CHANGES IN THE INVERTEBRATE FAUNA OF THORNE AND HATFIELD MOORS

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INTRODUCTION

The past and present insect fauna of Thorne Moors is unusually well documented. Most of the available records were reviewed by Skidmore *et al* (1987), and intensive recording during 1990 is summarised by Heaver and Eversham (1991). Hatfield Moors has consistently received less attention from naturalists than Thorne Moors (Eversham and Lynes, 1983; Limbert, 1985), and has perhaps suffered most from the lack of entomological study. Little has been published on Hatfield's invertebrates; most of the records used in this paper derive from the authors' unpublished records (evaluated by Key, 1986).

Because of this historical and continuing imbalance of recording, this paper concentrates on the changes which Thorne Moors' fauna has undergone in the past 170 years, and fewer examples are drawn from Hatfield Moors. However, the fragmentary information which exists strongly suggests that Hatfield Moors has suffered in the same ways, and probably to an even greater degree, than Thorne Moors, although its fauna and flora are different in several important respects (Eversham, 1991).

For a few groups of organisms, roughly equal effort has been expended on the two Moors. In particular, the lichens and the molluscs have received similar numbers of days' fieldwork by one of the authors (BCE), who is responsible for most of the records. In these cases, Hatfield has proven to be just as rich and important as Thorne, and in some respects was perhaps even more valuable, at least until the early 1980s.

Thorne Moors has benefited from considerable palaeoecological research, which has revealed the most extensive fossil insect fauna of any site yet discovered in Britain, mostly associated with the primary forest, the *Urwald* (Buckland, 1979). The woodland fauna occurring on Thorne Moors in the Bronze Age contained many species which are now rare or extinct in Britain; the assemblage would be regarded to-day as highly exceptional anywhere in Europe, and no equivalent sites survive in the British Isles (Shirt, 1987). Thorne and Hatfield Moors still support a rich and important woodland invertebrate fauna, including several 'ancient woodland indicator species' (Skidmore et al, 1987); but the changes in this element over the past 3,000 years are a salutary reminder of the over-riding impact of human activity on the landscape.

This paper deals only with changes occurring since the l820s, when the first written records and museum specimens from the Moors began to be kept. It thus focuses on the period after forest clearance, when first drainage and then peat cutting became the dominant factors influencing the fauna.

HISTORICAL CHANGES: EVALUATING THE EVIDENCE

In trying to document losses and gains from the invertebrate fauna, one has to allow for the nature of invertebrate recording. Many species are hard to locate without very specific search techniques, or are recognisable only to an experienced specialist. Others are highly seasonal, and would be overlooked if the Moors were not visited at the appropriate time of year. In many groups, it is thus difficult to determine with absolute certainty whether a species is still present on the Moors, let alone when it may have become extinct (if it has disappeared), or when it first arrived (if it is thought to be a recent colonist).

Despite these problems, it is possible to select species in groups such as the Lepidoptera, which have been quite thoroughly examined at several periods over the past century, for which the absence of a record for a species over several decades is strong evidence of its demise. In other orders, individual species may be chosen which, by reason of their size, microhabitat, or behaviour, are not difficult to locate if present, so that their prolonged absence from the records may reasonably be taken to indicate their extinction. Such choices of species are to an extent subjective. However, all of the apparently-extinct species included in the following tables have been searched for carefully, in suitable habitats, on both Moors on several or many occasions in the period 1980-1990, without success. The intensive 1990 survey provides further partial validation: the lists of putative extinctions were first drawn up without reference to the 1990 data, and only later cross-referenced to it. Of the 85 species originally listed, only two *(Teratocoris saundersi,* last seen on Thorne in 1979, and *Trigonotylus ruficornis,* last seen in 1978) were re-found on Thorne in 1990, and one species, *Hallodapus* rufescens, was found on Hatfield having last been recorded on Thorne in 1837. Thus, although one hopes that future surveys may re-discover more of the listed species, this now seems unlikely.

