The Entomological Value of Aspen in the Scottish Highlands

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Introduction

Aspen is one of the most widely distributed tree species in the British Isles (Perring and Walters 1976). It is present over most of the mainland and on the main offshore island groups such as the Hebrides, Orkneys and Shetlands. Aspen is also well distributed in Ireland. Throughout most of Britain aspen is commonly associated with sea cliffs and upland crags where it often occurs in small groups. The conditions in which aspen typically grows at inland situations do however seem to vary throughout the British Isles. In England aspen is generally a tree which is associated with heavy clay soils, often in conditions where waterlogging occurs. In places it forms dense stands up to about 60m in diameter but generally it is present in smaller isolated thickets. From observations made during this present survey we have found that, in contrast, aspen in the Scottish Highlands is usually associated with well drained, moderately rich soils often derived from glacial or fluvial deposits. In the Highlands aspen is usually found as a component of birch woods in association with other species such as juniper, hazel, bird cherry and rowan. In places where conditions are favourable it becomes co-dominant with birch and stands of aspen can extend over several hectares. Our studies suggest that these differences in the nature and size of aspen stands have an influence on the invertebrate communities which are associated with them.

The means by which aspen regenerates differs markedly from that of the other native trees found in the Highlands. In Britain the production of viable seed from this dioecious species seems to be a rare event and Worrell (1993) notes that natural regeneration from seed appears never to have been reported in the literature on aspen in Britain. Many stands were noted to contain seeding trees in the spring of 1996 following a very warm summer and a rather severe winter but such seed production in single sex stands may not have produced fertile seeds. The usual and the main means of propagation is asexual, vegetatively by the production of root suckers (Hollingsworth and Mason 1991). This usually results in dense stands of rather even aged saplings arising around the parent tree. This leads in time to the formation of a clone of genetically identical trees which can extend over a considerable area. The formation of single sex clones over large areas resulting in great distances between male and female trees may in part account for the lack of seed production. Reproduction by root suckers leads to the possibility that individual clones may be very ancient, having occupied the same geographic area since the time of their first colonisation. The ability to produce suckers which can draw on the resources of a nearby adult tree for their early development means that aspen has a great potential to regenerate into favourable areas once conditions allow. The leaves and stems of young aspen are however particularly attractive to grazing animals and unless grazing pressure is maintained at a low level regeneration will not be successful.

This present survey concentrated on the saproxylic insects associated with aspen many of which are confined to, or have their greatest abundance in, the Scottish Highlands. The presence of a well developed saproxylic insect community in any area is indicative of a long continuity of woodland cover. This is true of the large saproxylic insect community associated with native pine in the highlands and to a lesser extent with the aspen stands.

The continuity of aspen in the Highlands is due to the fact that only in this area is aspen still a part of the vegetational climax community. O'Sullivan (1974) studied pollen deposits in the Abernethy Forest in Strathspey. He found that shortly after the end of the last glaciation, in the early Flandrian period (approx 9000 years BP), open grass and heathland communities in this area were colonised by juniper scrub. This was in turn replaced first by

birch and then by a birch - hazel woodland with an aspen component. This rather open forest type was then colonised by pine in the period preceding 7600 yrs BP and a mixed pine birch forest was established. As the climate continued to ameliorate woodlands dominated by oak and elm displaced birch and pine forest in lowland Britain leaving the birch and pinewoods and their associated insect fauna confined to the highlands of Scotland. Species such as aspen and juniper formed important components of these pioneer birch and pinewoods and as a result they and their insect communities still survive as uniquely Scottish parts of the woodland climax community.

Although the distribution of aspen was surveyed for the Atlas of the British Flora (Fig.1) this gives no indication of the amount of aspen present in each area. No previous work seems to have been carried out on aspen stands in the Highlands but the distribution of juniper, another important component of the pioneer woods, was mapped out by McVean and Ratcliffe (1962) (Fig.2). The map of the main distribution centre of juniper shows a close similarity with one showing the present day main aspen stands (Fig 3). Both distributions are centred on Strathspey with areas in Easter Ross and East Sutherland included. In the past aspen may have occurred more commonly in highland Perthshire and in Deeside but today these areas only have rather scattered populations.

Information from the Phytophagous Insect Data Bank operated by the Institute of Terrestrial Ecology reveals that some 160 species of insect have been recorded as feeding on aspen in the British Isles. This includes some 22 species of Hemiptera, 60 of Lepidoptera, 30 Coleoptera, 30 Symphyta and 15 Diptera. The great majority of these species feed on the foliage of the tree and often will also feed on other Poplars and on willows. As a result most of these species are widely distributed in Britain with the greatest variety of species being found in the more favourable climate of southern England. We could find no evidence of any previous work which had been carried out on saproxylic insects associated with aspen in the Highlands or in indeed in the British Isles.

The main purpose of this present survey was to locate and quantify the remaining aspen stands in the Highlands, to assess their saproxylic insect fauna and, where necessary, to put forward suggestions for the conservation and management of these areas.

