


Spotting Pot Beetles

Survey Report and Habitat Recommendations

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Saving the small things that run the planet

Summary

Pot beetles (genus *Cryptocephalus*) are a fascinating group of beetles. Of the 19 species found in the UK, eleven have been recorded in Scotland and seven of these have conservation designations.

Scottish Natural Heritage (SNH) provided funding to Buglife through the 'Spotting Pot Beetles' project to run surveys and workshops to raise awareness and improve participants identification skills of the different species of pot beetles and their leaf beetle relatives.

During the summer of 2019 surveys with volunteers were carried out at Kirkconnell Flow Site of Special Scientific Interest (SSSI) in Dumfries and Galloway to survey for the Six-spotted pot beetle (*Cryptocephalus sexpunctatus*) and at the Black Wood of Rannoch in Perthshire to survey for the Ten-spotted pot beetle (*Cryptocephalus decemmaculatus*). The 2019 surveys successfully found both target species, 17 adults of the Six-spotted pot beetles were recorded at Kirkconnell Flow, 15 of which were within a new area at the site, and Ten-spotted pot beetles were recorded in two areas of a new 1km square within the Black Wood of Rannoch.

Guidance is provided within this document on managing habitat at both Kirkconnell Flow and Black Wood of Rannoch for their pot beetles to ensure the long term survival of both species in Scotland.

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1. Introduction to pot beetles

Pot beetles are a fascinating and charismatic group of beetles that are in the subfamily Cryptocephalinae within the Chrysomelidae leaf beetle family. These amazing beetles get their common name from the protective shell-like cocoon or 'pot' that the larvae live in, that is created using the beetle's own faeces (Figure 1) (Hubble, 2017).

Figure 1. A larvae of the Hazel pot beetle (*Cryptocephalus coryli*); image © Eakringbirds.

The pots are initially built by the female during and immediately after egg laying, with the egg being held between the rear metatarsi and covered by the female's faeces, the precise structure of the pot varies between the different pot beetle species (Hubble, 2017). Once covered, the pots are dropped to the ground amongst leaf litter and this often forms much of the larval diet. A hole is made at one end of the pot when the egg hatches allowing it to feed and move around in the leaf litter. As the larvae grow, the pot needs to be enlarged which it does using its own faeces. The larvae can take up to two years to develop into adults. Another key feature of this group is that the head of the adults is hidden under their bulging pronotum, that is used to block up the entrance of their pots when they are a larvae, and is the source of the scientific name for the genus '*Cryptocephalus*' meaning 'hidden head'.

There are 19 species of pot beetle known to occur in the UK (table 1), with the Violet pot beetle (*Cryptocephalus violaceus*) recently being described as extinct and no longer on the UK list (Hubble, 2014). At least eleven species are thought to occur in Scotland (six of these have recent records on the NBN atlas (www.nbnatlas.org) and five have historic records that pre-date 1979 or even before the 1900's (Table 1). Many species of pot beetle have suffered declines in their distribution across the UK and are now quite rare. Six species are described as Endangered and two as Vulnerable in the recent status review (Table 1) (Hubble, 2014). Additionally, nine are described as Nationally Rare and five as Nationally Scarce within Great Britain. In Scotland, two are on the Scottish Biodiversity List, the Six-spotted pot beetle (*C. sexpunctatus*) and the Ten-spotted pot beetle (*C. decemmaculatus*) (Table 1).

Table 1. List of *Cryptocephalus* pot beetles known to occur in the UK, with notes on when the species was described and those recorded in Scotland; records taken from NBN Atlas and Cox, 2007. Notes also include reference to rarity designations for each species as described by Natural England (Hubble, 2014) including IUCN threat categories - Critically Endangered (Possibly Extinct): CR (PE), Endangered: EN, Vulnerable: VU, Near Threatened NT and Least Concern: LC; Great Britain rarity- Nationally Rare NR and Nationally Scarce NS; and whether the species is on the Scottish Biodiversity List: SBL. Where scientific name is in bold, this highlights species with records (either historic or current records) from Scotland.

