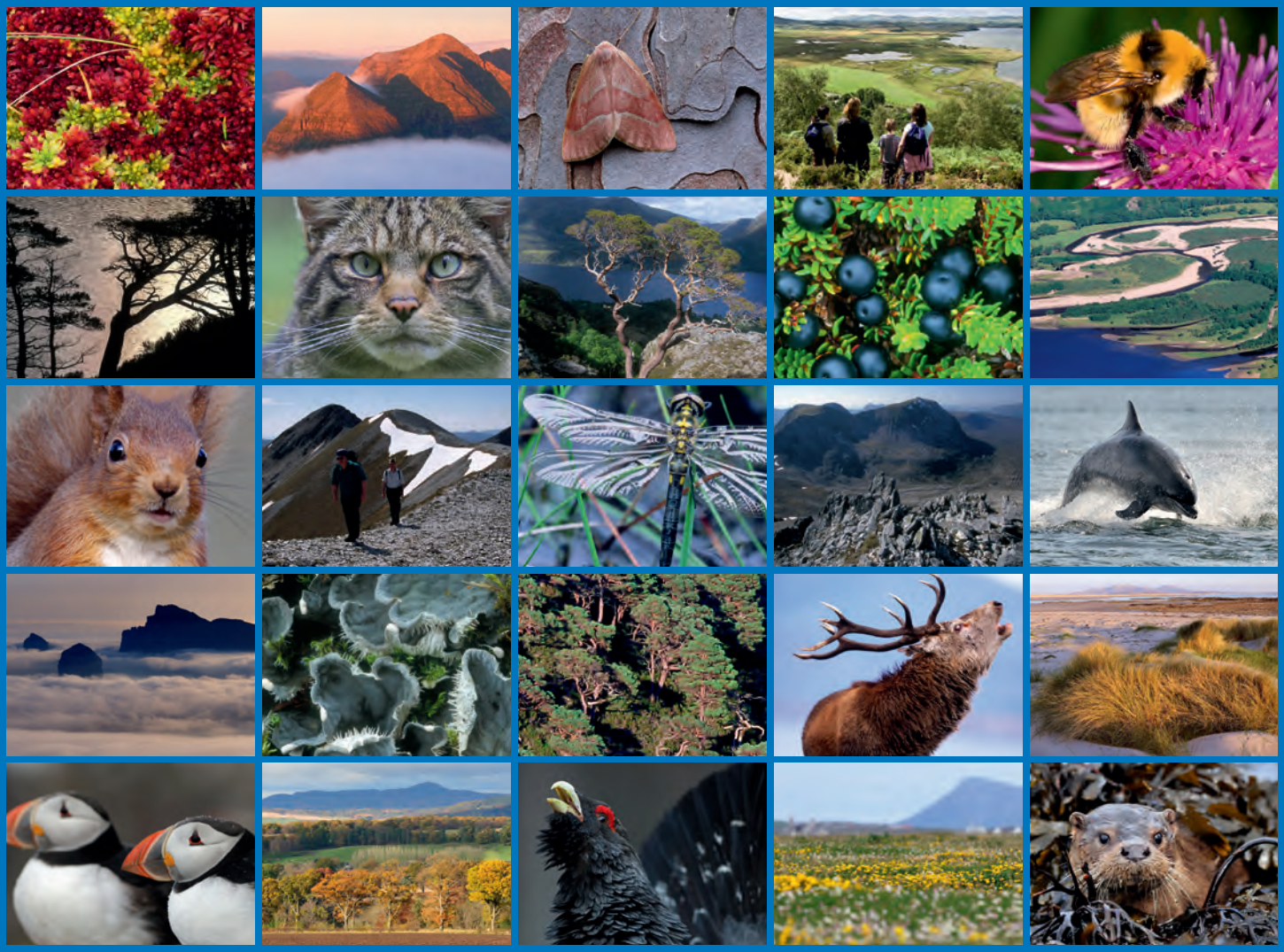
Scottish Natural Heritage
Commissioned Report No. 596

Status of five BAP species of Diptera (flies) in Scotland



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COMMISSIONED REPORT

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Status of five BAP species of Diptera (flies) in Scotland

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COMMISSIONED REPORT

Summary

Status of five BAP species of Diptera (flies) in Scotland

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Background

Scotland is the UK stronghold for five BAP (Biodiversity Action Plan) Diptera species for which there is limited information on range, population status and ecological requirements. Their biodiversity action plans call for basic research to be undertaken that will provide these missing data. This report gives the results of an attempt to obtain the missing data.

Main findings

- Data on known species ranges for each of the five BAP species were assembled from museum collections, publications, databases and liaison with experts.

- The Northern splinter fly was the most widespread of the five species examined here with a distribution covering northern to central and southern Scotland. The most restricted in distribution was the pine heartwood clusiid fly with only five sites, all but one of which is in Strathspey and centred on Nethy Bridge. The mountain dance fly and the large birch lance fly have somewhat restricted distributions centred mainly on the Cairngorms and central Perthshire, respectively. Probably due to adverse weather conditions during the period of this project, few extant populations were confirmed from the lists of sites obtained.

- Except for the mountain dance fly, basic requirements for breeding are assessed for each species. The large birch lance fly breeds preferentially in whitewood of large, fallen birch trees and branches but only when whitewood is moist and under decay by fungi. Populations appear to be characterised by high densities of larvae concentrated in only a few pieces of wood per site. The number of pieces of wood in the right condition appears to be a limiting factor.

- In contrast and on the basis of experience in Scandinavia, the pine heartwood clusiid fly breeds in wood of a similar nature but on pine, not birch, and is more dispersed, lacking an obvious preference for size of wood. Apparently suitable wood is widespread in Scottish pinewoods and there must be other factors, currently unknown, limiting the abundance of this species.