The Resource

In the early stages of this present survey it was soon realised that relatively little seemed to be known about the size and distribution of aspen stands in the Scottish Highlands. The first task was therefore to locate and map aspen stands. This work was carried out by members of the Malloch Society initially during 1989 and more fully in 1990. The 1990 survey was assisted financially by a grant from the British Ecological Society. Aspen stands were located by driving through what were thought to be suitable woodland areas or by viewing such areas from a distance by binoculars. Locating aspen among other trees such as birch is not too easy, we found that the best time to carry out survey work was during the autumn when the bright yellow colours of the aspen leaves made the trees stand out from the surrounding woodland species. Other information on the location of aspen stands came from foresters, local naturalists and staff of the Nature Conservancy Council.

The results showed that although small groups of aspen were well distributed throughout the Highlands, larger stands of over 1ha. in area were for the most part confined to Strathspey between Newtonmore in the south and Grantown on Spey in the north. There were a few other sites in the valley of the River Findhorn, Inverness-shire, Easter Ross, Wester Ross, south east Sutherland and Deeside (Fig 3). Although aspen occurs quite commonly throughout upper Deeside from Aboyne to Braemar it tends to occur in rather fragmented small stands with stands over 1ha being rare. This is perhaps due partly to the narrow nature of the glen in this area with the more fertile ground for aspen and agriculture being confined to a narrow area beside the river, unlike the wider strath of Strathspey. As a consequence the aspen fauna, despite there being much potential habitat, is somewhat restricted.

All the areas covered by aspen stands were plotted on maps at 1:10,000 scale from which their sizes were estimated. In some cases estimation of the area was straightforward as at these locations a pure aspen stand was present and it was a simple matter to map its extent. At other localities the aspen occurred in a more mixed woodland situation where other species such as birch, rowan and hazel were present. In these cases the boundary line was drawn around the main area of aspen within the wood. The density of aspen within the mapped areas is therefore variable ranging from dense pure stands of aspen to a more open scattered situation within a woodland matrix.

In some cases measurement of tree circumference at breast height (CBH) were taken of some of the larger aspen trees in a stand. This was done in an effort to learn more about the age structure of the stand and the longevity of individual trees. We did obtain a little information from tree cores and from cut stumps which indicated that on average an aspen increased its trunk diameter by approximately 4mm. per year. A graph of CBH plotted against age is shown in Fig.4. It should be stressed that this is only a very approximate correlation taken from a few trees, there is bound to be variation in the rate of tree growth based on factors such as soil fertility, aspect and altitude.

The size range of aspen (as CBH) growing at two different stands within Strathspey is shown in Figures 5 and 6. Figure 5 illustrates the state of a fairly typical grazed aspen wood with the bell shaped nature of the plot indicating that most of the trees present grew up during a relatively short time when conditions were favourable. With few if any young trees or saplings present this woodland is in urgent need of another phase of regeneration if it's long term viability is to be maintained. Figure 6 shows a healthier wood which has experienced several phases of regeneration over the last century which can perhaps be

linked to major changes in land use brought about by the coming of the railways, the two world wars and the arrival of myxamatosis. With good numbers of young trees present its future, and that of the insects which depend on it, seems more secure. Further work still needs to be done in this area so that the priorities for management action within the remaining aspen stands can be determined.

Stands of aspen less than 1ha. in area were usually poor in saproxylic invertebrates although on occasion they did contain the sap flow species. There is a greater possibility that smaller stands within the main Strathspey area can support certain saproxylic insects which can probably move relatively freely between stands provided there is a continuity of deciduous woodland cover. Similarly within smaller aspen stands located within river valleys or gorges localised movement almost certainly takes place as the individual aspen areas are by themselves too small to support the full range of habitats required. Many other stands are more isolated and any recolonisation is probably unlikely.

The ability of aspen to regenerate quickly once conditions are favourable can mean that what seems today to be a large stand can have originated at some time in the past from only a few individuals. In the case of an isolated site this restriction in habitat availability in the past will have led to a loss of the saproxylic insect fauna.

This survey has revealed that at the present time in the Highlands there is only a small group of some 21 remnant aspen stands over 1.5 ha. in area. Of these only 14 are above the 4.5 ha. which we consider to be the minimum area of aspen required to maintain the full aspen saproxylic community. Evidence for the continuity of these stands comes from the fact that most still support a diverse saproxylic insect community. In total these remnant aspen stands are only covering an area of some 159.5 ha., a tiny figure when compared to the main remnant woodland type of the Highlands, the native pinewoods which extend to some 12,000 ha. (Bain 1987). Unfortunately no figures are available at present for areas of juniper still surviving in the Highlands.

Of the 159.5 ha of larger remnant aspen stands only approximately 25 ha. are within present SSSI's or NNR's. The majority of the large aspen areas in Strathspey and the isolated stands in the northern Highlands do not at present have any statutory protection and are potentially vulnerable to changes in woodland management, urban and associated developments or changes in agricultural practices.

