magdalis carbonaria (L.) is found on older trees, and its larva feeds in a small cell just under the bark. Two other species of weevil, Curculio betulae (Steph.) and C. rubidus (Gyll.) are specific to birch. The former usually feeds on the foliage growing at the tops of the trees, and the latter species is more catholic and may be found anywhere on the tree. Labidostomus tridentata (L.) (Chrysomelidae) is a very local and uncommon buff-coloured beetle with blue head, thorax and legs. It occurs only on large trees, and the hairy case-bearing larvae feed on the epiphytic plants and other foreign growths associated with old trees. At East Malling, the species selects trees of twenty-five years or more, and it is never found on young bushes. Several Mirid bugs including Psallus betuleti (Fallen) and P. falleni Reuter are specific to birch and sometimes build up large populations. Two species of Pentatomid bug, Elasmostethus interstinctus (L.) and Elasmucha grisea (L.) are confined to fruiting bushes. They deposit their eggs on the foliage and the gregarious immature stages feed on the female catkins. Both species hibernate in the adult state, but are rarely noted during the dormant season.

Chestnut Coppice

The introduced sweet chestnut is strikingly devoid of insects but the very common weevil, Strophosomus melanogrammus (Forst.) is sometimes abundant on the foliage, upon which it feeds. The wood Leopard Moth, Zeuzera pyrina L. is sometimes plentiful in the stems of the pure stands of chestnut, and the larva is familiar to woodcutters who come across it in the course of their work. The chief interest of chestnut coppice centres around the two or three years immediately following the felling of the wood. During this period, the insect fauna is usually very rich. For example, three very local plant bugs are associated with newly coppiced areas of many Kentish woodlands. The red and black Shield bug, Eurydema dominulus (Scop.) (Pentatomidae), largely restricted to Kent, is confined to the cut-down areas of chestnut in which the cuckoo flower grows. The adult feeds on the leaves of the cuckoo flower in April and May and lays its eggs on the stems of the plant. The progency also feed on the leaves and on reaching the adult stage, they first aestivate and later hibernate in thick moss. The species is gregarious; as many as forty or more huddle together in a small area of moss. In April, they seek other newly cut-down areas of woodland where the cuckoo flower grows. In one small experiment, 40 overwintering adults were marked with yellow paint and replaced in the moss. The following May, 8 specimens were recovered on cuckoo flowers some eighty yards away.

The flat bug, Aradus aterrimus Fieber provides another very good example of an insect that disperses from one part of a wood to another to find suitable conditions to enable it to survive. The Aradid was first recorded in England in 1865 when two specimens were found, one in the centre of Norwich and the other at Darenth Wood. In 1930, the species was recorded again, this time in old sacking which contained wood chips. Since 1930, the species has been found many times at East Malling and elsewhere and always in association with piles of chestnut chipping which are infested by fungi. The chestnut chippings are made by woodcutters when making up and sharpening spiles. The chippings are left to rot when the wood is cleared. Adults, larvae and eggs are found in the fungus-infested chippings throughout the year. After two years, the bugs disperse from the chippings because the fungus upon which they feed is crowded out by other species of mould and fungi. It is a most fascinating experience to observe aggregations of the bug swarming on the chippings on a warm day in August. When the sun goes behind a cloud or at dusk, the bugs disperse in the pile of chippings and breed until the pile becomes unsuitable for their survival.

The Stenocephalid bug, Dicranocephalus medius (Mulsant and Rey) is a very local bug that occurs in coppiced wood where wood spurge grows. This very agile bug lays its eggs in the stems of the plant, while the adults feed on the fruits. This species is also partly predacious and runs about rapidly in search of its prey. The bug moves on as the wood grows up and wood spurge dies down. The lace bug, Oncochila simplex (H.-S.) is also associated with this plant, but the bug only occurs in the cut-down areas of the wood.