- The two splinter flies only breed in saturated, partially submerged and well anchored wood in small burns, springs and seepages in shaded conditions, usually high on glensides. The state of decay and degree of anchorage appears to be more important than type of wood although small pieces, under 20 cm in diameter, appear not to be used.

- The breeding requirements are unknown for the mountain dance fly. However, in common with other dance flies, larvae probably develop in the soil where they are predators of other insect larvae.

- Except for the mountain dance fly, direct species monitoring can be done using pupal or puparial stages that are left behind in the breeding site. Techniques for each species have been developed, partially tested and are described. Direct sampling of the mountain dance fly can be carried out using sweep netting along transects through patches of vegetation known for this species, such as *Racomitrium* moss heaths, *Racomitrium-Empetrum* heaths, *Deschampsia* and *Nardus* grassland, *Carex* heaths and dwarf shrub heaths.

- Of the five BAP flies, the pine heartwood clusiid fly appears to be the most severely threatened. A high priority is therefore suggested of a detailed assessment of the status and distribution of the only extant population discovered. This should be based on adult flies during the flight period and, particularly, empty puparia from late summer onwards. Within its central Perthshire stronghold, a similar study of dead birch and populations of the large birch lance fly is suggested as a second priority. A dedicated project is needed to investigate the basic ecology and requirements of the mountain dance fly. Discovery of extant populations is a suggested next step for the splinter flies, but the latter two projects are perhaps of a lower priority than work suggested for the clusiid and lance fly.

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Acknowledgements

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1. INTRODUCTION

Limited data are available on the range, population status and basic species requirements of five Biodiversity Action Plan (BAP) fly species known to be centred or confined in their UK distributions to Scotland (50-100% of populations). These species are, in checklist order:

- the Scottish yellow splinter fly, *Lipsothrix ecucculata* (Limoniidae);
- the northern yellow splinter fly, *Lipsothrix errans* (Limoniidae);
- the mountain dance fly, *Rhamphomyia hirtella* (Empididae);
- the large birch lance fly, *Lonchaea ragnari* (Lonchaeidae);
- the pine heartwood clusiid fly, *Clusiodes geomyzinus* (Clusiidae).

Their BAPs call for basic research to be carried out to provide the missing data which are required for site management plans and statements and to evaluate the feasibility of future population monitoring and, if required, devising and implementing targeted recovery plans.

The work described here reports research to acquire these missing data, specifically to investigate species ranges, population status, basic requirements and to develop methodologies for population monitoring.

2. METHODS

Information on each species' range and status was acquired by extracting data from museum collections, publications, databases, direct contact with experts and field searching. The museum collections examined were: the National Museums of Scotland (NMS), the Hunterian Museum, University of Glasgow (HM), the Natural History Museum, London (NHM) and the Oxford University Museum of Natural History (OUMNH). In addition, records were extracted from the Malloch Society Saproxylic Database (D. Horsfield pers comm) and literature records were obtained from the Scottish Insects Records Index (SIRI) maintained by the National Museums of Scotland. The latter is an almost complete listing of published records of Scottish insects.

For each species, field searches based on the life stages described below have been undertaken from May 2011 to October 2012. They are informed by lists of sites obtained from the sources mentioned above and using expert knowledge, mainly from members of the Malloch Society. We optimised site visits because they frequently fell within the remit of other ongoing projects for which access permissions had been obtained, in particular, SNH funded projects on Site Condition Monitoring for 42 Diptera species and conservation projects on the aspen and pine hoverfly. For example, in 2011, the NNR at Corrieshalloch, Wester Ross was visited as part of the Site Condition Monitoring project to specifically assess this site for the Scottish splinter fly and within the community woodlands surrounding Grantown on Spey, Inverness-shire, at the same time as this site was surveyed for puparial stages of the pine hoverfly, *Blera fallax* (Syrphidae) it was possible to search for puparia of the pine heartwood clusiid fly as they potentially occupy the same pine stumps. Given the time pressure due to the short periods available for sampling the splinter flies and the mountain dance fly, see below, and the amount of work required on all five species for both range and basic species requirements, this was an effective means of optimising time in the field.

It was agreed that the timescale for this project, 1 April 2011 to 30 March 2012, was too limited to enable us to complete the work on all five species up to the required standard and that the project may need to continue for 6 months or more after the end of the March 2012 report. This extra time has proved necessary and gave the project an extra season to complete acquisition of the required data. However, even an extra 6 months did not enable us to complete all site assessments. With nearly 50, widely scattered, known localities to examine, let alone search for new ones, completing this was not possible. An additional adverse circumstance is that the cold winters of 2009/10 and 2010/11 and the unusually wet summer weather in 2011 and 2012, may have adversely affected population levels and our ability to find them. Hence the details on range and population status provided here should be viewed as a starting point and provisional in nature. Data on species requirements and monitoring protocols are, however, more complete. Except for the northern splinter fly, we also include in this report unpublished results from investigations carried out prior to this project which directly relate to the aims and objectives described above. For example, few pine heartwood clusiid fly populations were encountered during this project and we used our experience of this species in Scandinavia to devise a set of monitoring protocols.

The life stages agreed for assessing population status and species range vary according to the particular ecologies of the five fly species. For the two splinter fly species, pupae are the most convenient life stage to sample but these are seasonal and time limited, from late May to late July. During this time, splinter fly larvae about to metamorphose move to exposed surfaces from the interior of wet, fallen wood lying in burns, springs and seepages that they have used for development. When the adult fly is ready to emerge, it wriggles forward until the anterior end of the pupa is exposed and pulls itself out of the pupal case which is left behind as a small, opaque, papery structure. Pupae are best collected before adults emerge and the emerging adult identified. Pupal cases can also be collected post emergence and

identified but key distinguishing features are provisional and require expert study to be sure of correct identification.