In a few orders of insects, all the species are conspicuous enough, and historical fieldwork was thorough enough, to be confident that earlier observers would have found the species if they were present, and that the species could not linger undetected on the Moors to-day. Table 1 lists the species of Odonata and Orthopteroid groups which have become extinct on the Moors, or have colonised, since recording began. These nine extinctions and one arrival come from a total fauna of only 27 species in these orders on the two Moors.

The first losses in the Odonata parallel the documented changes in the flora. The Downy Emerald Dragonfly *(Cordulia aenea)* and the White-faced Dragonfly *(Leucorrhinia dubia),* are peatland species which require undisturbed pools in which to breed. Such pools or 'wells' were plentiful on the Moors in the early nineteenth century, but disappeared during drainage, and with them plant species such as Rannoch-rush *(Scheuchzeria palustris)* and Mud Sedge *(Carex limosa)* (Limbert, 1990).

Other losses represent species close to their northern range limit in Britain, which would be sensitive to slight changes in climate (or periods of adverse weather) : the

Emperor Dragonfly *(Anax imperator*) and the Slender Groundhopper (*Tetrix subulata)* have not been found breeding as far north as Thorne since the 1837 records (Merritt *et al,* in press; Marshall and Haes, 1988). The Variable Damselfly *(Coenagrion pulchellum)* is mainly a fenland species in central and northern England, and is sensitive to pollution and drainage; its loss from Hatfield Moors coincided with the widespread use of pesticides and fertilizers on local farmland, although it still survives in grazing-marsh ditches a few miles south of Hatfield Moors.

HISTORICAL CHANGES WITHIN HABITATS

With the exception of the Odonata and Orthopteroids, no order has been surveyed thoroughly enough over a long period for a full 'balance sheet' of extinctions and arrivals to be drawn up. Even among a 'popular' group such as the butterflies, the current status of a few species, including the Green Hairstreak *(Callophrys rubi*) and the Dark Green Fritillary (*Argynnis aglaja),* is uncertain.

For these and other groups, the more readily recorded species, for which information is most reliable and comprehensive, may be considered individually. The resulting lists of miscellaneous species from a wide range of groups are arranged by broad habitats in Tables 2 to 5.

Table 2 lists the probable extinctions among the peatland fauna. Although amounting to only 11 species, this is almost 10% of the recorded fauna for the habitat, and all of the species are nationally rare or scarce. The losses represent a range of habitats within peatlands. The two Odonata, as already mentioned, require well-vegetated pools and disappeared through drainage. Others, such as the Silver-studded Blue *(Plebejus argus)* were probably lost in the nineteenth century when much of the Moors' surface was converted to agriculture by warping. The remainder probably depended on a particular wet peat microsite, which may always have been very local on the Moors, and which was particularly vulnerable to destruction through peat cutting. For example, the shorebug *Hicracanthia* marginalis is known to have occurred only in a small area near Casson's Garden, where it lived in small damp hollows among Cross-leaved Heath and Heather (Crossley, 1977). Most of the area was cleared and cut for peat c1980. The conspicuous and brightly coloured ground-beetle *Carabus nitens* lives among *Sphagnum* bogmoss, so may be particularly sensitive to intense drainage, such as occurred in the 1980s. The plume-moth *Buckleria paludum* feeds as a larva on the underside of the leaves of sundews *(Drosera);* although Round-leaved Sundew *(D rotundifolia*) still survives and is sometimes locally abundant, many of the largest patches have been lost to peat cutting, and in other areas it is not abundant every year, probably because of the lowered water table. Many insects are unable to cope with marked fluctuations in host-plant abundance.

Even species which have not yet become extinct may have declined drastically as a result of peatland habitat loss. According to the Doncaster entomologist, George Hyde, who had unparalleled experience throughout Britain, the Large Heath butterfly *(Coenonympha tullia)* populations on Hatfield Moors in the 1950s and 1960s were the largest in the country, certainly numbering many thousands. Now, the species is confined to one small area, and no more than a few dozen adults are seen each year.