Unusual insect habitats

It is the custom of woodcutters to burn all surplus wood and chestnut branches not suitable for making spiles, since it is part of their contract not to leave any waste wood about when the coppicing has been completed. Following the fires in the woods, the areas of burnt ground provide ideal situations for certain insects to breed in. In fact, two minute and very uncommon beetles require this kind of habitat. The Histerid beetle, Acritus homoepathicus Woll. and the Staphylinid, Micropeplus tesserula Curt. occur amongst the burnt embers, and are attached to the reddish fungus Pyronema confluens (Discomycetes) which often occurs in such conditions. These two species breed amongst the embers of burnt ground for two seasons and then disperse to other newly cut down parts of the wood.

Stool-oak

Although many of the oaks in Kentish woodlands have been clearfelled, a few stumps usually remain that are one or two feet high. These stool-oaks produce very vigorous growths which are often subject to severe attacks of mildew. The mildewed leaves and shoots provide the food needed by the larvae of the local moth, the Lunar Double Stripe, Minucia lunaris Schiff., a species much sought after by Lepidopterists. It is fortunate the mildewed shoots, which seem to be essential for the rearing of the larva, also occur on the pollarded oaks growing in the hedgerows, because the stool-oaks, once very numerous in the Forestry Commission's property at Ham Street, are rapidly dying because of continual cutting.

The stool-oak is also the habitat of the red weevil with black legs, Attelabus nitens (Scop.), a species rarely found on mature oak although it will survive on 'scrub' oak.

The importance of ivy-growing woodlands

A very rich fauna is often associated with ivy growing on trees, walls, fences etc., and this plant should always be encouraged when possible. For example, very old ivy with black stems provides the habitat for the very local Platystomid beetle, Choragus sheppardi Kirby, a shiny black species that possesses the power of leaping.

The thick stems of old ivy provide the habitat suitable for the Scolytid beetle, Kissophagus hederae (Schmitt), a species resident in Blean Woods Nature Reserve. The Anobiid beetles, Hebodia imperialis (L.) and Ochina ptinoides (Marsh.) are also associated with well-established ivy. The minute ladybird beetle Clithostethus arctuatus (Rossi) may occasionally be found on ivy leaves in October where it feeds on the aphids associated with this plant. The weevil, Liophloeus tessulatus (Müll.) and the variety maurus (Marsh.) both occur where the ivy grows thickly on trees and walls. The beautiful and delicate lace bug, Derephysia foliacea (Fallen) is another inhabitant of this host, and the bug feeds on the newly formed leaves while the Homopteron, Issus coleoptratus (Geoff.) selects the leaves of a more leathery nature.

Summary of Discussion

It was asked how insects at the tops of trees were observed. Observation after gales, roping down of trees and cutting them down were mentioned.

The detailed information given by Dr. Massee for named species was particularly valued and it was suggested that specific observational evidence of this sort was important in conservation to bridge the gaps until detailed experimental work was available for a better basis for management.

The difficulties of identification of specimens and retaining and storage of material were discussed in detail, particularly in relation to standard museum practice. The importance of having material reliably determined was stressed and it was the view of several Symposium members that more taxonomists should be recruited into the Conservancy. The suitability of taxonomic work as 'part-time' research for conservation branch staff was mentioned.

THE ROLE OF INVERTEBRATE COLLECTIONS IN THE CONSERVANCY

Edited summary of talk by

T. Huxley

From time to time since the Conservancy was formed sixteen years ago, staff meetings have considered problems of invertebrate conservation. Generally, discussions have been limited to particular aspects e.g. biological records, invertebrate fauna sections in management plans, a chart of animal habitats for Reserves, collections and surveys. Only rarely have such discussions led to an accepted methodology for coping with invertebrate problems and it would not be unjust to conclude that no Nature Conservancy policy for invertebrate conservation has yet emerged.