Scientific Name	Common Name	Notes
Cryptocephalus aureolus (Suffrian, 1847)		Historic records and a more recent record from 2015 in South Ayrshire. Rarity status: None, widespread across UK.
Cryptocephalus biguttatus (Scopoli, 1763)		Rarity status: VU, NR
Cryptocephalus bilineatus (Linnaeus, 1767)		Rarity status: LC, NS
Cryptocephalus bipunctatus (Linnaeus, 1767)	Two-spotted pot beetle	Historic records for this species from across Scotland. Recorded at Kirkconnell Flow SSSI in June 2017. Rarity status: LC, NS.
Cryptocephalus coryli (Linnaeus, 1767)	Hazel pot beetle	One record from Kincraig from 1946. No recent records. Rarity status: EN, NR
Cryptocephalus decemmaculatus (Linnaeus, 1767)	Ten-spotted pot beetle	Recorded in Scotland at Black Wood of Loch Rannoch, one site in England. Rarity status: EN, NR, SBL
Cryptocephalus exiguus (Schneider, 1792)	Pashford pot beetle	Rarity status: CR (PE), NR
Cryptocephalus frontalis (Marsham, 1802)		Rarity status: NT, NR
Cryptocephalus fulvus (Goeze, 1777)		Not recorded from Scotland. Rarity status: None, widespread in England and Wales.
Cryptocephalus hypochaeridis (Linnaeus, 1758)		Rarity status: LC, NS
Cryptocephalus labiatus (Linnaeus, 1761)	Black birch pot beetle	Recorded at several sites across Scotland. Rarity status: None, widespread across the UK.
Cryptocephalus moraei (Linnaeus, 1758)		Pre-1979 record for site in North Ayrshire. No recent records in Scotland. Rarity status: None, widespread in England and Wales
Cryptocephalus nitidulus (Fabricius, 1787)	Shining pot beetle	Rarity status: EN, NR
Cryptocephalus parvulus (Müller, 1776)		At least two old records from pre-1979 in Scotland. Rarity status: LC, NS.
Cryptocephalus primarius (Harold, 1872)	Rock-rose pot beetle	Records from Scotland from pre 1900s and none shown on NBN Atlas. Rarity status: EN, NR.
Cryptocephalus punctiger (Paykull, 1799)	Blue pepper-pot beetle	At least two old records from pre-1979 in Scotland. No recent records in Scotland. Rarity status: VU, NR

Cryptocephalus pusillus (Fabricius, 1777)		Recorded in Scotland in Dumfriesshire and Highlands. Rarity status: None, widespread across England and Wales.
Cryptocephalus quercetin (Suffrian, 1848)		Rarity status: EN, NR
Cryptocephalus sexpunctatus (Linnaeus, 1758)	Six-spotted pot beetle	Recorded in Scotland from Kirkconnell Flow NNR. Rarity status: EN, NR, SBL

2. Spotting Pot Beetles

Scottish Natural Heritage (SNH) provided Buglife with funding to run the 'Spotting Pot Beetles' project during 2017, 2018 and most recently in 2019. There is a dedicated page for this project on the Buglife website (https://www.buglife.org.uk/projects/spotting-pot-beetles/) where project reports can be found:

In 2019 our aims were to:

- Organise and run three training workshops to raise awareness and improve identification skills of the different species of pot beetles and their leaf beetle relatives in Scotland.
- Organise and run two survey days with volunteers to search for the Six-spotted pot beetle at Kirkconnell Flow SSSI in Dumfriesshire, and at nearby sites such as Mabie Forest.
- Organise and run two survey days for the Ten-spotted pot beetle at Black Wood of Loch Rannoch in Highland Perthshire.

3. Six-spotted pot beetle

The Six-spotted pot beetle has a reddish-yellow thorax and elytra with usually three black spots (sometimes four) on each elytral wing case (Figure 2) (Hubble, 2012). Adult beetles are between 4.5-6.5 millimetres (mm) in size (Hubble, 2012). This species has been found feeding on a number of plant species including Aspen (*Populus tremula*), Crack willow (*Salix fragilis*), Hawthorn (*Crataegus monogyna*) as well as young oak (*Quercus* species) and birch (*Betula* species) (Cox, 2007). Adults have also been seen on the flowers of Wood spurge (*Euphorbia amygdaloides*) and yellow Asteraceae species (Cox, 2007).

Figure 2. Six-spotted pot beetle recorded at Kirkconnell Flow SSSI in June 2017.

Adults emerge in mid to late May and females lay their eggs in low foliage before dropping them into the leaf litter below (Hubble, 2012). Eggs take about 3-4 weeks to hatch and the larvae take between 12-21 months to develop before anchoring themselves to a leaf, sealing the pot and pupating (Hubble, 2012). When ready to emerge from their pot, the beetle cuts a hole at one end.