Drainage of both Moors has intensified in the 1980s, and the introduction of pumps on Thorne Moors has caused marked changes in the wet peat -fauna. It is too early to

document extinctions with confidence, but there is unequivocal evidence of massive changes in abundance of wet peat insects over a few years. Over much of Thorne Moors in the 1970s, vast numbers of nationally scarce flies such as *Stilpon sublunata, Pogonota barbata, Cordilura rufimana* and *Ochthera mantis* could be seen around peat pools. Now, only occasional individuals of these species are found, and almost all of the pools themselves have been drained.

A few species have become much more abundant on Thorne Moors during the 1970s and 1980s. Most conspicuous of these is probably the Green Tigerbeetle *(Cicindela campestris)* which was seldom seen in the early 1970s, but is now widespread on the Moors on the drier baulks, especially on the NNR. Significantly, it is a species associated with dry heathland and grassland. not with peat bogs.

The clearest objective measure of changes to the wet peat fauna comes from trapping muscid flies on the Moors, by Malaise trap in 1987 and with water traps in 1990. Two species, chosen because their ecology is well understood (Skidmore, 1985), serve as a sensitive barometer of the state of the habitats. The nationally endangered *Phaonia jaroschewskii,* now know only from Thorne Moors, inhabits wet *Sphagnum* moss as a larva. In 1987, it was the most abundant fly trapped on the Thorne NNR, its numbers being far greater than those of any other muscid. The 1990 traps caught more muscids on the NNR than the 1987 Malaise trap (435, compared with 332), but not a single P *jaroschewskii* was taken on the NNR (although it survives on Crowle Moors and elsewhere). Its place had been taken by the common heathland fly *Helina evecta,* which breeds in humus soils and is tolerant of very dry or sandy conditions; it appears not to breed in waterlogged soils. There can be little doubt that the switch from P *jaroschewskii* to *H evecca* indicates a severe lowering of the water table of the NNR since 1987, and that this must be detrimental to many of the most important plants and animals on the reserve. The continued high water table on Crowle Moors (and, until drainage work in early 1990, on the south-eastern part of Thorne Moors), where P *jaroschewskii* still thrives, rules out the possibility that this is a result of lower than average rainfall; the explanation must lie in the new drains and the pumped drainage system installed in the late 1980s.

The non-acid wetland species included in Table 3 combine several habitats. Most are characteristic of rich fens, and the wainscot moths are most often found in reedbeds of *Phragmites australis.* The ground-beetles *Badister unipustulatus* and *Panagaeus cruxmajor* are usually found on mud or damp, peaty soil among sedges and other lush fenland vegetation. They would have occurred on the fenny margins of the Moors, and so been vulnerable both to drainage for peat cutting on the Moors. and to adjacent agricultural changes. The loss of the two large *Dytiscus* diving-beetles (and probably of many other species not listed) coincides with the disappearance of the last areas of extensive fresh water on and near the Moors: most of the weedy ditches on the Moors have been cleared out and are now regularly pumped. those on the Moors edges are eutrophicated by agricultural fertilizers. and the less acid pools on the Moors have been drained, the largest and best-known, the Shoulder o' Mutton Well. in 1988.

The two 'estuarine' species. the Short-winged Conehead *(Conocephalus dorsalis)* and the damselbug *Nabicula lineata* both thrive in damp. slightly brackish grassland and reedbeds, so might be expected to survive along the western edge of Thorne Moors. Their disappearance may be due to some subtle deterioration in the habitat. such as the reduction in saline water flow at Bell's Pond, or scrub encroachment at Inkle Moor.

The losses from the 'grassland' fauna shown in Table 4 reflect the national picture of habitat loss. The Forester Moth *(Adscita statices)* has disappeared from almost half its recorded localities since the 1940s, and losses have been particularly severe in the north (Heath and Emmett, 1985). The bumblebee *Bombus subterraneus* is now confined to a few sites near the south coast, largely due to the re-seeding and eutrophication of meadowland.