The deliberations of the Entomological Liaison Committee reflect this situation. Since its first meeting in March 1958, it has done good service in bringing to the Conservancy's notice the names of places where particular invertebrates require conservation, and it has been invaluable also in clarifying recurring ad hoc problems. Fundamental questions however have seldom found a permanent answer. In this respect, it seems that the Committee has failed, partly perhaps, because of the limited experience of the Conservancy's representatives. It may be that as scientists, we tend to avoid giving positive answers to questions whose matter is not our individual concern; if so, it is pertinent to observe that until the 9th meeting of the Liaison Committee, no member of staff employed full-time on invertebrate work had been present.

The main difficulty about invertebrates is that there are so many of them and that, despite their small average size suggesting simplicity, their autecology is often as complicated as that of vertebrates. Consequently, it is very difficult for a part-timer to be sufficiently informed about invertebrates to make much of a contribution to the problems they create for the Conservancy. The reverse may also be true; the full-timer is often so immersed in his work that he has no spare time to concern himself with wider issues.

It is essential therefore, that we employ more people whose special task is to bridge this gap, but they would need additional work to justify full-time employment; for instance the job of looking after Conservancy invertebrate collections. These have already created a problem in curating and a requirement for extra staff. Because our curators will of necessity be handling all kinds of invertebrates and getting to know the appropriate specialists and literature, they will be in a specially advantageous position to assist in dealing with many of the currently vexing questions which arise from the need for e.g. inventory lists and voucher specimens. The creation of an invertebrate service, based on collections is a natural development of this idea, giving a service similar to the other basic services in the Conservancy. Such a service would not of course, remove all obligations on Conservation Branch staff to think or take action about invertebrates, any more than the existence of the biometrics, geology, climate or library services for example, have done in their respective fields.

Because this idea of an invertebrate service has recurred to me in various forms during the last two years, I used Theme IV as an opportunity for advocating it in public. Theme IV was designed to cover the role of the Conservancy's invertebrate collections, the problem of invertebrate records generally (and especially whether the Reserve record is a suitable method for storing this information), and the need for voucher specimens. In this summary of my contribution, I have not repeated all the information presented by me at the Symposium and the following facts concerning the Conservancy's collections must suffice.

There are four main Conservancy collections and four small ones (see Table 1), containing about as many specimens - at an estimate of four specimens per species - as the 26,000 volumes held in the Conservancy's libraries. Some of the collections are adequately looked after, others are not; only a few are catalogued; none is housed in permanent specially built quarters and only one station (Edinburgh) is doing something about this. The collections have been acquired in several ways; by bequests, requests and collecting by Nature Conservancy staff. Most have been formed as aids to identification and although voucher collections also do this, only one of the larger collections has the holding of voucher material as a main aim. Storage equipment has cost the Conservancy about £900.

The existence of these collections establishes that collections of some kind are necessary for the proper functioning of the Conservancy. This conclusion will still be true even if some parts of collections are held only temporarily by the Conservancy because temporary collections will always remain a small proportion of the total stock held at any one time. Furthermore, just as permanent Conservancy reference collections are bound to enlarge, the Conservancy cannot avoid the additional task of maintaining some sort of minimum voucher collections. Alternative procedures to holding actual voucher specimens for ensuring the validity of National Nature Reserve records have been suggested and found wanting; some kind of voucher system is inevitable and although some Conservancy stations may be able to make arrangements with a local museum which will guarantee to hold their voucher material in perpetuity, others will not be so fortunate and will have to accept a heavy curating burden.

At this point in my talk, I enlarged on the subject of Conservancy servicing sections in general. Although the initial substance of servicing operations is often things e.g. books, maps or files, they also involve people, place, time and expertise. In addition to these five essential elements, there is another factor - extremely important in a democratic organization - a communal acceptance that servicing operations are essential and should be made to work well. The Conservancy has sometimes prided itself that it has not been subject to Parkinson's Law but there is a danger in taking this Law too seriously; without basic internal services, the operational staff, i.e. the people who are directly servicing the public, cannot cope. Fortunately - or unfortunately - according to one's point of view, the outwardly servicing Conservancy staff have become adept at making superficial knowledge go a long way. In respect of invertebrates, organized public pressure has not yet become great enough to show up our basic ignorance.

