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Conserving Britain's rarest moths

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Summary

The work of the Joint Nature Conservation Committee Moth Conservation Project has several components. The first involves servicing a national network of recorders which was set up in the winter of 1990/91 to trawl information on the current national distribution, status and conservation requirements of the rarer species of macro-moths in Britain. The information collected is being used to organise surveys and produce national surveys and produce national distribution maps, data sheets and a bibliography for the rarer moths. The rarer macro-moths have been defined as those species believed to occur in less than one hundred of the 10 km squares in Britain. Approximately 280 of the 730 or more macro-moth species that breed in Britain are in this category now. The collected information is used by the government conservation agencies to identify important breeding sites and advise on their management. Since its inception in 1987 the Moth Conservation Project has also been involved in devising and assisting practical conservation measures for a number of rare moths including six species of moths which receive legal protection in Britain and are listed on Schedule 5 of the Wildlife and Countryside Act 1981 and 1988 amendment. These six are *Zygaena viciae argyllensis* Tremewan, *Thetidia smaragdaria maritima* Prout, *Pareulype berberata* Denis & Schiffermüller, *Siona lineata* Scopoli, *Acosmetia caliginosa* Hübner and *Hadena irregularis* Hufnagel. Practical conservation measures for these species include site protection and defence, management work, ecological studies, captive breeding and translocation to establish new breeding colonies. The Moth Conservation Project also liaises with and promotes the work of a large number of other organisations and individuals involved in moth recording and conservation to raise public awareness and provide a national overview.

Introduction

This paper reports on the work of the Moth Conservation Project which was started by the Nature Conservancy Council (NCC) in 1987 and subsequently passed to one of its four successor organisations, the Joint Nature Conservation Committee (JNCC) following the reorganisation of the UK

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government conservation agency in April 1991. The JNCC is the UK government agency responsible for promoting nature conservation at the UK and international levels and is the coordinating body for the three separate country agencies of England (English Nature), Scotland (Scottish Natural Heritage) and Wales (Countryside Council for Wales). The author has been responsible for the Moth Conservation Project since its inception and the work has consisted of four main tasks. These are:

— to identify which species are where, keep the information up to date and actively encourage recording effort ;

— draw up a list of the species in greatest need of conservation ;

— organise, coordinate and promote practical conservation measures ;

— promote greater awareness of moths and other invertebrate animals and their value as indicators of habitat quality and change.

Details of these activities have been provided by WARING (1988a ; 1989a,b,c ; 1990a,b,c ; 1991a,b,c,d ; 1992a,b,c) and references contained therein. This paper is intended as a summary and guide.

Locating and documenting the resource

In Britain there is a long history of recording moth distribution and abundance. FUST (1868) provides an early account of the distribution of moths in Britain. More recently the late John Heath (based at the Biological Records Centre (BRC), Institute of Terrestrial Ecology, Monks Wood) organised a national recording scheme and this has formed the basis for the distribution maps which have been published in HEATH & EMMET (1976-1991). The recording scheme was discontinued due to lack of resources on the retirement of John Heath in 1982. There has been no decrease in the amount of voluntary recording effort however. The author estimates that several thousand light-traps are operated by private individuals and organisations each year in Britain and covering many more locations. There is a strong tradition of local recording which extends back more than two hundred years. For consistency local schemes are usually based on the Watsonian vice-county system which continues to be strongly advocated (MORRIS, 1990). Local lists continue to be published on a regular basis and often provide information on the habits and phenology of species. Increasingly the county lists are including distribution maps as well. CHALMERS-HUNT (1989) provides a recent bibliography of local lists. In addition the Rothamsted Insect Survey continues to maintain a network of nearly one hundred light-traps which are operated every night of the year throughout Britain. So far it has not been possible to set up a national recording scheme again that is capable of processing all the moth data that is being collected in Britain. At the same time conservation organisations frequently require greater detail about the occurrence of certain species than the basic grid reference and date class collected by John Heath's scheme. To provide the information required in conservation issues the

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Nature Conservancy Council developed the Invertebrate Site Register (ISR) in 1979, with computerisation of the data-base from 1986 onwards. The ISR aims to maintain files on all UK sites of known invertebrate importance and to supply information about the species of conservation interest for use in site evaluation, protection, defence and management. Currently the ISR holds files on some 8500 sites. Many sources of information have been trawled to prepare short-lists of species which are nationally rare, restricted to particular habitats or are of conservation interest for some other reason, such as a population subject to long-term study. The ISR stores and retrieves this information. The data can be accessed by species rather than by site to allow compilation of a list of sites at which a particular species has been recorded or for production of a distribution map.