The early stages of the mountain dance fly are unknown and the adult stage is the appropriate sampling stage. Sampling is limited to the adult flight period, from June to mid July. For the pine heartwood clusiid fly and the large birch lance fly, it is the puparium that is the most convenient sampling stage. The puparium should not be confused with the pupa: the puparium is the dried and inflated integument of the final stage larva which provides a protective shelter for the pupa and the developing adult. The puparium is the unique defining life stage of the most species-rich, higher fly taxon, the Cyclorrhapha. In both the clusiid and the lance fly, sampling is not time-limited as in the other BAP species considered here, because empty puparia remain in the breeding site, well decayed and softened stumps and fallen wood not lying in water, for two or more years. In both species, puparia can be identified using characters readily observed using a hand lens or binocular microscope.

3. RESULTS

3.1 Scottish yellow splinter fly, *Lipsothrix ecucculata* (Limoniidae) and the northern yellow splinter fly, *Lipsothrix errans* (Limoniidae)

These small, delicate, pale-coloured craneflies are associated with woodland burns and seepages where they breed in partially submerged, wet wood.

3.1.1 Range and Status

The Scottish yellow splinter fly is known from five regions and 12 localities (Table 1). It appears to be fairly widespread from northern Scotland down to Stirlingshire with no obvious stronghold or concentration of populations. Most sites include, or are within or close to, woodlands and a high proportion are at a distance from each other suggesting that the species exists in a series of fragmented populations.

The northern yellow splinter fly is known from 10 regions and 18 localities (Table 2). It is more widespread than the previous species, being known from northern Scotland down to Lanarkshire. It similarly appears to have no concentration of populations and a high proportion of sites are distant from each other, suggesting the species exists in a series of isolated, fragmented populations.

Table 1. The historical range of the Scottish yellow splinter fly, Lipsothrix ecucullata *and status assessment made during this project (confirmed = breeding resources available).*

Region	Site	Date range of records	Status assessment
Inverness-shire	Belladrum Wood, NH5139	1981	not assessed
Inverness-shire	Garten Bridge, NH9419	1982	not found
Inverness-shire	Inshriach, NH8504	1981	confirmed
Inverness-shire	Loch Meiklie, NH4230	1981	not found
Inverness-shire	Moniack Burn, NH5543	1984	not assessed
Perthshire	Rannoch, NN45??	1967	not assessed
Stirlingshire	Ballagan,Strathbane, NS5679	1967	not found
Stirlingshire	Dollar Glen, NS9699	1992	confirmed
Stirlingshire	Kippenrait Glen, NS7898	1981-2000	confirmed
Sutherland	Achany Glen, NH5197	2000	confirmed
Sutherland	Inveran Glen, NH5197-9	1882-2000	not assessed
Wester Ross	Corrieshalloch, NH2077	1969-2000	confirmed

Table 2. The historical range of the northern yellow splinter fly, Lipsothrix errans *and status assessment made during this project (confirmed = breeding resources available).*

Region	Site	Date range of records	Status assessment
Aberdeenshire	Craig Castle, NJ4724	1977	not assessed
Angus	Den of Airlie, NO2952	1977-1981	not assessed
Argyllshire	Glen Nant, NN0217	1975-1976	not assessed
Argyllshire	Oban, NM8631	1926	not found
Dumfriesshire	near Drumlannig Bridge, NS8500	1969-2000	not assessed
Inverness-shire	Lochaber, Carnach Wood, NN0958	1976	confirmed
Inverness-shire	Loch Morlich, NH9709	2008	confirmed
Inverness-shire	Moniack Burn, NH5543	1984	not assessed
Lanarkshire	Avon Gorge, NS9679	1903	confirmed
Lanarkshire	Fiddlers Glen, NS8447	1989	not assessed
Perthshire	Glen Lochay, NN5136	1932	not assessed
Perthshire	Rannoch, NN5657	1931	confirmed
Renfrewshire	Cambuslang, NS5658	1899	not assessed
Renfrewshire	Kenmuir, NS6258	1899	not assessed
Renfrewshire	Milngavie, NS5658	1899	not assessed
Stirlingshire	Strathbane, NS5679	1899	not assessed
Ross and Cromarty	Beinn Eighe, NH0263	2007	not assessed
Ross and Cromarty	Gairloch, NG8076	1972	not assessed

Despite several hundred *Lipsothrix* pupae found during this project, none of them were identified as belonging to either of the two target species. All were from the common *Lipsothrix remota*. Hence, we were unable to confirm any extant population of the two BAP splinter flies. However, at many sites assessed, wet, decaying wood was found, i.e. breeding resources were present, which is reflected in Tables 1 and 2 under the status assessment criterion, 'confirmed (indirect)'. A lack of confirmation does not mean populations are absent from historical localities, only that we were unable to find them. In addition to localities in Tables 1 and 2, 15 other sites were visited and wet, decaying wood searched for pupae (Table 3). Again the only *Lipsothrix* material found was *L. remota*.