An important point about a good internal service is that it is generally able to deal with more than its original task. Libraries for example, not only house books but also deal with printing, publications and press cuttings. As an example of another basic service which works well, I described at the Symposium the Edinburgh Office Registry, and as a measure of the communal importance attached to it, I pointed out that scientists as well as administrators had collaborated in its design. A similar collaboration, with scientists taking the lead, is needed to overcome the Conservancy's organizational difficulties concerning invertebrates.

With regard to an invertebrate collections service, I suggested that eventually there might be five reference collections - at Furzebrook, Monks Wood, Merlewood, Bangor and Edinburgh - with a curator in charge of each and clerical assistance guaranteed. Each collection should be housed in a special room with working space for two persons, the additional space being required for visiting taxonomists (for no curator could be expected to identify everything). The final number of reference collections is not important and in recommending five, I meant simply to imply that the collections service must be deployed in several centres in Great Britain as it is essential that curators not only look after specimens collected from Nature Reserves, but also actually visit and themselves collect in some of the Nature Reserves in the group of regions which they service.

Scientific Officers as well as Experimental Officers should be involved in the running of the service. The situation should be avoided of an Experimental Officer stuck away in a corner with some insects, responsible to a Principal Scientific Officer or a Senior Principal Scientific Officer who never gets enough time to help in and guide the work. Indeed, as scientists, the curators should have close links, or perhaps even be directly responsible to the head of the Conservation Research Section, rather than to the Director of the Station in which they are located.

The duties of the collections service would relate to the whole field of invertebrate survey on Reserves, advice on permits to collect, invertebrate data for management plans and invertebrate nomenclature. Eventually, all lists of species now scattered through files and Reserve records should be collated by the appropriate collections service and in this part of their task, the curators would work in close collaboration with the Biological Records Centre.

This idea of a deployed invertebrate (collections) service was the main thought that I wanted to get across at the Symposium. Unfortunately, both in my paper and in the discussion which followed, it got rather lost in the problem of National Nature Reserve voucher specimens. These certainly create an enormous potential commitment which will never be solved until several Stations have tried to tackle it with the full support of the Conservancy. Yet a decision as to whether we try to persuade National Museums to curate our voucher specimens or whether we try to take on the commitment ourselves is of less importance at the present time than that we agree that permission to collect on National Nature Reserves should be subject to the condition that at least one voucher specimen of every species collected be offered to the Conservancy. The specimens need not be accepted of course if we already possess a voucher of it or know where one is located.

There are, I appreciate, dozens of difficulties in this latter proposal and there will be lots of exceptions (i.e. exceptional people) involved. Much more important is the fact that we cannot put this condition on collecting into effect until a deployed collections service is established and this will take many years to become staffed fully. Inevitably, there will be some centres of the Conservancy - perhaps at Monks Wood and Edinburgh - where it may be possible to make better progress than elsewhere. Again this does not matter so long as some progress is made somewhere.

Additional benefits should be felt. Just as the advent of our first full-time applied entomologist at the 9th Meeting of the Entomological Liaison Committee was a turning point in its deliberations, so could the arrival of our first curator be another. From the start, he and later his colleagues, must supply a broad-based invertebrate service. Until in some such manner the Conservancy meets the "outside" world of invertebrate experts half-way, it will not get the best out of them or vice versa. It is because the Conservancy has met the "outside" world half-way in respect of other organisms, notably birds, that we have been so successful in making inroads into the problems of their conservation. The time has now come when the Conservation Branch, working in collaboration with the Conservation Research Section and the Biological Records Centre, should demand that a similar organizational effort be put into the conservation of invertebrates.

Summary of Discussion

In answer to a question which doubted the value of maintaining voucher specimens, Mr. Huxley said that any way in which the volume of work can be reduced is a good thing, and he did not intend that the suggestion to maintain a voucher collection should be applied too rigorously. He thought that eventually ways would be found of doing away with the need for such a system. Mr. Elton asked whether reference collections could be combined with voucher collections in one system.