Hadley (1983 ; 1984) was the first to compile a list of the nationally scarce macro-moths. This was produced by using the BRC maps and by drawing on the experience of active field workers in the major British entomological societies. For the macro-moths, which may be regarded as those species included in Skinner (1984), the nationally scarce species were defined as those recorded since 1960 from less than one hundred of the 10km squares in the Ordnance Survey National Grid which covers the UK. This amounted to some 256 species. Hadley (1983) also drew on local lists to define additional species of regional interest. Since then information on these species has been entered on the ISR. A Red Data Book (Shirt, 1987), compiled at the same time and published in 1987, lists the species recorded from fifteen or fewer of the 10km squares and categorises these as endangered, vulnerable or rare on the basis of known threats to the sites in which they occur. This list includes 99 species or subspecies of macro-moths.

The Moth Conservation Project has been able to draw on the above publications and on the facilities and data in the ISR. The first step was to issue a list compiled from Hadley (1984) and Shirt (1987) and trawl in the data on these species from the years since 1980. This information has been used to compile up to date distribution maps and see if the species still merit their existing conservation status. Information on a further 80 localised species was also requested to assess whether any had moved into the nationally scarce category based on their status from 1980 onwards. The information was collected by contacting all existing county recorders, active field workers and by extracting records from the national entomological journals. In addition the Rothamsted Insect Survey kindly supplied copies of their records on disc and the Biological Records Centre have provided their data which enables comparison of distributions pre- and post-1980. At the time of writing, virtually all the data required for production of maps of the scarce species has been entered onto computer and maps such as Fig. 1 are being prepared for circulation to recorders for checking. This new generation of maps uses 1980 onwards to distinguish recent records and larger spot sizes to indicate multiple records of adults from the same 10 km square or evidence of breeding such as reports of immature stages. This is intended

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to focus attention on breeding colonies and distinguish them from records which may refer to vagrant specimens. The current generation of recorders is not in the habit of sending in details of numbers of moths seen and is mainly oriented to work with light-traps but it is hoped that the new maps will promote valuable work on larvae. At present it is true to say that much more information is being collected from the field than the national organisations are capable of trawling and processing and that the latter have been the weak link in the chain. During 1992 it is intended that an Atlas of up to date distribution maps and an accompanying text will be prepared for JNCC. This will make available the information collected so far.

Preparation of a list of nationally scarce macro-moths

The new maps will be used to define the current nationally scarce species. It is quite clear from the results that some species have increased and others have declined in range dramatically in the last ten years, even allowing for possible differences in recording effort and coverage. A good example is that of *Thera juniperata*. Since the last distribution map of this species was published (in WARD, 1977), *T. juniperata* has extended its range greatly, in part dispersed as immature stages on young juniper bushes (*Juniperus* spp.) which have become popular with gardeners in the Midland counties and elsewhere (WARING, 1992b). The current situation (Fig. 1) is very different from the mid-1970s and before, when *T. juniperata* was largely confined to parts of Scotland and to the chalk of south-eastern England. Some species have expanded their ranges greatly over the same time span, such as *Rhyacia simulans*, with no apparent assistance from man, while others have declined. Published map information and recording effort has sometimes proved to be a less than adequate indication of the real situation. The map of *Cucullia lychnitis* in HEATH & EMMET (1983) shows records from only three 10 km squares in mainland Britain since 1960. A survey of this species in 1991 (WARING, 1992c) discovered post-1960 records from several other localities and that the species has bred in at least sixteen 10 km squares since 1980. It was found to be occupying almost all of these in 1991.

Practical conservation measures for nationally scarce species

National reviews and mapping projects are on-going but can become ends in themselves. The purpose of NCC and JNCC involvement has always been to use these as tools to launch and sustain practical conservation measures for the species in greatest need. When the Moth Conservation Project was started in 1987 the rarest species of macro-moth had already been identified and five of the species listed in SHIRT (1987) as endangered had been given legal protection from collection and sale since 1981 under the terms of Schedule 5 of the Wildlife and Countryside Act of 1981. A sixth species had been proposed for inclusion in the quinquennial review of 1986 and was added in an amendment to the Act in 1988. A first priority in 1987 was to investigate the current status of the protected species on the ground.