Table 3. Additional sites visited between May and September 2012 and wet dead wood searched for Lipsothrix *early stages.*

Region	Site name	Grid Ref
Perthshire	Kincardine Glen	NN9410
Perthshire	Cloan Glen	NN9610
Perthshire	Loch Venachar	NN5605
Perthshire	Glen Finglas	NN5307
Perthshire	Den of Riechip	NO0647
Perthshire	Loch of Lowes	NO0443
Perthshire	Pitlochry	NN9357
Perthshire	Loch Faskally	NN9158
Perthshire	River Tummel	NN8960
Perthshire	Pass of Killiecrankie	NN9162
Fife	Raithe Lake	NT2591
Arygll	Glen Cruitten	NM8730
Perthshire	Glackmore, Blair Atholl	NN6487
Perthshire	Methven Wood	NO0526
Inverness-shire	Craigellachie	NH8811

3.1.2 Requirements

Both *Lipsothrix* species breed in fallen, dead wood that accumulates naturally in running water, particularly in small burns, springs and seepages where the wood lies partially submerged and shaded by the canopy. Such wood can be in the form of isolated pieces or several pieces that have drifted together and formed jams. Depending on the size of wood, such jams can persist for several years.

The wood used for breeding is that which is saturated and decays to a soft, friable state yet maintains a basic structure, i.e. it has not collapsed or fragmented. Between the layers of wood, a biofilm of bacteria and fungi build up and it is probably these organisms that are accessed by larvae tunnelling through the wood to form the major item in the larval diet. Fully submerged wood is not used, primarily because females cannot access it for egg-laying. Larvae are, in any case, not aquatic and must have access to the air for respiration. It is the exposed parts of wet wood that pupae project from in late May to mid-July, often pupae are more frequent on the most shaded parts, such as the undersides of the wood.

Judging from the distribution of pupal cases, wood that is firmly anchored seems to hold higher numbers of specimens, but whether females are capable of actively selecting such wood is unclear. They may oviposit in less well anchored wood where larval mortality is greater due to it being washed downstream or becoming wholly submerged.

At Kippenrait and Inveran Glen, the greatest concentration of saturated, partially submerged yet well anchored wood occurred in small burns and seepages high up on the sides of glens. Here the water flow is relatively sluggish, at least in pools, near boulders, etc., and where sediment or vegetation helps to restrict flow and at the same time hold fallen wood in place. Sharing the breeding site is another very common and widespread *Lipsothrix* species, *Lipsothris remota* and also many other craneflies, particularly *Molophilus* species. As with the clusiids, it is unlikely that larvae compete for resources as fallen wood is generally an abundant resource in relation to larval size and density. Judging from the numbers of empty

pupal cases, *Lipsothrix* densities are relatively low even when common species like *L. remota* are included. The densities of pupal cases at the wood surface in a handful of counts undertaken at Kippenrait and Inveran Glen, rarely exceeded 1/100 cm^2.

It is unlikely that the species of wood, its shape or volume are more important than the state of saturation by water, decay and possibly the degree of anchorage. Size seems to be important, with wood over 20 cm in diameter being favoured for breeding.

Adult Scottish and northern splinter flies have not been encountered in the field, but *Lipsothix* adults of other species are generally found in shaded conditions close to breeding sites, either resting on rocks and boulders or among overhanging vegetation.

3.1.3 Monitoring

Unfortunately, if larvae are disturbed they are difficult to rear and mortality is high. Their bodies are long, thin and appear to be fragile and easily injured. Hence searching through saturated wood to count larvae is not an effective means of monitoring. Emergence traps are also not recommended. Cattle, deer and people tend to disturb this type of trap and they cannot be left for more than a day during peak emergence times because adult flies are likely to die due to lack of food within traps. Furthermore, the two target *Lipsothrix* species are difficult to identify in the field and all trapped *Lipsothrix* and *Lipsothrix*-like craneflies would have to be removed and identified in the laboratory. This could impact on populations of target and non-target species and the cost effectiveness of emergence trapping. Due to the uneven topography characterising many burns, sweep netting for adults along a standard walk is difficult to achieve so is also not recommended.

Hence the recommendation made above is for direct survey using pupae during late May to mid-July. Live pupae can be collected from pieces of wet wood by carefully and slowly scraping exposed surfaces with the point of a knife. Helpfully live pupae are active and wriggle in response to being disturbed. Pupae can be collected into individual containers with a little wet wood and kept in shaded conditions until adults emerge. Adults can be identified using one of several readily available keys (Chandler, 2010). Empty pupal cases can also be collected but identification is complex and specimens should be submitted to relevant experts, for example, members of the Malloch Society (http://www.mallochsociety.org.uk).

3.2 The mountain dance fly, *Rhamphomyia hirtella* (Empididae)

This medium-sized, red and grey, narrow-bodied, predatory fly has been known in Scotland for nearly 120 years. It is a montane species occurring at and above 800 m.

3.2.1 Range and Status

Known from four regions and 10 localities (Table 4). These localities lie mostly at either end of the Grampian mountains revealing a disjunct distribution. All records are above about 800m. The stronghold appears to be the Cairngorms, but intervening peaks between the Cairngorms and Bidean nam Bian, such as Bean Alder and Ben Nevis, have yet to be assessed. Such assessments are a priority for work on understanding the range and status of this species.

Table 4. The historical range of the mountain dancefly, Rhamphomyia hirtella *and status assessment made during this project.*

Region	Site	Date range	Status assessment
Aberdeenshire	Little Loch Elchachan, NJ0100	2000	not assessed
Argyllshire	Bidean nam Bian, NN1454	1997	not assessed
Inverness-shire	Creag Meagaidh, Carn Liath, NN4187	2009	not assessed
Inverness-shire	Lairig Ghru, NH9700	1933	not assessed
Inverness-shire	Cairngorms, NH9902	1962-1984	not assessed
Inverness-shire	Braeriach, NN9799	1986	not assessed
Inverness-shire	Caenlochan Glen, NO1677	1987	not assessed
Inverness-shire	Glas Maol, NO1776	1987-1991	not assessed
Inverness-shire	Lurcher's Gully, NH9703	1988	not found
Morayshire	Tomintoul, NJ1618	1962	not assessed

3.2.2 Requirements

All that is known of the ecology and requirements of the mountain dance fly comes from habitat associations and observations of the adult stage. Early stages are unknown but by comparison with other dance flies, they are likely to develop in leaf litter and soil where they will be predators of other insect larvae. Adults are also predatory but prey ranges are unknown. Adults have been observed on montane flowers but which species they visit, and whether they visit them to feed on pollen and nectar or as a place to encounter prey, is unknown.