Mr. Huxley said that although a voucher collection can also function as a reference collection, this did not always work in the reverse way. A reference collection could be bought from entomological suppliers for instance.

Table I

Numbers of species in Conservancy Invertebrate Collections (plus sign = present in unknown numbers; numbers in brackets = sub-totals).

Name	Bangor	Edin-burgh	Furze-brook	Merle-wood	Monks Wood	Nor-wich	Oxford	Rhum
Protozoa) Porifera) Coelenterata)		1		50				
Platyhelminthes		4			+			
Rotatoria								
Nematoda								
Annelida		(25)		(30)				
Polychaeta		7						
Oligochaeta		10		30	+			
Hirudinea		8			+			
Mollusca		(116)	(50)	(50)	+			
Lamellibranchia		15			1			
Gastropoda		101	50	50	6			
ARTHROPODA:								
Crustacea		56	8	10	12			
Myriapoda	+	28	5	30	8			
Arachnida	(45)	(13)	(425)	(274)	(650)			
Opiliones	5	13	4	12	10			
Araneae	40		420	150	490			
Acari			1	110	150			
Pseudoscorpiones				2				
Insecta	(400)	(1114)	(1478)	(1482)	(711)	(165)	(c.250)	(542)
Apterygota			2	60	50	30		
Orthoptera		8	35	5	3	5		
Dermaptera		1	1	1	1			
Plecoptera		13	3	1				
Ephemeroptera		13		6	1			
Odonata		10	20	2	+			7
Hemiptera		162	20	111	100			37
Megaloptera		1	2	2	1			
Neuroptera		4	15	1	10			
Trichoptera		43	30		5			
Lepidoptera		152	700	420				285
Coleoptera	c.200	488	200	500	400	60		79
Hymenoptera		50	100	12	60	60		51
Diptera	c.200	169	350	c.361	80	10		83
TOTAL:	445	1357	1966	1926	1388	165	c.250	542

GENERAL DISCUSSION

During this session on the last afternoon, members raised points which they considered of value to the discussions of the different themes. Although the following is an edited version, we have tried to include a reference to all the subjects discussed in order to place on record the many points of view expressed during the Symposium.

Opening the discussion, E. Duffey said that one of the basic points arising out of the Symposium was that after fifteen years, we were still working on the basis of proposals which were framed seventeen years ago in the 1947 White Paper (Cmd. 7122). Did we not require a re-assessment of the Conservancy's conservation policy, taking into consideration all that had been said about invertebrate studies as well as other wildlife? We could not discuss the problems of invertebrate conservation in isolation from the other commitments of the Conservancy's scientific staff. There had been general agreement among the members of the Symposium that a re-assessment of the scientific objectives of the Conservancy's research programme in relation to conservation was necessary.

A second basic point he said, arose from the papers and discussions on invertebrate surveys. Was there general agreement that surveys on Nature Reserves should be extended and developed in order that the Conservancy and other organizations with similar responsibilities should know what it was we were trying to conserve? In short, did we not need a national inventory of wildlife on Nature Reserves?

J. Eggeling said that in Scotland, the first task was to include representatives of major habitats on Nature Reserves, judged in the first instance from the botanical interest. A statement of the Conservancy's policy as a whole was certainly needed. He had mentioned this word "interest" because it was used in a variety of ways. Among the Conservancy's staff, it was generally understood, but it was not always clear to others. "Interest" should be defined so that policy about the preservation of habitats and species could be known. It was not known at present how far we were prepared to go to safeguard rare species on Reserves in relation to preservation of the habitat. This also tied up with the request that we should have wildlife surveys on land outside Nature Reserves.