The Scottish Aspen Resource

Area	Number of Stands Over		Total Area
	1.5 ha	4.5 ha	ha
Sutherland	1	1	6.0
Wester Ross	-	1	5.0
Easter Ross	-	1	7.0
Inverness	1	-	3.5
Nairn	-	2	15 (est.)
Strathspey	1	8	105.0
Deeside	4	1	18.0
Total	**7**	**14**	**159.5 ha**

The Highland Aspen Saproxylic Insect Community

The community is characterised by the following insect species:

Species	Status**
Ectaetia christiei (Dipt.Scatopsidae)	New species
Mycetobia obscura (Dipt. Anisopodidae)	New to Britain
Lonchaea hackmani (Dipt. Lonchaeidae)	New to Britain
Medetera freyi (Dipt.Dolichopodidae)	New to Britain
Hammerschmidtia ferruginea (Dipt.Syrphidae)	RDB 1
Homalocephala biumbratum (Dipt.Ottitidae)	RDB 1
Strongylophthalmyia ustulata (Dipt.Tanypezidae)	RDB 1
Tachypeza heeri (Dipt.Hybotidae)	RDB 2
Tachypeza truncorum (Dipt.Hybotidae)	RDB 3
Medetera inspissata (Dipt.Dolichopodidae)	RDB 3
Brachyopa pilosa (Dipt.Syrphidae)	RDB 3
Gnophomyia viridipennis (Dipt. Tipulidae)	Notable
Clusoides apicalis (Dipt.Clusidae)	Notable
Stegena coleoptera (Dipt.Drosophilidae)	Notable
Lonchaea peregrina (Dipt.Lonchaeidae)	Notable
Systenus pallipes (Dipt.Dolichopodidae)	Notable
Xylota tarda (Dipt.Syrphidae)	Notable
Criorhina ranunculi (Diptera Syrphidae)	Notable
Saperda carcharius (Col. Cerambycidae)	Notable
Sphegina clunipes (Dipt.Syrphidae)	
Lonchaea fugax (Dipt.Lonchaeidae)	
Lonchaea patens (Dipt.Lonchaeidae)	
Xylophagus ater (Dipt.Xylophagidae)	
Lycoriella lignicola (Dipt.Sciaridae)	
Lycoriella solani (Dipt. Sciaridae)	
Sylvicola cinctus (Dipt.Anisopidae)	
Phaonia goberti (Dipt.Muscidae)	
Glischrochilus quadripunctatus (Col.Nitidulidae)	

** The status rating of the Dipteran species is based upon Falk (1991).

Sap run species are included in this community assessment although in strict terms they are not saproxylic insects which are defined as - species which at some point in there life cycle are dependant upon dead wood, on wood inhabiting fungi or upon the presence of other saproxylics.

Further Information and Contexting of Rare and Uncommon Species

Ectaetia christiei

At present this new species to science is only known from two sites in Strathspey where the larvae have been found in decaying sap under the bark of fallen aspen. Although we reared relatively large numbers of this species from individual fallen aspen, it never the less appears to be truly restricted and localised in it's distribution. this is clearly a species which requires further work so that its true status can be ascertained.

Mycetobia obscura

Recorded as new to Britain from larvae collected at a sap run on aspen in Deeside (Hancock, Robertson and MacGowan 1996). In Europe this species has been reared from fermenting tree sap in tunnels of a wood boring hoverfly and from rot holes in deciduous trees. There is therefore a possibility that it may occur on other tree species in the British Isles in addition to aspen.

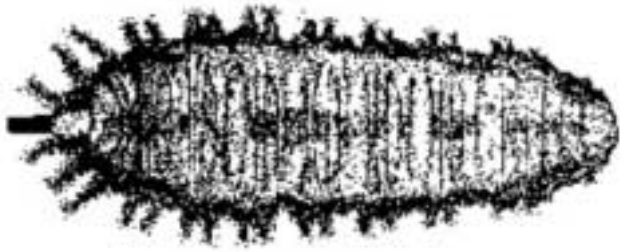
Lonchaea hackmani

Recorded as new to the British Isles in 1998. This is one of the key indicator species for boreal aspen stands in Scotland. It is only found in association with larger stands over 4.5 ha. The very similar L. peregrina replaces this species in smaller stands or in stands outwith the core area for boreal aspen. L. hackmani is also known from the Scandinavian and Russian aspen stands. This species is apparently specific to aspen.

Hammerschmidtia ferruginea

This species was always regarded as one of the rarest of all the British hoverflies. It was first captured in June 1905 by Col. J. W. Yerbury, who took specimens on aspen stumps in the vicinity of the new Spey Bridge (Wainwright 1944). The first breeding records of this species which were obtained during this survey show that the larvae of species is most frequently associated with decaying sap under the bark of fallen aspen more than 30cm in diameter. It also occurs less frequently in sap runs on live aspen. Although this survey extended the known range of this species and learned more of its ecology it is still only known in the British Isles from eight 10 km squares (12 sites) in the Scottish Highlands with it's main stronghold in Strathspey between Newtonmore in the south and Grantown on Spey in the north. There are also a few other sites in the valley of the River Findhorn, Inverness-shire, Easter Ross, Wester Ross, south east Sutherland and Deeside.

This species is included in category 1 "Endangered" of the Insect Red Data Book. It is also included by Speight (1989) in a list of saproxylic Diptera which are so localised in their European distribution that there presence can be regarded as indicators of forests of international importance. (In the list it is referred to as *Brachyopa ferruginea*). Recently included in the list of British species for which action plans will be required under the United Kingdom Biodiversity Action programme.



Larva of *Hammerschmidtia ferruginea*

Homalocephala biumbratum

Previously mis-identified in Britain as *Homalocephala albitarsis* the true identity of this species has only recently been established. Prior to this survey this species was only known from a few specimens taken in Strathspey. It is included in category 1 "Endangered" in the Insect Red Data book. The first breeding records of this species which were obtained during this survey show that the larvae of species is most frequently associated with decaying sap under the bark of fallen aspen more than 30cm in diameter. Its distribution includes all the main aspen areas in Strathspey, Deeside, and around the Moray Firth but it also interestingly occurs in Wester Ross.