Most records have come from pan and pitfall traps, which can be successful in capturing adults. For example, Horsfield (2002) reports that at Braeriach, in 1 month, 15 June to 14 July 1986, pan traps caught 59 males and 47 females. On the other hand, 3 months of pan trapping on Creag Meagaidh in 2009 only produced two males (Rotheray, unpublished data). Hence population size appears to be variable from year to year or from locality to locality.

The habitat associations of captured adults suggest that *Racomitrium* moss heaths, *Racomitrium-Empetrum* heaths, *Deschampsia* and *Nardus* grasslands, *Carex* heaths and dwarf shrub heath particularly on northern facing slopes are the vegetation and habitat zones characterising mountain dance fly populations. However, adults have also been captured on scree slopes, bryophyte springs, mossy snow beds and among tall herbs on rocky ledges.

3.2.3 Monitoring

Without any knowledge of early stages, the adult stage must be used for direct monitoring of mountain dance fly populations. Pan traps can be used but they catch many other insects and setting them up and sorting catches can be time-consuming. Nonetheless, as noted above, pan traps can be successful. Sweep netting is another option but adults are often deep within the vegetation and catching them in a net can be difficult.

Both techniques are restricted to the adult flight period, June to July. Adult *Rhamphomyia* specimens are fairly easy to spot among trap catches and in sweep nets. Not many *Rhamphomyia* species occur on Scottish mountains and the other more common species is *R. morio*. These two species can be easily separated in the male by the larger and more conspicuous genitalia of the mountain dance fly. Females require a little more experience.

A combination of pan traps and sweep netting is suggested for direct monitoring. Pan traps should be yellow or white, filled with water, a few drops of detergent and about 20% by volume of 4-6% formalin and sunk into the ground or placed among rocks and boulders. They should be emptied once a fortnight. Sweep netting along a standard transect either of a set length or time is recommended. Sweep-netting is most successful on warm, still and ideally, sunny days. Indirect monitoring can be undertaken based on the quality and quantity of vegetation zones apparently preferred by the mountain dance fly, i.e. northern facing *Racomitrium* moss heaths, *Racomitrium-Empetrum* heaths, *Deschampsia* and *Nardus* grasslands, carex heaths and dwarf shrub heath.

Due to persistently poor weather disrupting fieldwork, only one site was visited, Lurcher's Gully, Inverness-shire, NH9703, on 25 July 2012. However, despite collecting insects by sweep-netting and searching for dance flies on flowers, no specimens of the mountain dance fly were obtained.

3.3 Large birch lance fly, *Lonchaea ragnari* (Lonchaeidae)

This shiny-black, small, housefly-sized species was only discovered in Scotland in the 1990s. It is associated with old and well established birchwoods, *Betula* spp.

3.3.1 Range and Status

Prior to this project, the large birch lance fly was known from four regions and eight sites. Of these historical sites, it was confirmed as present at three, not confirmed at two and three were not visited (Table 5). Considering all recorded sites, the stronghold appears to be central Perthshire but the historical distribution extends eastwards into Angus and northwards to Ross and Cromarty. Within this range populations appear to be isolated from one another. However, at the stronghold, populations may not be so isolated if they are present in a majority of the many birch stands bordering the river glens of the Garry, Tay and Tunnel between Dunkeld northwards to Strathspey. Casual inspection suggests many appear to be of the right quality and condition to house populations.

Table 5. The historical range of the large birch lance fly, Lonchaea ragnari *and status assessment made during this project (confirmed = breeding resources available).*

Region	Site	Date range of records	Status assessment
Angus	Glen Isla	2009	not assessed
Inverness-shire	Strathfarrar, NH3802	1993	not assessed
Ross & Cromarty	Novar	1993	not assessed
Perthshire	Netherton, NO1452	1998	not confirmed
Perthshire	Rannoch, NN6055	1923	not confirmed
Perthshire	Fungarth, NN0442	1996-2011	confirmed
Perthshire	Tomanbuidhe,	1998-2010	confirmed

Ross & Cromarty	NN7359 Glen Affric, NH1823	2010	confirmed

Eight sites additional to those listed in Table 5 were visited during the period, May to September 2012 (Table 6). Habitat suitable for breeding, i.e. large, decay softened, standing or fallen, dead birch tree trunks, were present at all localities. Although empty puparia were frequent, only at two sites, Balnagard, Perthshire and Craigellachie, nr Aviemore, Inverness-shire, were puparia of the large birch lance fly located (Table 6). The condition of these empty puparia was good i.e. they showed no evidence of decay, such as losing their shiny appearance or being fragmented. Adults had probably only just emerged from these puparia earlier in 2012, perhaps by a matter of a few days or weeks.

Table 6. Sites visited between May and September 2012 and dead birch wood searched for early stages of the large birch lance fly.