J. Satchell supported what Dr. Eggeling had said and felt that a clear statement should be made of what our aims should be in relation to the conservation of invertebrates. Maintenance of habitat diversity should be accepted as the primary aim, but another aim should be the preservation of particular species of special interest. He would like to see written into the recommendations of the Symposium an expression of the view that these aims could best be achieved on an international basis. He pointed out that a number of important invertebrate communities, especially marine and freshwater ones, were not well represented in the current series of Reserves. The "interest" that a particular species had might be scientific (e.g. relict species) or aesthetic, of appeal to the general public.

C. Elton wished to clarify one point which affected the early history of the Nature Conservancy. At that time Captain Diver considered the possibility of having a large staff trained in taxonomy to do survey and inventory work, but instead an organisation of regional officers was instituted and a great deal had developed from that. There had never been a policy or a feeling that, because of the Charter, the Conservancy was under an obligation to make inventories in its Reserves although it was assumed that these would be done. Mr. Elton thought that it was more important to collect and convert this information into a fund of knowledge by making scientific studies on Reserves. Some Reserves had been established largely for one species, e.g. Havergate Island for the Avocet. Was it necessary to make a survey of the mud in which the Avocet fed? Some system of priorities should be established in cases of this sort. He said that the point he wished to make was that we should attempt the possible, not the impossible.

F. Perring referred to Dr. Satchell's second point about the preservation of species of particular interest and wondered whether the acquisition of land where they occurred could be the responsibility of Naturalists' Trusts rather than the Conservancy. The Botanical Society of the British Isles was doing this through information gained by the inventory method. In many cases, small areas of an acre or so would be an embarrassment to the Nature Conservancy, yet there was a case for their preservation because of the existence of a rarity.

E. Duffey wondered whether the Conservancy accepted the commitment to conserve rare animal species, and how rarity was assessed. Dr. Satchell had given some guidance on one aspect of this, but when selecting Reserves, how was information about the rarity of species to be used? Were the criteria the same for all animals, or were there different standards for birds compared with invertebrates?

J. Satchell said that what he had in mind when he mentioned an international view-point was that priority should be given to the endemic species of this country and those which have their main centres of distribution in Britain. Other countries should be encouraged to do likewise through the International Union for the Conservation of Nature, so that a more comprehensive and more scientifically based policy of conservation could be formulated.

J. Frazer asked whether it was not possible that an interesting animal species might move away from a Reserve established for its protection. He also wondered at what point in time introduced species could be regarded as having become naturalised.

W. O. Steel gave as an example a species of beetle from New Zealand, first recorded in 1940, which was now breeding in Berkshire. He also mentioned two other New Zealand species of the same genus. One, first recorded in 1870, was now one of the commonest British beetles; the other had come in just before the War and now extended as far as Yorkshire. On this evidence, some species could become naturalised within twenty years.

C. Elton was of the opinion that such species should be studied but that no special effort should be made to preserve them.

J. Eggeling stressed the difference between England and Wales on the one hand and Scotland on the other in regard to their Naturalists' Trusts. There was no likelihood that the whole of Scotland would be covered by County Trusts, yet there were just as many hazards to animal and plant populations of interest in Scotland as in England and Wales.

Several members then spoke on the problems of carrying out a national inventory of wildlife, both inside and outside National Nature Reserves. Suggestions included the publication of a monthly conservation journal in which information about interesting species and their distribution could be made available to Conservancy staff. It was suggested that taxonomic specialists should be consulted to find out which species were in danger and other members thought that the Conservancy should have its own taxonomists to cope with the problem of surveying the wildlife on National Nature Reserves. The argument again came round to the question of rarity and how this should be defined in relation to the Conservancy's commitments. The 1947 White Paper was referred to, particularly the proposal which stated that "A representative sample of the British fauna and flora" should be preserved on the National Series of Nature Reserves.

C. Elton stated that there were rare species which were special cases, e.g. the Avocet, but that it was better not to emphasize them too much. On Wytham Hill near Oxford, there were 6,000 - 7,000 species of animals, and so one fifth of the British fauna occurred on two square miles of English countryside. On 120 National Nature Reserves, he would have thought that nearly all the species of the British fauna were reserved including most of the rarities.