Some of the grassland fauna occurred in marginal habitats on the Moors edges (prone to agricultural spray-drift). and others have probably suffered from the cessation of grazing of uncultivated warplands such as Inkle Moor. But several of the extinct species occurred on the Moors proper, the Grizzled Skipper butterfly *(Pyrgus malvae)* for instance, living on Snaith and Cowick Moors before the area was cleared and cut for peat in the late 1970s. The slightly more basic conditions along tramways undoubtedly favoured many grassland insects, and the loss of these narrow corridors of 'non-peat' habitat, through the use of heavy tractors rather than narrow-guage locomotives, and the application of herbicide. has speeded the decline of many commoner grassland insects such as the Small Copper butterfly *(Lycaena phlaeas).*

The wooded fringes of 'Thorne and Hatfield Moors still support a diverse insect fauna. but the absence of recent records for the range of scarce and conspicuous species listed in Table 5 suggests that this fauna may be declining. Some of the best marginal woodland, such as Whittaker's Plantation on the southern edge of Thorne Moors, had largely been felled before it could be surveyed in detail by entomologists. Elsewhere, intensification of peat cutting has reduced the area of woodland, for example on the northern edge of Thorne Moors. Gravel extraction has destroyed some of the best sallow carr on the southern and western edges of Hatfield. The surviving areas, of which the most extensive is Will Pits, have also been damaged: a limestone road 10 m wide now bisects Will Pits, and dust from the heavy traffic here and along Swinefleet Warping Drain may have some impact.

LOSSES OF HABITAT AND REDUCTION IN AREA

All habitats on and around the two Moors have lost species during the past century. The loss of microsites such as bog pools is well documented, but other changes have been more subtle. Many invertebrates rely on a small-scale mosaic of microhabitats, utilising different parts of the habitat during different stages in their life (Key, 1988). The maintenance of this mosaic is more likely the larger the area of each habitat remaining. It is a commonplace of biogeography that large habitat 'islands' support more species than small ones (MacArthur and Wilson, 1967), and this principle has been built into the criteria for statutory wildlife site assessment (Ratcliffe, 1977).

It follows that each small area of habitat which is destroyed (even if the loss is 'temporary' in the sense that vegetation becomes re-established at a later date) will reduce the total fauna of the site. For example, the reclamation of Durham's Warping Drain for arable in 1983 virtually wiped out the Moors' only Great Crested Newts, and an important population of the Red Data Book pondsnail, *Lymnaea glabra.* The felling of the Scots Pine *(Pinus sylvestris)* in Mill Drain Marsh in 1989, apparently preparatory to peat cutting, has probably wiped out the only populations of the harvestspider *Oligolophus hanseni* and the plantbug *Camptozygum aequale* on Thorne Moors. The drainage of the oldest surviving area of revegetated hand graving, in the south-east of Thorne Moors, in early 1990, has threatened a much larger assemblage

of nationally rare species which are not found elsewhere on either Moors, of which the raft spider *Dolomedes fimbriatus* is the most striking.

Many invertebrate species are highly specialised in their habitats, nationally scarce or rare, with a very patchy distribution, and tend not to be very mobile. Together, these properties make recolonisation after extinction at a site very unlikely. For example, the nearest raft spiders to Thorne Moors are probably in central Wales, and the species seldom leaves its heath-and-bog habitat.

A final consideration, for the more mobile invertebrates, may be the total area of habitat present. It is well known that bird species often require a large territory or feeding area in order to breed successfully. There is growing evidence that, although not 'territorial', some invertebrates can sustain populations long-term only in large areas of habitat. The Northern Eggar Moth *(Lasiocampa quercus callunae)* occurs on heathland throughout Britain, but at its sites in Surrey, it occurs only on areas of 1 sq km or more, perhaps visiting the smaller pockets of habitat but not breeding. Even if a species does not become extinct immediately, reduction in the area of its habitat may have serious consequences. Isolation of butterfly populations in small 'habitat islands', such as the Swallowtail butterfly *(Papilio machaon)* in fenland sites, has led to a measurable genetic shift within the populations in just 60 years: the butterflies are smaller and their flight is less powerful (Dempster *et al,* 1976*).*