Region	Site	Grid Ref	Status assessment
Inverness-shire	Craigellachie	NH8811	new
Perthshire	Balnagard	NN9451	new
Perthshire	River Tummel	NN8960	not found
Perthshire	Pitlochry	NN9357	not found
Perthshire	Glen Finglas	NN5307	not found
Perthshire	Glackmore, Atholl	NN6487	not found
Deeside	Morrone Birkwood	NO1491	not found
Perthshire	Carnach Wood	NN3545	not found

3.3.2 Requirements

The large birch lance fly breeds in trees and branches of fallen birch, *Betula* spp. and appears to be confined to birch: no rearing records have been obtained from alder, ash and pine searched at the same sites as *L. ragnari* was reared from birch. However, the size and condition of fallen birch appears to be important. At Fungarth and at Tomanbuidhe, assessments were made of the size and condition of wood used by this species. These sites were walked over in May 1996 and 1998 and September 2007. Fallen birch was searched by hand for puparia. From previous investigations, *L. ragnari* breeds deep within fungus decayed and softened whitewood, i.e. sapwood and heartwood, that can be broken into and crumbled by hand. Puparia are usually found between the layers of fungus decayed wood, often at or near the surface of the wood. Puparia can be identified using the key in MacGowan & Rotheray (2008). However, a simple, field recognition feature is the presence of a hook-like projection above each of the posterior spiracles. Other lonchaeid species breeding in the same habitat are *Lonchaea caucasica* and *L. limatula*, but their projections above the posterior spiracles are smoothly curved and do not have a hook-like shape (see figures in MacGowan & Rotheray (2008)).

About 130 pieces of fallen birch wood, varying in diameter from 10 to over 60 cm, were encountered and searched. Puparia of *L. ragnari* were only associated with fallen wood that was about 30 cm in diameter and above and had decayed to the level that the whitewood was soft and moist. All eight pieces containing *L. ragnari* were lying flat on the ground and fungal infestation was actively present, as revealed by the presence of grey-white sheets of

fungal mycelia growing through the wood layers. The larva of *L. ragnari* appears to develop on the interacting products associated with fungal decay.

Although no quantitative assessments were made due to the destruction of the breeding site that this would entail, the abundance of puparia in fallen wood can be high. This can mean dozens of puparia present in the largest pieces of wood, usually the main trunk of the tree. Furthermore, at all localities visited, the number of large pieces of fallen wood in the right condition were relatively rare. Based on the figures above, this was about 6%, but they were all colonised. Suitable wood probably provides a breeding medium for a period of 2-4 years, after which relevant fungal decay ends and decay proceeds to a different stage which is no longer suitable for *L. ragnari*. In other words, *L. ragnari* populations are characterised by only utilizing large and scarce pieces of fallen wood, but when they are colonised, abundance can be high. Hence, a considerable proportion of the next generation is probably concentrated in just a few pieces of dead wood per site.

Adult lonchaeids are rarely seen in the field. Males and females spend most of their time high in the canopy where they are difficult to sample (MacGowan & Rotheray, 2008). However, from the characteristics of the birchwood, a closed canopy does not appear to be essential and birch trees growing in more open situations, such as found over much of the site at Tomanbuidhe, appear just as able to support a population. We observed adult lonchaeids feeding on aphid honeydew coating tree foliage and on two occasions we saw them feeding on fluids exuding from a 3 m tall, birch snag at Tomanbuidhe. At other times, adult lonchaeids were found sheltering on the underside of tree leaves and sweep netting foliage sometimes captured adults. To date, no *L. ragnari* have been obtained in this way.

3.3.3 Monitoring

The most convenient monitoring stage is the puparium which remains behind in the breeding site and sampling using this stage does not affect population abundance. The puparium of *L. ragnari* is straightforward to identify from the small hook-like projections associated with the posterior spiracles. This feature also serves to distinguish it from fly puparia of other families present in fallen wood. Given the longevity of empty puparia, surveying is not restricted up to about 2 years post emergence, following which puparia fragment. A disadvantage, however, is that fallen wood has to be broken into to find puparia and care is required to limit disturbing breeding sites.

Emergence trapping is an alternative method which has the advantage of not disturbing the breeding site. Emergence traps placed over part or all of a fallen tree or branch are inexpensive and relatively simple to construct using wire hoops and mosquito netting (not treated with insecticide) and stones or pieces of wood to hold down the edges. Disadvantages of emergence traps are that cattle, deer and people tend to disturb them and they cannot be left for more than a day during peak times because emerging flies are likely to die due to lack of food within traps. Furthermore, *L. ragnari* is difficult to identify in the field and all trapped lonchaeids would have to be removed and identified in the lab, impacting on populations and the cost effectiveness of emergence trapping.

We suggest that hand searching for puparia is the most effective and low impact method of direct population assessment, provided care is taken in searching fallen wood. To avoid harming eggs and actively developing larvae, fallen wood should be assessed in September to November and March to May in any one year. To assess populations the following method is recommended. Use a standard walk of a set time or length for each locality and, along the walk, record and search every piece of fallen wood above 30 cm in diameter. Record the following states per piece of wood:

1. fresh, bark intact, whitewood firm = future breeding resource, in 1-2 years time;

2. bark cracking, partial decay with outer layers of whitewood soft, rest hard = possible breeding medium, possibly more suitable in 1 year, search for puparia in softened parts;
3. bark loose but attached and whitewood soft throughout and moist = ideal, search for puparia;
4. bark falling off and/or whitewood dry or powdery and brown not white in colour = decay has proceeded beyond the point suitable for *L. ragnari* larval development.

Search for puparia at one broken end or a place where whitewood is exposed, or lever up cracked or broken bark and search underneath for a set time, e.g. 10-15 minutes per piece of wood. Remove all empty puparia. To prevent damaging breeding sites, do not disturb more than 5-8% of a piece of wood and replace disturbed and loosened material. Either identify puparia on the spot or take back to the laboratory for identification using the key from MacGowan & Rotheray (2008).