Strongylophthalmyia ustulata (Zetterstedt)

The first British record of this species was from the rather unlikely source of a suction trap at Monks Wood experimental station in England. In Europe this species is only known from Finland (Krirosheina 1981). We can record it from only two further sites both in Strathspey where it was bred from dead aspen.

Tachypeza heeri

This species is only known in Britain from the Scottish Highlands where it was first discovered at Dunphail on the River Findhorn in 1902. A further record mentioned by Collin (1961) is from Aviemore in 1935. Since that time we can find only a few further records from the native pinewoods at Coille Choire Chuilc and Black Wood of Rannoch. During this survey we can record it from a further three sites in East Ross, Strathspey and Deeside where it has been bred from aspen. There are however several other recent records from non-aspen areas and one breeding record from birch which suggests that it can also use this tree as a larvae. It would seem however that within the aspen zone of the central and eastern Highlands that aspen is the favoured larval tree.

Tachypeza truncorum

The only recent British records are from Aberdeenshire (MacGowan 1986). This species is considered to be part of the Scandinavian element of the British fauna. We found larvae at an Aberdeenshire site in the decaying heartwood of an old aspen, but it has also been bred from birch. We can find no previous breeding records for this species.

Medetera inspissata

Fonseca (1978) records this species from only three British localities; Nethy Bridge, Newmarket and Somerset. Since that time this species has been bred from poplars in England (I. Perry pers comm). Its small size and its ability to avoid capture may well mean

that it has been overlooked at aspen sites in the past. It is classified as category 3 "Rare" in the insect red data book. We can record it from a further ten sites within the Highland aspen area. being a relatively small species which can breed in smaller fallen branches it is one of the few aspen species which can be found in relatively smaller aspen stands.

Brachyopa pilosa

This species breeds in sap runs on aspen but has a disjunct distribution and apparently a different ecology in different parts of the British Isles. *Brachyopa pilosa* occurs as an uncommon species in southern England where it is associated with sap runs on beech in mature woodland areas such as the Windsor forest. In Scotland it has only been taken as a larva on sap runs on aspen even although sap runs on other tree species are available nearby. This survey recorded it from southeast Sutherland, Easter Ross and Inverness-shire. Interestingly although we have made special efforts to search for it there are no records of this species from the aspen stands of Strathspey or Deeside.

Gnophomyia viridipennis (Gimmerthal)

Falk (1991) states that records of this species are scattered widely in England as far north as Durham but that the records show a strong southerly bias. It was only found very recently in southern Scotland. The record from Achilty in Easter Ross represents a major expansion in the known range of this species. In England the larvae are known to have a preference for poplars, especially *Populus nigra*.

Clusoides apicalis (Zett.)

Stubbs (1982) states that the very few known British specimens are from the Scottish Highlands. He also states that it is associated with birch. Most records are recent with only some eight known post 1960 sites (NCC report).

Stegena coleoptera (Scopoli)

This is a widespread but uncommon species in the British Isles. Chandler (1987) states that several of the collected specimens have been from birch woodland and that they have been beaten from birch foliage. A female has also been taken at oak sap. A series of both sexes was taken on birch at Beinn Eighe in 1953 by O. W. Richards. Our record of a larva of this species from under aspen bark is the first indication that this species may also be associated with aspen.

Lonchaea peregrina (Becker)

Only four localities are mentioned by Collin (1953); Cambridge, Bristol, Grantown on Spey and Nethy Bridge. Due to the confusion with *L. hackmani* in the past the Highland records of this species need to be re checked. Collin quotes Perris who in 1839 bred this species from larvae found under the bark of various dead trees including poplars. We have found it to be a species which is present in the smaller and more peripheral aspen stands in Scotland. There are more recent records of this species in England and southern Scotland where it has been reared from tree species such as willow indicating that this species is not confined to Poplars or aspen.

Systenus pallipes

Fonseca (1978) only records this species from a few individuals taken in southern England. Many of the records show that this species is associated with elm sap and indeed it has been reared from sappy elm debris. Fonseca gives its status as rare. Previous to this report records there were no previous records of this species in Scotland. We first found the larvae of this species living in the sappy tunnels of the polar longhorn beetle *Saperda carcharius*. Since that time however this species has been found widely in Scotland on a range of deciduous trees and on conifers.

Criorhina ranunculi

This is a little known species in Scotland with only a handful of recent records. Interestingly the records are from two distinct areas, around the Solway Firth in the south and a grouping within the Highlands which is centred on the larger aspen stands. It may well be the case that as in other Dipteran species that there is a distinct Highland type which breeds exclusively in aspen. The first Scottish records in 1952 were of two adult specimens taken in Strathspey by P.Harwood. Our records thus confirm the continuity of this species in Strathspey area and indeed identify this area as being one of it's strongholds in Scotland. This was the first time that a larva of this species had been found and described.

Xylota tarda

It is interesting that both of these hoverfly species, which are associated with sap runs on aspen, show a disjunct distribution in the British Isles.