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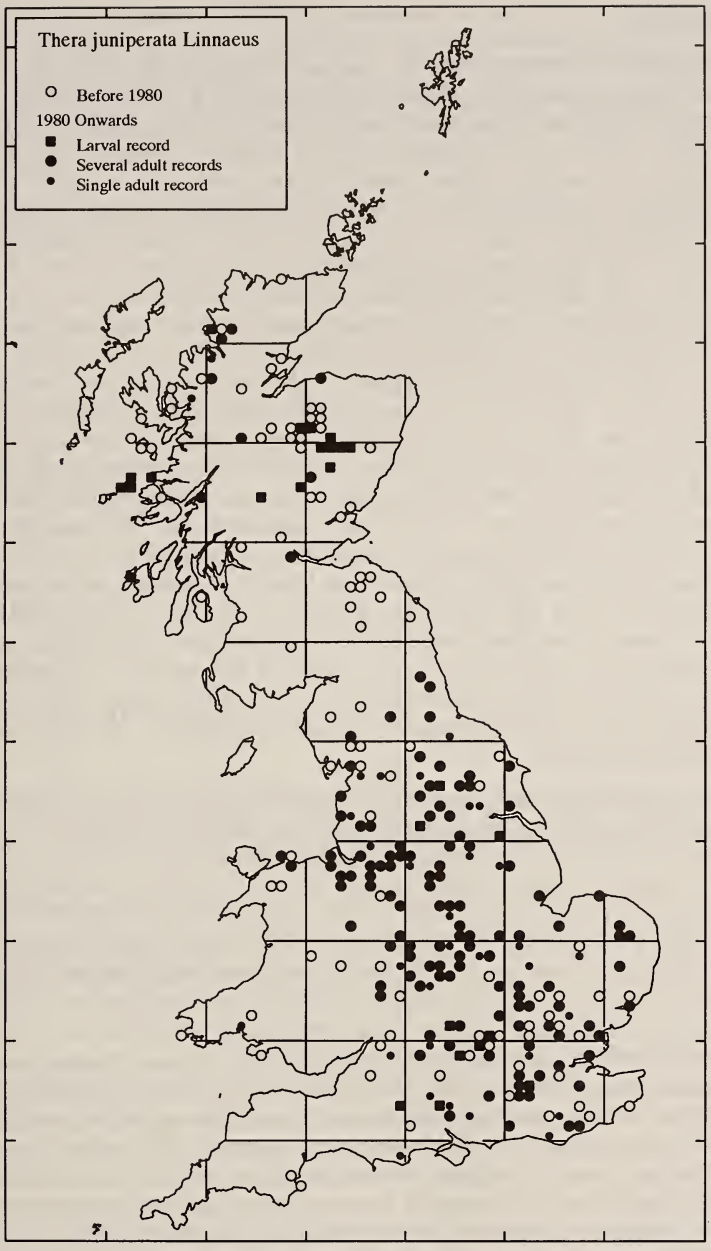

Fig. 1. The distribution of *Thera juniperata* L. in Britain.

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Siona lineata

Within weeks of starting the post, work commenced on *Siona lineata*. This species is now confined in Britain to two fields of rank grassland in Kent although in the past it was more widespread (Waring, 1988a ; 1990a). The local NCC office had been sent a copy of a paper in draft which had been submitted to a leading British entomological journal by a highly respected entomologist complaining about the mis-management of part of one of the two remaining sites which is a National Nature Reserve. Sheep had been allowed to hard-graze part of the site and had reduced the turf height to less than 2 cm. which entomologists consider is much too short to provide suitable conditions for the moth to breed. Meetings were held with the regional staff responsible for the reserve and with the author of the draft. It soon became clear that although numbers of the adult moth had been counted annually since 1976 on a transect walk used for monitoring butterfly populations on the site, the ecological requirements of the moth and its immature stages were poorly known. The larval food-plant in the wild was generally considered to be *Brachypodium pinnatum*, upon which wild females had been seen laying and it was also considered that the tussocks of this plant probably provided important over-wintering refuges for the larvae. These impressions have had major implications when determining and reviewing the management of the site. The hard-grazing of part of the site had been an accident caused when sheep were penned there because of problems with stray dogs elsewhere on the site. In other parts of the reserve *B. pinnatum* was rampant to the virtual exclusion of other herbs and grasses. The moth was now absent from the hard-grazed site and dwindling in numbers elsewhere for unknown reasons.