CHANGES REFLECTING NATIONAL TRENDS

Habitat loss through changing patterns of land use is a national problem, not confined to the Humberhead Levels. Many species which survive at Thorne or Hatfield have already become extinct in much of the rest of Britain, so their decline here could be seen as part of a national trend. Conversely, this emphasises the importance of conserving as much as possible of what remains of the Moors: as noted by Key (1988), a remarkably high proportion of the Thorne and Hatfield fauna is rare over the rest of Britain.

Beyond these trends in land use, however, some species have become more or less widespread and abundant on a scale which cannot be explained in terms of habitat availability. Among the losses, a few species may have contracted their range southward, and thus vacated Thorne and Hatfield, perhaps in response to a past shift in climate. The Emperor Dragonfly is one example, and the Broad-bordered Bee Hawk-moth *(Hemaris fuciformis)* also seems to have disappeared from sites which still retain suitable habitat for it. More conspicuous national trends are the species which are expanding their range, and which happen to colonise Thorne and Hatfield Moors in the process. Table 6 lists those recent arrivals which are believed to be spreading northwards, with the date of the first Thorne/Hatfield records. Many of these are probably responses to weather patterns; the two molluscs are fairly recent arrivals/introductions to Britain, and are still colonising new areas rapidly.

THE FUTURE

The invertebrate fauna of both Thorne and Hatfield Moors is still of the greatest national importance. However, a review of historical changes shows that the status of the scarcer species in particular is precarious. Habitat loss through direct destruction, for peat extraction or for agriculture, has wiped out many species for which records exist, and doubtless exterminated many others before they could be documented. The

continuing loss of habitat will accelerate the rates of extinction, and as the total area of intact vegetation is reduced, the consequences of each successive episode of destruction will be greater. The evidence of history contradicts the notion of 'equivalent areas', because whole assemblages of species now rely on microhabitat combinations which are unique to single areas on the Moors.

Changes within habitats have also had a marked effect in the past. Eutrophication of freshwater habitats is probably responsible for the loss of many species. The impacts of agricultural spray drift is far less easily demonstrable, and the subtle impacts of limestone dust on the peatland may not be apparent for many years. Finally, the most crucial change in the past decade is probably the lowering of the Moors' water table, through new drains and the installation of pumps on Thorne Moors, and a combination of drainage for peat milling and a water abstraction borehole close to Hatfield Moors. If this problem is not tackled soon, many more wet-peat species will undoubtedly become extinct on the Moors.

TABLE 1

LOSSES AND GAINS IN THORNE AND HATFIELD MOORS ODONATA, ORTHOPTERA AND DERMAPTERA. BASED ON THE DATES OF THE LAST (EXTINCTIONS) OR FIRST (COLONIST) AVAILABLE RECORDS

Order and Species	**Thorne / Hatfield**	**Last Date**	**First date**
Odonata			
Cordulia aenea	T	1823	
Anax imperator	T	1837	
I.eucorrhinia dubia	T	1890	
Coenagrion pulchellum	H	1950S	
I.ibellula depressa	T	1966	
Aeslma mixta	T		1983
	H		1986
Orthoptera			
Conocephalus dorsalis	T	1837	
Tetrix subulata	T	1837	
Chorthippus albomarginatus	T	1975	
Dermapt:era			
L1bia minor	H	1981	

TABLE 2

LOSSES FROM THE PEATI.AND FAUNA OF THORNE MOORS

Order	**Species**	**Date of last record**
Odonata	*Cordulis senes*	1823
	Leucorrhinis dubia	1890
Homoptera	*Aphis vaccinii*	1933
Heteroptera	*Hicracanthia marginalis*	1977
Lepidoptera	*Buckleria psludum*	1891
	Plebejus argus	pre-1919
	Idaea sylvestraria	1885
	Diacrisia sannio	1978
	Carsia sororiata	1877
	Dyscia fagaria	1928
Coleoptera	*Carabus nitens*	1976

TABLE 3

LOSSES FROM THE NON-ACID WETLAND FAUNA.
Most of these are fenland species; those marked 'E' are estuarine.