There was no previous information on the larval habitat of this species in Scotland. *Xylota tarda* shows a similar distribution having been recorded in mid and southern England as well as in the Scottish Highlands.

Stubbs and Falk (1983) record the adults as being associated with the fringes of damp woodland but there is apparently no previous information on the larval habitat.

Saperda carcharius

There have only been four previous records of this large longhorn beetle in Scotland, only two of which have been this century. Evans (1892) records that whilst staying at Cromdale, near Grantown on Spey, his son brought him a specimen captured at rest on an aspen. There is the possibility that the specimen originally came from the nearby Speybridge aspen site. Ritchie (1915) records a specimen found one mile east of Kincardine O'Neil on Deeside. The other records are from Sutherland (1852) and Braemar (1954). We have found it at sites in Strathspey, Easter Ross and Deeside.

Saproxylic Microhabitats

Larvae and puparia were usually found in particular microhabitats such as sap-runs, decaying sap under the bark of fallen trees and branches, decaying sapwood and decaying heartwood. Some of these microhabitats were present in every woodland visited, however there was considerable variation in the quality and quantity present. Most saproxylic Diptera appear to be specific to microhabitat. The most species-rich microhabitats were found in association with fallen trees and branches: decaying sap under bark and decaying sapwood.

Sap-runs

In live trees sap is under pressure and if the vessels carrying it are fractured, it can exude copiously like oil, and so form a sap-run. Sap-bearing vessels fracture in the following ways:

When storms and high winds bend and twist trees;
When close-growing branches rub against each other;
When sapwood is cut or broken.

The damage may be repaired with callus growth, but micro-organisms can interfere. For example, if damaged sapwood is invaded by certain bacteria eg *Erwinia*, associated fermentation creates pressure inside the tree forcing out sap and dissolved gases. This may result in a more or less continuous extrusion of sap. Sap-runs mediated by micro-organisms are longer-lived than sap-runs caused by physical damage, and are richer in saproxylic Diptera. Wood-boring larvae of certain insects also cause sap runs, such as the poplar longhorn beetle *Saperda carcharius* in aspen. Whether sap-runs are caused by physical damage, micro-organisms or wood-boring insects, they are a natural feature of the woodland ecosystem and an individual tree may have several of them. The trophic structure of these regular elements is that *Anisopa*, *Aulacigaster*, *Brachyopa*, *Dasyhelea* and *Mycetobia* feed directly on the decaying sap and associated micro-organisms and *Phaonia* and *Systenus* are predators. From the point of view of conserving RDB species, sap-runs on aspen are particularly important as they are the only sap-runs used as breeding sites by the RDB species, *Brachyopa pilosa*, *Hammerschmidtia ferruginea* and *Xylota tarda.*

Decaying sap under bark of fallen wood

When a tree or branch falls it slowly decays over several years. The process has three distinct stages: formation of decaying sap under the bark; softening of the sapwood and heartwood; break-up of the softened wood. The first stage consists of the cambial layers and sap under the bark decaying to form a wet, pungent-smelling layer. This first stage is presumably caused by micro-organisms, which together with the sap on which they live, formed the most species-rich saproxylic microhabitat. It is also the most important microhabitat for RDB and notable species. This layer of decaying sap is, however, a temporary phenomenon because as decay proceeds, the bark loosens from the sapwood, cracks and eventually falls off. This lets in air, which dries the sap and kills the associated micro-organisms. The speed of this process is determined chiefly by species of tree, size of branch and its physical circumstances. In moist, shady conditions with a minimum 30cm diameter branch, the process is slow and may last up to four years. Below 30cm diameter and the branch is usually *too* small for a sufficient layer of sap to accumulate. On the other

hand, the larger the tree or branch the more persistent the layer of decaying sap, probably because the bark is thicker and it takes longer to crack and fall off. With a layer of decaying sap being the first stage of the decay of fallen wood and a temporary phenomenon, continuity is an important factor i.e. that new fallen wood inputs to the system at a rate sufficient to ensure a continuous supply. There was again regularity in the group of Diptera found in the layer of decaying sap under bark. In the early stages, when the bark is still quite firmly attached to the sapwood and the layer of decaying sap is building up the earliest colonisers are dolichopodids of the genus *Medetera,* sciarids such as *Lycoriella soloni,* lonchaeids and xylophagids belonging to the genus *Xylophagous.* Later, when the bark starts to become cracked and loose a range of other species from a wide variety of families may appear. The composition of this group is less predictable. A particularly rich community of over forty flies and beetles were found in decaying sap under the bark of aspen (MacGowan 1993). This included 1~ RDB and notable species (Table 1) and a species of *Ectaetia* (Diptera, Scatopsidae) new to science.

In addition to decaying sap found under bark, large amounts occur in tunnels of certain wood-boring beetles.