Other entomologists were contacted immediately and it became apparent that no one had reared *S. lineata* successfully in captivity in Britain, at least not recently, in spite of several attempts supplying both grasses and dicotyledonous herbs. A literature search suggested that the latter was the more likely pabulum (e.g. Scorer, 1913 ; Skou, 1986). Field observations that summer confirmed the habit of ovipositing on *B. pinnatum* and other grasses and some eggs were collected for rearing. In a choice experiment newly hatched larvae were offered the range of common herbs available at the breeding site. From these they selected *Origanum vulgare* upon which they proceeded to develop. As the larvae grew in size they were transferred to as near natural conditions as possible, using potted turves from the site. The potted turves were enclosed in nets out of doors and the larvae were released into these before the winter to study their habits. Overwintering was successful and seven larvae were reared to adult on *O. vulgare*. Subsequently larvae have been found in the wild in association with damaged leaves of *O. vulgare* upon which they have fed. *B. pinnatum* appears to be important in providing daily roosting and basking sites for the larvae, which match the dry stems in colour, and in providing spinning sites for the zygaenid-like spindle-shaped cocoon this species produces. Full details and photographs of this work are given in Waring (1988a ; 1989a and 1990a).

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Following the ecological work, the management of the parts of the site which the moth occupies has been modified to create a balance between sufficient *B. pinnatum* and abundant *O. vulgare*. In 1991 numbers of adult moths counted on the transect walk were higher than in any year since 1979 (Fig. 2), although this is probably the result of the dry weather and high temperatures experienced in 1990/91 as well as the management.

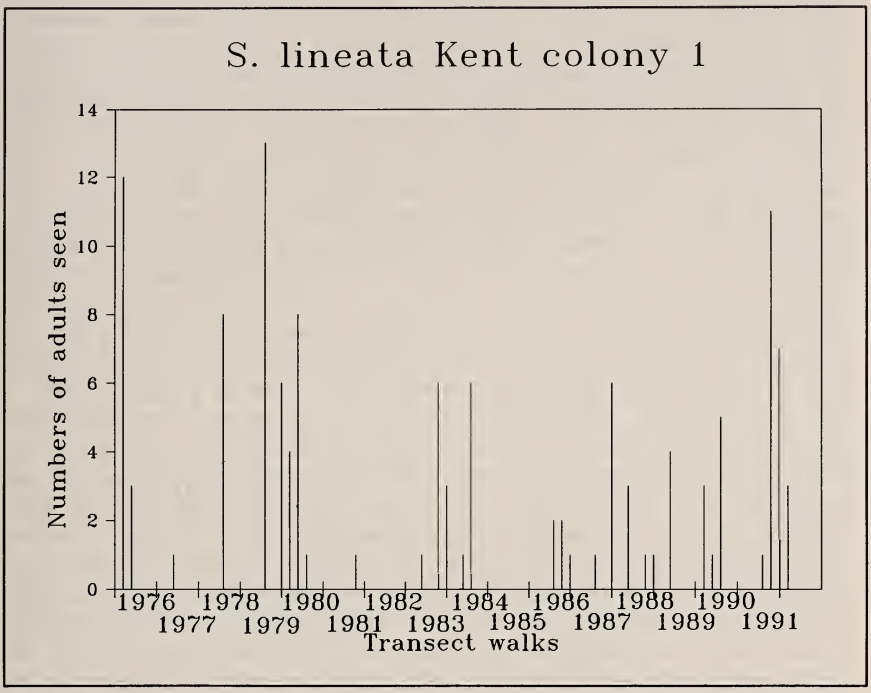

Fig. 2. The number of *Siona lineata* Scop. adults seen at one of the two known localities in Britain between the years 1976 and 1991.