Populations are assessed by the quality and quantity of fallen wood per locality according to the four stages above and by the number of puparia sampled. Indirect sampling can be carried out by surveying fallen wood above 30 cm diameter and assessing the stages of decay 1-4 above.

No specific threats to fallen wood were noted at site visits. A potential threat, however, is overgrazing around fallen wood or clearing or draining land such that fallen wood becomes exposed and dries out. However, at sites of extant populations, all dead wood above 30 cm in diameter should be conserved. This is all the more important given the concentration of breeding within just a few pieces of dead wood of this size per site. Continuity of breeding resources is very important and regular assessment of the state of fallen birch wood at sites of extant populations is recommended. The large birch lance fly provides a proxy for a diverse and rich community of saproxylic and other organisms utilising fallen birch including other lonchaeids, clusiids, muscids, various nematocerans and other cyclorrhaphans (Diptera), ants, beetles, hibernating bumblebees, parasitic Hymenoptera and a range of other invertebrates, fungi and lower plants.

3.4 The pine heartwood clusiid, *Clusiodes geomyzinus* (Clusiidae)

This 3-4 mm long, narrow-bodied and colourful fly with mottled white, red and brown body markings and black marked wings has been known in Scotland for over 120 years, but it appears to have always been rare and has declined in recent decades. It is associated with Caledonian pinewoods.

3.4.1 Range and Status

The pine heartwood clusiid fly is known historically from two regions and five sites (Table 7). The stronghold is or was, Strathspey in Inverness-shire with an outlying population in Sutherland. The four Strathspey sites are all at the western end of the Strath and within fairly close proximity of each other. The last known record is from Grantown in 2001 (Malloch Society Saproxylic Database).

Table 7. The historical range of the pine heartwood clusiid fly, Clusoides geomyzinus *and status assessment made during this project.*

Region	Site	Date range of records	Status assessment
Inverness-shire	Abernethy, NJ0108	1985-1989	not confirmed
Inverness-shire	Grantown, NJ0327	1985-2001	not confirmed
Inverness-shire	Loch Garten, NH9717	1933	not confirmed
Inverness-shire	Nethy Bridge, NJ0020	1900-1915	not confirmed
Sutherland	Lochinver, NC0922	1911	not confirmed

All Inverness-shire sites were visited during August 2012 and two additional sites in Strathspey were also visited, Curr Wood, NH9923 and Rothiemurchus NH9110. Habitat suitable for breeding (pine stumps and fallen pine wood that have decayed to the point that bark is intact but the whitewood is soft and moist) was searched and empty clusiid puparia were found to be frequent at all sites. However, only in pine stumps at Cemetery Wood, Grantown, Inverness-shire, NJ0020, was the characteristic puparium of the pine heartwood clusiid found: two individuals in one pine stump. The condition of these empty puparia was good, i.e. they showed no evidence of decay such as losing their shiny appearance or being fragmented. Adults probably emerged from these puparia earlier in 2012, in June or July.

Cemetery Wood is close to the site of the last records for this species, where adults were found on the cut surface of pine stumps in pine woods continuous with but just south of Cemetery Wood.

Apparently suitable habitat is widespread in Scotland, especially north-east Scotland and its congener, *Clusiodes caledonica*, which shares the breeding site, was frequently discovered and is generally common and widespread. The similarity between the two large hoverflies, both saproxylic and associated with Caledonian pine, is striking. *Callicera rufa* was once considered to be endangered but is now known to be spreading (MacGowan & Rotheray, 2006) and has been recently discovered in England but the pine hoverfly is confirmed as endangered and is only known from two localities in the same area of Strathspey as the pine heartwood clusiid fly. *Clusiodes caledonica* is, like *Callicera rufa*, mainly confined to Scotland but is also known in one or two localities in England. It is possible that the same factors are responsible for the apparent decline in both the pine hoverfly and the pine heartwood clusiid fly. However, these factors are unlikely to be the lack of dead wood in suitable condition or competition with other fly larvae. Given the small size of the clusiid flies and the large quantity of dead wood in a fallen branch or tree, it is very unlikely that larval resources are limiting. This could result in competition between the pine heartwood clusiid fly and *C. caledonica*. Indeed, our experience of the pine heartwood clusiid fly in Scandinavia, suggests that it can be common in pine and spruce and it is only one of a community of clusiids breeding in association with these conifers.

It is possible that current conditions of climate or environment do not favour the pine heartwood clusiid fly and explain its decline but, without more research, such factors cannot be assumed. At Abernethy, Loch Garten and Grantown, searches for the pine heartwood clusiid fly have been made sporadically since 2000, but even more so in 2011 during the course of this project. Only being able to re-discover one extant population is a considerable

concern and further searching over both a wider area, combined with concentrated searching in pine woods in and around Grantown, the site of the most recent records, is a priority.

3.4.2 Requirements

We have reared the pine heartwood clusiid fly many times in Scandinavia (Norway, Finland and Russia) where it breeds in pine and spruce. With the discovery of puparia at Grantown, pine is confirmed as a host tree in Scotland. Given that Scottish populations are unlikely to have experienced spruce until it started to be planted in Scotland, we do not know whether Scottish populations will also breed using this tree species.