Decaying sapwood

The second stage in the decay of fallen wood follows the formation of decaying sap and the loosening of the bark. This is the softening of the sapwood and heartwood. Under attack primarily by fungi, the sapwood and heartwood become soft and moist although retaining their pale colour. A final, third stage involves the soft, decayed wood becoming wet and dark in colour and fragmenting under the influence of weathering and various biological agents, eventually returning to the soil. The speed of these stages is again determined chiefly by species of tree, size of branch and its physical circumstances. In moist, shady conditions with a 30cm diameter branch, the process may last up to five years In terms of providing a breeding site for Diptera. Decaying sapwood can also be located on live trees: in broken and dead branches. However, apart from common sciarids such as *Lycoriella soloni,* and tipulids belonging to the genus *Ctenophora,* some of which seem to specialise in breeding in broken branch ends, we found fallen wood to be much richer in saproxylic Diptera. One reason why decaying sapwood is a species-rich microhabitat for saproxylic Diptera are the numerous species associated with the fungi that breakdown the sapwood such as drosophilids, lauxaniids, fanniids and nematocera, combined with species breeding in the decaying sapwood such as clusiids and tipulids and various muscid and rhagionid predators which can be very common during this stage.

Wet decaying heartwood

Heartwood is the dead material at the centre of a tree or branch. The agents responsible for its decay are bracket fungi (Polyporaceae) and species such as the honey fungus, *Armillaria mellea* (Basidomycetes). These fungi enter the tree through roots, cut or broken branches and damaged bark. Without showing any external sign, they can live within the tree for many years gradually growing through the heartwood causing it to become soft. This softened heartwood eventually falls away and a hollow tree is formed. However, in the roots of even the oldest trees and most decayed stumps, as long as the bark surrounding the root is intact, moisture and decayed heartwood tend to accumulate. Under these conditions, secondary decay by micro-organisms invariably occurs and, contained by the bark, a mass of wet decaying heartwood builds up forming a rich breeding site for Diptera. Such pockets of wet decay may persist for many years and are used over and over again by

successive generations of saproxylic Diptera, particularly Syrphidae. A mere fragment above ground is sufficient because, like icebergs, a greater mass often exists below ground. Sometimes the entire underground mass of the stump is decayed. In stumps like these, many hundreds of larvae can be present. Such stumps are clearly major breeding sites. When ready to pupate, larvae move up to drier areas and puparia can be found behind loose pieces of bark or in the upper soil layers round the stump. We found the rare hoverfly *Criorhina ranunculi* breeding in such situations in aspen in Strathspey.

Previous Work on Aspen Insects

Much of the previous work on insects and aspen has related to the phytophagous species. Ashbourne and Putnam (1987) compared phytophagous species associated with aspen in Canada and Britain. They found there to be an equal species richness for native aspen in both countries. The sample sites for the British aspen were in Suffolk and Hampshire. In North America the samples were taken from *Populus tremuloides,* which is considered to be an exact ecological analogue of the European aspen *Populus tremula*. The American aspen is a very common and widespread species, Mueggler (1987) states that there are 1.49 million hectares of this species in Colorado alone. It is not surprising therefore that much scientific work on aspen has taken place in North America. Much of the work however is concerned with the position of aspen in vegetational succession or on genetics. Some work has been done on phytophagous pest species such as the American aspen beetle (Mason and Lawson 1982) and on the wood boring Saperda calcarata (Drouin and Wong 1975).

One of few papers which mentions insects being attracted to the smell of the exposed sub cortical layer is by T.E.Hinds (1972). He studied the insect transmission of the canker causing fungus *Ceratocystis* sp between *P. tremuliodes* trees in the western U.S.A.. To attract insects the aspens were wounded with a hatchet. Insects attracted to the wounds were then collected and identified. Hinds found that Nititulid beetles usually appeared first followed by Staphylinids and flies. Only two species of flies were recorded however, a Drosopholid and a Tachinid the latter presumably being parasitic on larvae already developing in the wound. There is no mention of any other Diptera being attracted to the wounds.

Information on aspen insects in Europe is also somewhat limited. In his paper on the vulnerable Diptera of Finland Vaisanen (1982) states that in true boreal forests the presence of old willows and aspens has a markedly enriching effect on the invertebrate fauna. He records the finding of the rare Statiomyid *Solva interrupta* under the bark of decaying aspens. In Finland species of *Clusidae, Lonchaeidae, Tanypezidae, Stratiomyidae* and *Solvidae* are associated with live or dead aspen trunks. In Sweden the *Coenomyid, Coenomyia ferruginea* may also share the same habitat. In Finland the amount of ancient forest has decreased dramatically since 1940 and as a result many of these species are at risk. In Sweden Aulen (1991) studied the possibility of increasing saproxylic insect abundance by killing aspen, birch and alder trees in order to provide a food supply for endangered woodpeckers. Trees were killed either by placing a herbicide in a notch made in the trunk or by ring barking the trees. The results showed that the most common insect colonists of the dead or dying aspen were the beetles *Saperda perforata, Sinodendron cylindricum* and *Xiphydria* spp. As far as Diptera were concerned only one un-identified species of Tipulidae was noted. The study concentrated entirely on standing dead timber rather than on fallen trunks, which were not utilised to any great extent by woodpeckers. Perhaps if the fallen timber had been studied more Dipteran species would have been encountered.

Aulen also comments that the notching and ring barking of deciduous trees such as aspen was carried out on a large scale by Swedish foresters. The aim of this treatment was to eliminate deciduous trees from managed commercial forests thereby increasing the efficiency of conifer production. In the province of Dalarna for example "thousands" of birch and aspen were notched and ring barked after a clearfell of conifers. The new forest regrowth consisted almost entirely of conifers and no old deciduous trees were left. This

again highlights the vulnerability of the aspen insect fauna in northern Europe. In the Baltic area Egina (1964) records that the larvae of the elaterid beetles *Adrastus limbatus, Melanotus rufipes* and *Selastomus aeneus* were found in aspen stumps in Latvia.