Other work on *S. lineata* during the project has included monitoring the effects of an accidental fire which burned 10% of the site of the second remaining colony. It has been demonstrated that the moth will recolonise an area burned in May as early as the growing season of the following year, at which time adults have been seen ovipositing and the resulting larvae located later in the year. Searches for the moth in other fragments of rank chalk grassland elsewhere in Kent and in possible former localities in Dorset and Somerset have been organised but the moth has been found at none. Management to recover a former site in Kent at which the moth occurred up to 1984 has been set in motion and the second of the two known colonies has been

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scheduled a Site of Special Scientific Interest (SSSI) which confers a measure of protection from changes in land use under the terms of the Wildlife and Countryside Act 1981.

All five of the other Schedule 5 protected species have been given attention.

Acosmetia caliginosa

A. caliginosa had not been seen since 1984 and seems to have died out from both of its last known sites which were the edges of rides in conifer plantations on the Isle of Wight. The moth was described in NCC files as a creature of woodland rides and requiring sensitive ride-side management. Surveys for the moth were organised in 1987 (for larvae) and 1988 (for adults) and these covered former sites and a number of others known to support the larval food-plant *Serratula tinctoria.* A strong colony of the moth was discovered surviving on a site from which it had been reported nearly forty years previously and the breeding grounds were found to extend into a neighbouring property (Waring, 1990a,b). Both of these sites are open heathland and the larvae have since been found on plants of *S. tinctoria* growing in full sun amongst sparse vegetation — a much drier and warmer situation than the lush conditions which now exist in the edges of the plantation rides. As with *S. lineata*, this single discovery has profound implications for management and the shade from conifers and scrub is now seen as a major threat to the species. At one of the former sites scrub invasion has been cleared and nearly 800 larvae were reared and released in 1989 in an experiment to see if a colony can be established. The larval food-plant is now abundant and adults produced by the original larvae were recorded at light-traps in 1990. No adults were found when light-trapping took place in 1991 but this coincided with an extended period of adverse weather during which many species known to be resident were not recorded. Light-traps will be operated at the site again in 1992. The knowledge gained during this study indicates that this is currently a sub-optimal site. Owing to the small size of this woodland clearing and the proximity of trees and shrubs, it has been necessary to coppice the site every second winter to control the woodland regeneration and in spite of this treatment conditions at this site differ substantially from the surviving breeding grounds on heathland. The situation will not be resolved without clearance of a much larger area and use of domestic animals or other means to keep woody growth at bay.

Interest in establishing colonies of *A. caliginosa* continues, with the aim of replacing colonies that have been lost because of adverse management in the last forty years and because the species now appears to be restricted to what is basically one locality. The possibility of a return of the insect to the mainland, from which it was last seen in 1961, is being investigated by English Nature as part of their Species Recovery Plan. Meanwhile negotiations are underway to maintain and improve management at the remaining colony. Some adjacent scrub has been cleared to extend the size of the breeding grounds and further scrub clearance followed by rotational management is planned.

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Pareulype berberata

The third of the Schedule 5 species, *Pareulype berberata*, was formerly widespread in Britain and reached at least as far north as Yorkshire (Waring, 1989a,b ; 1990a ; 1991c) although there is also a record from Scotland. During the late nineteenth century it was discovered that the larval food-plant, *Berberis vulgaris*, was a host of the wheat rust *Puccinia graminis* and there began an extensive campaign to eradicate *B. vulgaris* from field hedgerows and wood margins and this resulted in the loss of colonies of the moth (Barrett, 1902). There is evidence that the practice of *Berberis* destruction continues today to some extent even though modern wheat strains are resistant to the rust. Additional losses have been caused by general grubbing out of hedgerows to increase the size of fields to accommodate modern farming methods and by fires resulting from badly controlled stubble burning (Waring, 1989b ; 1991c). By the late 1970s the moth was apparently reduced to a single colony in Suffolk. This colony, which has been known since the 1860s (Waring, 1989b), has been eroded in size as bushes have been removed to accommodate improvements in nearby roads. During the 1970s the whole site was threatened with obliteration because it was in the proposed route of a new by-pass. Fortunately the eventual route taken by the by-pass narrowly avoids the site. In 1983 vandals started a fire which scorched some of the best bushes. Because of the precarious nature of this remaining colony a captive stock was established from a single female captured in May 1988. This stock has been used in three establishment trials aimed at setting up new colonies. The discovery in 1991 of larvae of a successor generation at one of the establishment sites suggests that the trial may be on the way to success. The necessity of such extreme and time-consuming measures for these species was emphasised in August 1991 when an accidental fire at the donor site burned 73% of the *Berberis* at this colony at a time when the larvae were feeding. The entire standing volume of *Berberis* before the fire was estimated to occupy only 120 m^3 (Waring, 1989b) and there is currently doubt as to whether any *P. berberata* have survived to recolonise the site if and when the *Berberis* recovers from the fire. Arrangements are underway to propagate new bushes to replace those that have been lost over the years. Meanwhile a second colony of the moth has been discovered by investigating old records of occasional adults taken at light in Gloucestershire (Waring, 1991c) and arrangements have been made to protect these breeding grounds. Surveys of a number of other sites with the potential to support colonies have been conducted (e.g. Waring, 1992a), so far without finding any more colonies. However the capture of a single adult female at light in 1990 in Hampshire suggests that at least one undiscovered colony survives so the search will continue.