N. Moore asked whether it was agreed that as many species as possible should be conserved so that they could be passed on to future generations. The rare ones should be conserved as far as resources permitted. Richness of flora and fauna must be maintained, endemic species conserved, and certain butterflies and birds protected for aesthetic and educational reasons.

R. Goodier said that the maintenance of diversity was a main aim according to many participants in the Symposium, but that it could not be applied in all cases. It had not been too difficult to obtain a representative selection of different major habitats, but diversity in relation to the multitude of the British fauna was impossible to achieve. Diversity could be established in relation to vegetation, but not in the same sense to soils and climate. Diversity should not be introduced at the expense of some other factor which was worth conserving. In the selection of characteristic habitats which were represented on National Nature Reserves, a certain minimal area for each was implicit, so that they could survive and their faunas with them. They must not be endangered in an attempt to achieve maximum diversity.

J. G. Skellam endorsed Mr. Goodier's remarks and said that certain types of uniformity were necessary to enhance scientific knowledge.

N. Moore denied that it was his intention that diversification should destroy an existing habitat; if it did so, it could not be supported.

T. Huxley agreed that it was impossible to include the requirements of all 20,000 British insects on National Nature Reserves but pointed out that in practice, some approximation to this was being attempted when additional habitats desired on National Nature Reserves were being defined. Although the Conservancy began by defining in very broad terms what should be included on Nature Reserves, they were now chosen - woodlands for instance - on the basis of a dominant species. The same principle might form a similar basis for the selection of future reserves for invertebrates; action of this sort would be needed to safeguard endemic and rare species.

R. Steele replied that woodland reserves were not selected purely on the basis of dominant species but that broader principles were taken into account.

M. G. Morris warned against such attitudes that "if the flora was conserved the fauna looked after itself" and asked members of the Symposium to keep the exceptions in mind.

C. Elton pointed out that the habitat classification in management plans went beyond this to include animal habitats such as dead wood.

A. M. Massee referred to the Coleoptera of Moccas Deer Park where an exceptional fauna occurred in a very limited area. He deprecated any suggestion that such places should be left out of the National Nature Reserves Series because the insects were not so rare on the Continent.

M. Labern mentioned the value of survey work in assessing the success or failure of management in two major woodland reserves in the south-east region.

J. Phillips said that an attempt was being made to perpetuate coppice-with-standards on those reserves and that it would be valuable to know whether there were invertebrate species of such conditions which would indicate which form of management to use.

J. G. Skellam pointed out that survey work was done for a special purpose. It could be a means to an end for the selection of the best site for a nature reserve, or to measure the success of conservation practice. The aims of a survey should be clearly stated.

E. Duffey said that the ignorance on management research for invertebrates had been abundantly illustrated. He stated that two useful types of investigation were intensive studies on single species in relation to their habitats, and studies of the faunas of particular habitats which were changing or being modified in some way. It was better to take a limited problem and expand this in relation to the most useful lines worth following. To do this, many more applied ecologists were required and he suggested that this need should be emphasized to the Conservancy.

J. Dempster said that if the principle that special species must be conserved were accepted, then more information was required on what was governing the numbers of the species. It was necessary to know the pattern of behaviour of the species in the field and more about its general biology.

C. Elton mentioned that for many years, he had stressed the need for more studies on populations.

In the final part of the Discussion, reference was made to the practical problems of scientific survey and inventory work. It was emphasized that as this is a national problem, all scientific staff should be encouraged to contribute in some way or other. On the question of storing and indexing the data, it was generally agreed that one or two centres would be sufficient at the present time; the Edinburgh office for Scotland and Monks Wood Experimental Station for England and Wales. With regard to the latter, the Conservation Research Section would act as a collating body while the processed material would be stored by the Biological Records Centre. It was pointed out however, that this task could not be undertaken without additional staff.