In Scotland Bagnall (1932) studied Cecidiomyids on aspen and visited sites at Grantown on Spey, Aviemore, Newtonmore, Kingussie, Amulree (Perths) and Montrose. Unfortunately he does not give any more exact locations for his Strathspey sites. Even the early Dipterists who did so much collecting in the Nethy Bridge and Grantown on Spey areas and found many of the aspen rarities did not go on to study aspen in any great detail or to search out other possible aspen sites. The lepidopterists too found interesting species on the Strathspey aspens. The Tortricoid moth *Gypsonoma nitidulana* was first collected at Aviemore by T.C.Cruttwell in June 1907 with further specimens being taken in 1908. It has not been recorded in Britain since that time. *Paraleucoptera sinuella* was first discovered in Britain in 1909 at Aviemore in a spinney of aspens near the railway station. It persisted there until the 1950's when it suddenly disappeared. This species has also been recorded from "an aspen wood on the banks of the River Spey, just outside Grantown. This presumably refers to the Speybridge site. Little follow up work seems to have been done on these moths since the 1950s.

Size Requirements for Aspen Sites

The availability of suitable habitat is obviously critical for the survival of saproxylic insects and this in turn is directly related to the aspen biomass present in any given area. In this report we have estimated aspen abundance by measuring the area over which the tree occurs but obviously the density and biomass of aspen can vary greatly between sites. Aspen can grow in dense single species stands or as a component of an open deciduous woodland community. The aim of the present survey was however only to identify and map the current aspen areas so that any changes in distribution in the future could be related to this 1990 baseline. A more meaningful statistic would be of the volume of timber or number of trees required to support a saproxylic community. Further work in this area is required in the future. In the meantime the area figure is used as a rather gross estimate of the size of the aspen resource.

In an area such as Strathspey the amount of aspen required to support a community of saproxylic insects can be much less than that required in other areas. This is due to the large amount of aspen present within the strath. The large aspen stands act as reservoirs from which colonisation of smaller stands can take place when conditions are favourable. It is by studying the saproxylic communities present in the smaller, more isolated stands that we can begin to gain some insight into the size of resource needed to support the various species. Several of these stands are rather fragmented within existing broadleaved woodland and the implication must be that many of the saproxylic insect species are highly mobile, moving between the aspen stands in the locality when suitable habitat becomes available.

The full aspen insect community is present within Achany Glen where there is an estimated 4.5ha of aspen present in several scattered stands within the birch woods. Situated within a glen and within continuous woodland movement between the aspen areas must be quite straightforward. At Gairloch an estimated 5ha of aspen is present but this is far more dispersed along a rather exposed coastline. Never the less all the aspen insects are present apart from *Hammerschmidtia*. The reason for the absence of this key species is as yet unclear. The implication must be that the resource is too scattered for Hammerschmidtia to utilise or alternatively it may not be suited to the high rainfall and exposed nature of this northwestern coastal site. On the other hand the aspen area at Torboll is only an estimated 1.5ha. Despite there having been a reported sighting of *Hammerschmidtia* at this site we could find no trace of any characteristic aspen insect apart from *Xylota tarda* despite finding suitable habitat. At Inverfarigaig only 3.3 ha of aspen is present. Here to only the sap run species *Xylota tarda* and *Brachyopa pilosa* have been found. We would suggest that there is not enough aspen resource at Torboll or Inverfarigaig to support the full aspen community.

It would appear that the sap run species *Xylota tarda* and *Brachyopa pilosa* are capable of maintaining their populations in relatively small stands of aspen. This is probably because sap runs do occur at reasonably high frequencies within stands of aspen and can be successfully utilised by these species. Only rarely has *X. tarda* been found in dead wood. *Hammerschmidtia* on the other hand is probably the most sensitive species to any decrease in the size of aspen areas. The larvae require fairly large pieces of dead timber in which to develop. Even in suitable conditions a single piece of dead timber may only remain suitable for *Hammerschmidtia* for three or four years. A large resource is therefore required to maintain a consistency of larval resource.

In conclusion, based on present information, we would predict that in order to sustain a complete and viable saproxylic aspen community an aspen area must meet the following criteria:

1. The stand must be 4.5ha or greater in extent, or
2. Must be part of a complex of aspen stands which extend over at least 4.5ha within a deciduous woodland matrix or
3. Be within 2.5Km of an aspen stand of over 4.5ha

Management Recommendations

1. Protect the existing aspen stands
2. Encourage regeneration of aspen and extension of the core areas
3. Prevent the removal of dead aspen wood from the aspen sites
4. Limit access to entomologists
5. Encourage understorey development where necessary
6. Encourage food plants which can be used by adult insects
7. Link up isolated aspen stands
8. Where possible position dead timber in shaded locations
9. Experiment with sap run creation
10. Protect genetic clones

1. We would consider that the first step which should be taken in ensuring the continuance of aspen stands and their associated insect communities is that certain key sites be recognised By FA and SNH as areas in need of protection and appropriate management. Inherent in the need to protect the aspen sites is a requirement to monitor the state and extent of the resource in future years using the figures produced in this report as a baseline figure from which future changes can be identified.