The condition of fallen wood is important. The pine heartwood clusiid fly larva develops deep within moist, fungus-decayed and softened pine whitewood, i.e. sapwood and heartwood that can be broken and crumbled by hand. Puparia are usually found between the layers of well decayed wood, often at or near the surface. Puparia can be readily identified as belonging to the Clusiidae by the pair of red-brown, curved and tapering hooks to the outside of the posterior spiracles. From Scottish pine, the Malloch Society have reared two other clusiid species, *C. caledonica,* which is centred in Scotland in its UK population, and the common and widespread *Clusia flava*. The former species appears to be confined to conifers, the latter additionally breeds in broad-leaved trees. Fortunately, the puparium of the pine heartwood clusiid fly is readily separated from the puparia of these two other clusiids. The pine heartwood clusiid fly has the anterior spiracles with about eight respiratory bulbs and lacks pupal spiracles, a pair of pale brown, spiracle-encrusted, pin-like projections from the dorso-lateral surface of the first abdominal segment. In puparia of the other two clusiids, the anterior spiracles have 3-5 respiratory bulbs and they possess pupal spiracles. These features are, in many instances and with experience, visible using a hand lens, but due to the anterior spiracles sometimes being damaged, in a collapsed state or obscured by adhering debris, a proportion always need checking with a binocular microscope.

In Scandinavia we reared the pine heartwood clusiid fly from a wide size range of pine branches, from diameter about 8 cm upwards and also from pine snags and stumps. Fallen branches and snags and stumps in the right stage of decay were found to be extensive, even abundant, throughout Abernethy, Loch Garten and Grantown. Yet the only puparia we found were those of *C. caledonica*.

The amount of wood in suitable condition is proportionately so great against that colonised by this rare clusiid, that the chances of locating specimens is correspondingly low. This is in direct contrast to the situation in Scandinavia where the pine heartwood clusiid fly is more frequent. In Scandinavia, adults are usually found on fallen wood where males walk and run around defending small territories. In high winds and rain they shelter in bark crevices or under leaves of nearby vegetation. It is unknown if they visit flowers.

3.4.3 Monitoring

Larvae are small, difficult and time-consuming to locate and the breeding medium has to be broken up to find them. Hence looking for larvae as a means of direct monitoring is not recommended. Emergence trapping for adults is an alternative method but the same comments apply as made for the large birch lance fly. Emergence traps placed over part or all of a fallen tree or branch are inexpensive and relatively simple to construct using wire hoops and mosquito netting. Disadvantages are that cattle, deer and people tend to disturb emergence traps and they cannot be left for more than a day during peak times because emerging flies are likely to suffer from lack of food within traps. To use emergence traps for the pine heartwood clusiid fly may be difficult due to the problems of locating adults within

them. Rather than fly upwards to walk on the netting which facilitates location, adult clusiids tend to remain on the wood and either fall or fly to the ground if disturbed. Under these circumstances they will be hard to spot within the trap.

The puparium that remains behind in the breeding site can be readily found and survey using this stage does not affect population abundance. The puparium of the pine heartwood clusiid fly is, as noted above, straightforward to identify. Given the longevity of empty puparia, surveying is not restricted up to about 2 years post emergence after which puparia become brittle and fragment. A disadvantage of searching for puparia is, however, that fallen wood has to be broken into to find them.

As a result of the above considerations, we suggest that hand searching for puparia provides the most effective and lowest impact method of direct population assessment, provided care is taken in searching fallen wood. To avoid harming eggs and actively developing larvae, fallen wood should be assessed in September to November and March to May in any one year using the method as described for the large birch lance fly, except that pieces of pine wood from about 8 cm upwards in diameter can be searched. Indirect assessment can be made by recording the amount of fallen wood in the right condition, again using similar criteria for determining the stage of decay as for the large birch lance fly. However, all of this is predicated on locating extant populations, which is the highest priority for ongoing work involving this species.

4. RECOMMENDATIONS FOR FUTURE WORK

From the number of historical and extant populations found during this project, the pine heartwood clusiid fly is the most restricted and hence, probably the most endangered of the five BAP species studied in this report. The flies with most widespread historical populations are the splinter flies, but extant populations were not discovered during this project, probably due to adverse weather rather than populations being lost or absent. The large birch lance fly and the mountain dance fly are intermediate in range and status between these extremes.

Based on these results, as a first priority, future work should be directed towards the pine heartwood clusiid fly. This work should involve a more detailed assessment of the status of the species at Grantown, presently the site of the only known extant population. The community woodland trust who manage woodland surrounding Grantown, should be made aware of the importance of the Grantown woods for this endangered species, especially its need for pine stumps and fallen pine wood. The population assessment would involve searching the surfaces of pine stumps and fallen pine wood for adults in June and July and searching the decayed sapwood for empty puparia from about mid-August to the autumn. The latter period would avoid inadvertent damage to the vulnerable egg and early larval instars when searching sapwood. On the basis of the results obtained from such a detailed population assessment, important parts of the pinewoods surrounding Grantown could be identified and pine stumps and fallen wood maintained and encouraged especially in these areas.

For the large birch lance fly, a similar population assessment is suggested for birchwoods within the stronghold area of the river glens of the Garry, Tay and Tummel between Dunkeld and Strathspey. This should also include quantitative assessment of the amount, occurrence and size (diameter and length) of dead birch in its various stages of decay to inform whether and how to manage dead birch for this species.

A factor limiting work on the mountain dance fly is an understanding of its breeding requirements, but obtaining these data is likely to involve a great deal of difficult work in attempts to either breed the species or locate larvae. The larva of the mountain dance fly is probably a soil predator. Hence for the dance fly, a dedicated project is suggested to progress work on understanding the basic ecology of this species, perhaps at one of its more accessible sites, such as Creag Meagaidh NNR, Inverness-shire.

For the splinter flies, future work should be directed at attempting to locate extant populations, but such work is probably a lower priority than work on the pine heartwood clusiid fly and the large birch lance fly.

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