This species was once widespread in southern England with scattered records as far north as Ayrshire in Scotland (Piper, 2002; Anon., 2010a). The current status of the beetle is that it now has an extremely localised distribution in the UK with only one known site in Scotland (at Kirkconnell Flow SSSI) and two sites in England, at Stockbridge Down in Hampshire and a recent discovery of a population in Lincolnshire (Piper, 2002; Anon., 2010a; Charlie Barnes, personnel communication 2019). At Stockbridge Down, despite repeated searches, only a few individuals have been recorded since 1990 (Piper, 2002). The pot beetle was recorded at Kirkconnell Flow SSSI in the late 1990s and two adults were rediscovered during year one of this project with the help of volunteers in June 2017 (Burgess & Shanks, 2017). No adults were recorded during the single survey day at Kirkconnell Flow in 2018 (Lemon & Shanks, 2019).

Current threats to the Six-spotted pot beetle include the loss of broad-leaved woodland and inappropriate woodland management including the neglect of coppicing which has led to the development of high forest with little regeneration of young trees (Piper, 2002, Littlewood & Stockan, 2013). Habitat fragmentation has led to isolation of populations of this species. There is a potential concern that this isolation is causing reproductive failure.

3.1. Kirkconnell Flow SSSI

Located 6 kilometres (km) south of Dumfries, Kirkconnell Flow SSSI is a raised bog that lies on the flood plain of the River Nith (Figure 3). Due to the dramatic decline in the area of raised bog habitat across Europe since the start of the nineteenth century, it is important that sites recognised as having ‘active’ raised bogs are protected and managed

appropriately. The UK, along with Finland, Sweden and Ireland, has several large raised bogs and therefore has a responsibility for conserving them. In the UK, there are very few active raised bogs that remain undamaged. Most raised bogs have been affected by activities such as peat cutting, forestry and drainage over the last two hundred years.

Figure 3. The open area of peat bog at Kirkconnell Flow.

The impact of past land use at Kirkconnell Flow has reduced the original dome of the raised bog. The cutting of peat and the excavation of drainage ditches has lowered the water table and this has changed the types of plants found on the bog, with mosses such as *Sphagnum* being replaced by heather (*Calluna vulgaris* and *Erica* species) and sedges (Anon., 2019c). As a result the central area of the bog is a mosaic with active areas that are still forming peat and degraded areas that are unable to form peat (Anon., 2019c). The drier areas within the degraded patches have allowed trees such as Silver birch (*Betula pendula*) and Scot's pine (*Pinus sylvestris*) to colonise (Anon., 2019c).

The trees have further exacerbated the damage to this bog by lowering the water table and shading out bog mosses. The drier the bog becomes, the more conditions favour tree growth and therefore more trees can colonise the bog surface. Due to its raised bog status, Kirkconnell Flow was designated a National Nature Reserve (NNR) in 1959 and was bought by SNH in 1998 (Anon., 2019c). When bought by SNH a large-scale programme was developed to help restore the site to ultimately raise the water table and re-wet the bog and this would allow it to regenerate (Anon., 2019c). Part of the programme involved clearing woodland from across the site and blocking drains to make the bog wetter (Anon., 2019c). A fringe of woodland was left around the site to reduce visual impact on the landscape that clearing the woodland within the central area may have caused (Anon., 2019c). It is this area of remaining mixed woodland, where young birch and oak are allowed to germinate and grow that has provided habitat for the Six-spotted pot beetle. The site was de-designated as an NNR in May 2018.

Due to it being an 'active' raised bog, the site has several other conservation designations. Kirkconnell Flow is a Site of Special Scientific Interest (SSSI), it lies within the Solway Mosses North Special Area of Conservation (SAC) which covers an area of 652 hectare and lies within the National Scenic Area (NSA) of the River Nith (Anon., 2019c).

3.2. Six-spotted pot beetle volunteer survey

In 2017, two adults of the Six-spotted pot beetle were recorded in an area adjacent to the bog at grid reference NX 9643 7020 (Figure 4). These were the first two individuals of this species to have been recorded in Scotland since the late 1990's (Burgess & Shanks, 2017). In 2018, the area was revisited with volunteers on the same weekend as in 2017 to determine the health of the beetles at this site. During the survey in 2018, one and a half days were spent on site, but no species of pot beetles were found. As only two adults were found during the first two years of the project it was important to revisit Kirkconnell Flow to determine the size and health of the population at this site. This year two full days of surveys were held (again on the same weekend) on Friday 21st and Saturday 22nd of June 2019 with volunteers. Permission was obtained from SNH to complete the surveys over the two days.

Figure 4. Map of locations where pot beetles were recorded during surveys in 2017 and 2019. Green marker at NX 9643 7020 where 2 adults were recorded on the 24th June 2017. Red markers are from surveys in 2019. Aerial image © Google Maps.