2. At many aspen sites saplings or any evidence of regeneration is lacking. to ensure the continuity of these stands in the future measures must be taken now to encourage regeneration. In some cases this can be done quite simply by excluding domestic stock but in other areas where the main culprits are rabbits or deer fencing or tubing may be necessary. Aspen does have a great ability to regenerate quickly from root suckers so it is likely that a new generation could be established relatively quickly. Extension of the present core areas by regeneration around the fringes would be a very effective conservation measure.

3. It is very important that no dead wood is removed from the present aspen core areas identified in this report. This will obviously lead to a reduction in the amount of habitat available for saproxylic insects and in many cases to a loss of individuals to the site. Aspen stands adjacent to housing may be most vulnerable to firewood collection.

4. As we have discovered during our survey damage can be caused to suitable dead wood by the very act of searching for larvae. As suitable dead wood is such a limited resource any loss caused by this means can have a major effect on local saproxylic insect populations. With the interest in insects slowly increasing there might be a tendency for collectors of some of the more popular groups such as Hoverflies to attempt to collect a voucher specimen of one of the aspen specialities. Where possible any such approach by individual or more particularly groups of entomologists should be discouraged. The locations of some of the smaller and more isolated sites should not be disclosed.

5. At certain sites aspen grows almost in isolation from a grassy grazed sward. In such situations fallen timber is open to the effects of sun and wind and soon becomes too dry to sustain insect communities. At these sites an understorey of hazel, juniper or bird cherry should be encouraged with ideally a few younger aspen. Even if this is not possible the encouragement of a longer field layer can usually increase the humidity at ground level and so decrease the rate of desiccation.

6. The dead aspen hoverfly *Hammerscmidtia ferruginea* has been recorded on several occasions feeding at the flowers of wild rose and bird cherry. Other dead wood species may also have the same requirements of an easily accessible nectar source as adults. This is especially true of the females which are producing eggs. We would recommend that these flowering shrubs are encouraged in the vicinity of aspen stands.

7. Many aspen stands are rather fragmented and satellite stands may be separated from the main woodlands by open fields, roads or conifer plantations. It would be a good management policy to establish broadleaved woodland links between these isolated stands and so increase the total amount of aspen resource available to the local aspen insect populations. These woodland links do not need to contain aspen, a birchwood link would probably suffice, but at least some representation of aspen would probably be an advantage if only to increase the potential aspen resource.

8. As has been pointed out previously dead timber can decay at varying rates depending on its situation. Dead timber is a scarce resource and steps should be taken to maximise the length of time that it is available for use by the saproxylic insect community. One of the most obvious cases is where a fallen limb or trunk is lying in a position where it is in full sunlight. If possible the dead wood should be moved into a shaded position. If the trunk is too heavy to be moved it may be worth partly covering it with branches, bracken or even sacking to try and reduce the rate of dehydration. Many aspen trees snap off in high winds rather than uprooting. The result is often that the top of the tree is left suspended from a point on the stump some 3 or 4m above ground level. We would recommend that in such situations the top of the tree is pulled off the stump and left to lie at ground level.

9. Sap runs provide an important micro-habitat in aspen stands and are exploited by the larvae of *Xylota tarda*, *Brachyopa pilosa* and even occasionally *Hammerschmidtia ferruginea*. Further work should be carried out to establish whether it is possible to create man made sap runs by marking or cutting the bark of aspens. If this is possible it may provide a means by which populations of these species can be encouraged.

10. There is some information in the literature that different aspen clones do show different characteristics with relation to growth rate and susceptibility to disease. Certainly in Strathspey it is noticeable that different clones come into leaf and lose their leaves at differing times. It is possible that different clones provide slightly different conditions for saproxylic insects. There may for example be variation in the thickness of the subcortical layer or in the amount of nutrients which it contains. At the present moment there is little information relating to this field but it is something which we should consider. Until we have further information we should try and prevent the total destruction of any aspen clone.

Conclusions

The large aspen stands of the Scottish Highlands are a remnant of the boreal woodlands which colonised this area after the last glaciation. These stands still have associated with them a diverse saproxylic insect fauna which shows strong similarities with that found in Scandinavian countries and Finland. The insect community contains many rare species, including one species new to science, two species new to Britain, seven listed in the Red Data Book and eight Notable species. In The British Isles this community is unique to the large Highland aspen stands. It is only in these areas that the continuity of dead wood and suitable niches such as sap runs can be guaranteed. In total we estimate that only some 160ha of larger aspen stands remain in the Highlands at this time. In British terms this is a small and potentially vulnerable resource, the importance of such areas in European terms is also increasing as pressure grows to remove aspen from commercially orientated Scandinavian woodlands. The importance of certain of the insect species associated with aspen has been recently recognised by the Council of Europe.

We have found that many of the aspen stands in the Highlands are suffering from lack of regeneration caused by overgrazing resulting in a lack of young trees for the future. Management action is required now to ensure the continued survival of the aspen stands and associated fauna in this country. At present the most effective way of ensuring the protection of the existing stands would be to have the best examples notified as Sites of Special Scientific Interest. Only a small percentage of sites are protected at the moment and even then not specifically for their aspen interest. In addition to giving statutory protection SSSI designation would also highlight the nature conservation value of these areas to landowners, tenants and other groups such as planners and foresters and may allow resources to be made available for management.

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