Zygaena viciae and *Thetidia smaragdaria*

Two more of the Schedule 5 species are *Zygaena viciae* and *Thetidia smaragdaria*. Both of these have been covered by extensive surveys, monitoring of their single known colonies and ecological studies which are still underway.

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Further details are provided by Barbour & Waring (1991) and Waring (1989c ; 1990c). The latter species has been the subject of a major captive rearing programme aimed at building up numbers of larvae for return to the wild. This has not been an easy job with this species. Whereas it was possible to produce over 1000 larvae from a few *A. caliginosa* females within one generation, *T. smaragdaria* has been much less accommodating. During 1987 only eleven larvae were found in the wild after a major survey of the Essex and Kent salt marshes to which this species has always been confined in Britain. These were used to establish a captive stock (Waring, 1989c). The females are capable of laying only 70 or 80 eggs as a rule and it has been our experience that many lay fewer or none. From eleven pre-hibernation larvae in autumn 1987 numbers have been raised in captivity to over 100 in autumn 1988 and over 600 in autumn 1989. In 1990 the captive stock was dispersed between several entomologists skilled in breeding moths and arrangements were made for releases of the progeny into the wild. However breeding success was extremely poor and resulted in just over 100 larvae only in autumn 1990. From the resulting adults over 400 larvae were reared in autumn 1991 and at least 350 have survived the 1991/92 winter. This is barely sufficient for establishment trials and many fewer than we would have expected after five years of hard work and much care. The reason for such poor reproductive success, which is a common experience among those maintaining captive moth populations, is usually attributed to inbreeding. There is no denying that the captive stock of *T. smaragdaria* is inbred. Neither of the two colonies that have been recorded in the last fifteen years have numbered more than 100 larvae at any point during this time so inbreeding has been inevitable. Another reason for the poor reproductive success could be a build up of pathogens in these small inbred populations. Larvae have been reared at low density on new potted food-plants each year and have not displayed the characteristic symptoms of viral diseases. In fact larval mortality has been very low in each generation. The poor reproductive success stems from the fact that many adults fail to pair or pair but produce few eggs or infertile ones. Arrangements are being made for specialists to examine the stock for protozoan and viral infections during 1992. One technique for reducing the possibilities of virus transmission is to surface-sterilise the eggs with a dilute solution of formaldehyde and in 1991 this was applied to a small batch of eggs to establish whether *T. smaragdaria* eggs would survive this treatment. The hatch rate was very poor in both the treated sample and a control batch from the same females. This treatment greatly increases the time that has to be spent on the culture. Protozoan infections can be controlled using drugs sprayed onto the food-plant for the larvae to ingest. Depending on the results of the examinations for pathogens, these treatments may be applied to part of the captive stock in the future.

Meanwhile the numbers of larvae found in late summer counts at the last-known wild colony in Britain have declined from 56 in 1988 to 27 in 1989, 28 in 1990 and none in 1991. The causes of loss of previous colonies have been variously attributed to land reclamation, sea-wall construction and main-

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tenance, removal of large numbers of larvae by insect collectors, crowding of the larval food-plant, *Artemisia maritima*, by coarse grasses and trampling by domestic livestock. There is no evidence that any of these factors are responsible for the decline at the last-known colony, although a fire narrowly missed wiping out the colony in 1989. Could it be that such small colonies, reduced to fragments of their former habitat, can ultimately become too inbred or disease-laden to remain viable even if their immediate habitat remains suitable? Hence the importance of the pathogen tests.