Adults of the Six-spotted pot beetle are known to feed on a range of plant species; their preferred plant at Kirkconnell Flow appears to be the saplings of Silver birch. During this survey, volunteers looked for adults feeding on the leaves of small saplings of Silver birch (and saplings of other deciduous trees). They also used sweep nets to survey for the beetles and to record other invertebrates.

On day one (Friday 21st), one member of Buglife staff was joined by seven volunteers for the survey; this included three members of staff from SNH who manage the reserve. During day one, the same area was targeted where two adults were recorded in 2017, and that was again surveyed in 2018, following the main path directly out of the car park heading east, surveying the birch woodland on either side of the path. In this area, two individuals of the Six-spotted pot beetle were found, they were found at separate locations along the path at grid reference NX 9629 7017 and NX 9635 7020. During the day the survey was continued along the path beyond the woodland to investigate the birch saplings on the open bog, up to roughly 200m from the woodland edge before stopping (Figure 5). No pot beetles were found in this area of the site, but other species of invertebrate were recorded.

Figure 5. Volunteers surveying habitat at Kirkconnell Flow for the Six-spotted pot beetle.

On day two (Saturday 22nd) one member of Buglife staff was joined by four volunteers for the survey. A new area of the reserve suggested by SNH was targeted for this survey day. The area surveyed at grid reference NX 9633 7048 was an area of open bog (though very dry) of roughly 0.8 hectare in size that was surrounded by woodland. The open area had a very high abundance of young birch saplings which appeared to be ideal habitat for the beetle. This area was surveyed by methodically going across the bog moving south to north surveying the birch saplings whilst the group went. A total of 15 adult Six-spotted pot beetles were found in this area including one which was found caught in a spider's web and was no longer alive (Figure 6).

Figure 6. One of the Six-spotted pot beetles recorded during day 2 of the survey.

It should be noted that the area of open bog surveyed on day one, where no beetles were found, was considerably wetter and had many pools, unlike the new area surveyed on day two which was extremely dry.

During the two-day survey we had hoped to visit Mabie Forest to determine if suitable habitat for the Six-spotted pot beetle is present. Mabie Forest is very close to Kirkconnell Flow and is a well manged and protected site owned by Forestry and Land Scotland. Due to time constraints in this project and visiting the new area at Kirkconnell Flow on the second day of surveys it wasn't possible to visit Mabie Forest at this time.

A number of other species of invertebrate were recorded during the two days including the common Black birch pot beetle (*C. labiatus*) and long-horned leaf beetle *Luperus longicornis* (Figure 7). A list of invertebrates recorded during the surveys at Kirkconnell Flow on the 21st and 22nd of June 2019 is in Appendix 1.

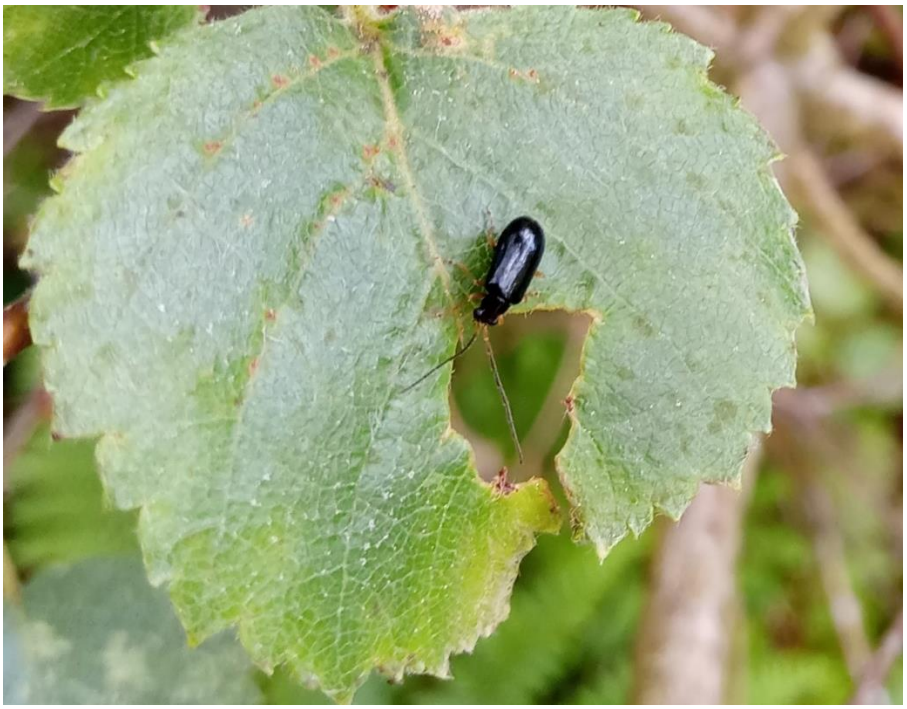

Figure 7. Several adult long-horned leaf beetles *Luperus longicornis* where observed feeding on birch at Kirkconnell Flow.