Order	**Species**	**Date of last record**
Orthoptera	*Conocephalus dorsalis* E	1837
Odonata	*Tetrix subulata*	1837
	Anax imperator	1837
	Libellula depressa	1966
Heteroptera	*Nabicula lineata* E	1963
Lepidoptera	*Crambus silvella*	1837
	Anticollix sparsata	1975
	Mythimna straminea	1974
	Photedes pygmaea	1978
	Nonagria typae	1975 Thorne, 1980 Hatfield
	Arenostola phragmitidis	1970
	Chilodes maritima	1974
	Plusia putnami gracilis	1974
Diptera	*Leptogaster cylindrica*	1946
Coleoptera	*Trechus discus*	1976
	Bembidlon saxatile	1913
	Panagaeus cruxmajor	pre-1946
	Badister unipustulatus	pre-1946
	Dytiscus circumcinctus	1969
	Dytiscus dimidiatus	1965
	Donacia semlcuprea	1910
	Donacla simplex	1910
	Plateumaris sericea	1914
	Hydrothassa glabra	1903

TABLE 4

LOSSES FROM THE GRASSLAND FAUNA OF THORNE MOORS

Order	Species	Date of last record
Heteroptera	*Hyrmus miriformis*	1837
Lepidoptera	*Adscita statices*	1946
	Erynnis tages	1951
	Pyrgus malvae	1971
	Eilema complana	1837
	Hythimna comma	1974
	Photedes minima	1974
	Hesoligia furuncula	1974
Diptera	*Dioctria atricapilla*	1970
Hymenoptera	*Bombus subterraneus*	1934
Coleoptera	*Synuchus nivalis*	1969
	Amara apricaria	1905
	Onthophagus similis	1903
	Sermylassa halensis	1904

TABLE 5

LOSSES FROM THE WOODLAND FAUNA

'C' indicates species particularly associated with carr (damp sallow, willow or alder woodland). Records referring to Hatfield rather than Thorne are marked 'H' next to the date.

Order	Species	Carr	Date of last record
Heteroptera	*Anthocoris limbatus*	C	1976
	Anthocoris gallarum-ulmi		1976
Lepidoptera	*Sesia bembeciformis*	C	1969
	Comibaena bajularia		1962
	Rheumaptera undulata	C	1984H
	Bena prasinana		1969
	Pseudoips fagana		1964
	Pseudopanthera macularia		1983H
	Hemaris fuciformis		1969
	Cerura vinula	C	1978
	Notodonta dromedarius		1974
	Diloba caeruleocephala		1965
	Orgyia recens		1978, 1982H
Diptera	*Chrysogaster solstitialis*		1979
	Physocephala rufipes		1972
Coleoptera	*Pyropterus nigroruber*		1969
	Hyrrha octodecimguttata		1905
	Halyzia sedecimguttata		1907
	Phytodecta pallida		1837

TABLE 6

COLONISATION OF THORNE AND HATFIELD MOORS BY INVERTEBRATES WHICH ARE EXPANDING THEIR RANGE IN BRITAIN

Order	**Species**	**Thorne**	**Hatfield**
Odonata	*Aeshna mixta*	1983	1986
Heteroptera	*Ischnodemus sabuleti*	1976	1980
	Sehirus bicolor	1978	1979
	Kleidocerys resedae	1977	1980
Lepidoptera	*Polygonia c-album*	1990	[1949]
	Pararge aegeria	1990	-
Diptera	*Stratiomys potamida*	1982	-
Mollusca	*Deroceras caruanae*	1973	1978
	Boettgerilla pallens	-	1988

(The Comma *(Polygonia c-album)* underwent an expansion in the 19305 and 19405, during which period it reached the Humberhead levels briefly, and was recorded on Hatfield Moors)

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