Hadena irregularis

The latest addition to the list of moths to be given legal protection in the UK, *Hadena irregularis*, was added to Schedule 5 in 1988. The same year a major survey was organised covering all the known sites for the larval food-plant, *Silene otites*, which has been the subject of botanical surveys in recent years. The plant is confined to the East Anglian Breckland area. No larvae were found. A second survey, in 1989, covered the most promising areas again but with negative results. Subsequent enquiries indicate that the moth had almost certainly declined to extinction some years before it was proposed for inclusion on Schedule 5. The last known sighting was in 1977. This case draws attention to the need for improved and continuous monitoring of the rarest species so that the current status is always known. With only irregular surveys and out of date information species are being lost before we have time to realise and react to their decline.

Other work

While this account has concentrated on the Schedule 5 species, the breeding grounds of many other rare moths have been visited during the last five years. Surveys have been organised and assistance given in protecting and managing sites all over the UK, from the steep coastal slope inhabited by *Z. viciae argyllensis* in western Scotland to the sand-bank occupied by *Luperina nickerlii leechi* in the extreme south-west of England, the estuary on the coast of eastern England where *Gortyna borelii* resides, to the bog in west Wales where the larvae of *Eugraphe subrosea* are counted every year. The responses of moths to various types of management such as coppicing and conifer planting in ancient broad-leaved woodland, fenland management and the harvesting of wild-flower seed in hay-meadows have been examined (Waring, 1988a,b ; 1989d ; 1990d ; Waring & Haggett, 1991). A large number of independently organised moth recording and conservation projects have been promoted via publications and radio and television broadcasts and it is apparent that moths and moth conservation enjoy a higher profile now than at the inception of the project.

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The future for moth conservation in the UK

Central to the development of moth conservation in the 1990s is the need to find means of sustaining a long-term programme of action. Conservation efforts remain piecemeal and sporadic, sometimes subject to the vagaries of funding but more often critically dependent on the enthusiasm and time of highly motivated local volunteers. The latter are the most valuable conservation resource. Much can be achieved simply by providing a national overview in the context of which the importance of particular local projects can be seen and attention focused. Local action groups thrive on encouragement and the realisation that what they are doing is recognised to be of value by others outside the group. There is no doubt that county-based recording will continue to thrive and that more detail will be recorded as computers and other aids make it easier to process and retrieve this information. This will be of increasing use in local conservation issues. However a national recording scheme is needed to encourage recorders to poorly worked areas and to aid the interpretation of local data. Hopefully the production of the Atlas of rarer moths will stimulate many more local projects but past experience with the Red Data Book (Shirt, 1987) suggests that this alone may be insufficient to ensure that the rarer species are conserved. Promoting recording and making recommendations for action is one thing, the logistics of ecological study and practical conservation measures can rapidly require full-time commitment to achieve even modest progress. Within the conservation organisations staff that are able to build such projects into their work programme for a few days or weeks per year and contractors and researchers wishing to tackle these jobs also find an up to date national information network useful to quickly locate other colonies or experience. This is apparent from the number of enquiries the author receives. With so much of this service now in place it is hoped that ways and means can be found to continue and build upon it in the years to come. As it is increasingly realised that moths are sensitive indicators and integrators of habitat quality and change in our environment, and as the large-scale declines of some species become more widely known, public support for the monitoring and conservation of moths will grow in the same way that it has for butterflies. The scientific value of conserving the isolated British populations for study by evolutionary biologists, ecologists and taxonomists hardly needs stating, particularly as some of the British forms are recognised as separate subspecies from those of continental Europe. One of the above species, *P. berberata*, has been collected as long series from the same site in Britain over many years, beginning in the 1860s when the colony was first discovered. In fact the great majority of specimens in British collections come from this one site. It is likely that such a wealth of preserved dried material of known origin and date will be of value to many disciplines, not just geneticists and entomologists in the future. But unless special conservation measures continue to be taken now, these populations and the link with the past will be lost. It is also true to say that for too long moth recording and conservation in Britain has proceeded with an imperfect

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knowledge of the situation elsewhere in Europe. The case of *S. lineata* is a good example. There must be many other cases where the biology of particular species is better known or can be more easily studied abroad, although the habits of *T. smaragdaria* indicate that the results may not always be applicable in Britain. Greater contact with workers in other European countries is desirable and Societas Europaea Lepidopterologica is the obvious medium.

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