3.3. Habitat management recommendations for Six-spotted pot beetle

Previous habitat management recommendations in reports produced by Buglife in 2017 and 2018 have been followed by SNH staff who manage Kirkconnell Flow. SNH and Butterfly Conservation have organised several volunteer work parties at the site through their 'Bog Squad'. These groups have removed birch saplings from the peat bog itself whilst ensuring that young birch saplings around the periphery of the site are left. This will help ensure that there is an ongoing food of young birch trees for the Six-spotted pot beetle.

The following actions have been provided as further advice in managing Kirkconnell Flow SSSI for the Six-spotted pot beetle.

1.
Action - Ensure that a plentiful supply of young birch saplings is maintained at Kirkconnell Flow SSSI.
Reason - All adults of the Six-spotted pot beetle found during the surveys in June 2017 and 2019 were swept from saplings of Silver birch ranging in height from 1.5-3 metres (m). Silver birch is a problem on the bog itself but it is important not to remove it from across the entire site to ensure that a range of heights and ages of birch trees as well as other tree species are available.

2.
Action - Maintain good structural diversity and species within woodland along the edge of the site by creating glades and cutting areas in rotation to create sheltered micro-climates.

Reason - Adult Six-spotted pot beetles are known to feed on a range of plant species and require open glades. Within the woodland border it is important to ensure there is a diversity of tree species and areas where new growth can occur. This will benefit not only the Six-spotted pot beetles but also other invertebrates and wildlife that require a varied structure and range of species in a woodland setting.

3.
Action - Minimise ground disturbance during the spring (April-June) when adults are seen.
Reason - Fully-grown larvae may be in the leaf litter at this time and may be more sensitive to trampling if there is very heavy disturbance. Any planting or habitat work in the area should be carried out in autumn or winter and avoid trampling and disturbance of leaf litter around existing young birch.

4. Ten-spotted pot beetle

The Ten-spotted pot beetle is characterised by five black spots on each yellow-orange elytron and a black pronotum with a distinctive yellow mark in the centre (Cox 2007; Hubble, 2012). The markings of this species are highly variable, displaying a range of spot sizes (Figure 8). Melanic forms with completely black elytra but retaining the yellow mark on the pronotum are known from the UK (known as subspecies *C. decemmaculatus bothnicus*) (Piper, 2002). Around 30% of both male and female individuals found at Camghouran at Loch Rannoch during the survey visit in year one of this project displayed this colour form (Burgess & Shanks. 2017). No melanic forms were found during the surveys in 2019.

Figure 8. Three Ten-spotted pot beetle at Camghouran by Loch Rannoch in July 2019 showing the colour variation between a mating pair. From this image it is possible to see the size difference between the female and male.

Clear sexual dimorphism is non-apparent, although female beetles are often slightly bulkier reaching 4 mm in length, whereas males can reach 3 mm, females have relatively shorter prothoracic limbs and antennae (Figure 8) (Hubble, 2012). Adults of both sexes have wings,

and will readily fly if disturbed, but studies of dispersal indicate they generally don't fly great distances; none were observed in flight during surveys in 2019 and when disturbed would typically feign death (thanatosis) and drop to the ground. The larvae of this species are brownish white with a black sclerotised head capsule and prothorax (Piper, 2002).

The Ten-spotted pot beetle is associated with willow (*Salix* species) growing in sheltered *Sphagnum* covered heathland habitat on hillsides on the edges of quaking bogs. Favoured host plants in Scotland appear to be small specimens (under 1 m tall) of Eared willow (*Salix aurita*) (Figure 9). Grey willow (*Salix cinerea*), Goat willow (*Salix caprea*), and occasionally Downy birch (*Betula pubescens*) have been recorded as being used in England (Cox, 2007); an adult was observed on a Silver birch (*Betula pendula*) sapling during surveys in 2019.

Figure 9. Ten-spotted pot beetle feeding on Eared willow at Black Wood of Rannoch.

Adults of this species are usually found in May and June in England, although individuals have been found through to the end of August at the well-studied Wybunbury Moss NNR in Cheshire (Piper, 2002). Observations of wild larvae show that the immature stages of this species can be found beneath the adult host plants feeding on leaf litter from the adult host plant. Larval development generally takes two years in the wild, with some years very few adults emerging.

Only two sites are currently known to support Ten-spotted pot beetles in the UK, Wybunbury Moss NNR in Cheshire and Camghouran on the south side of Loch Rannoch in Perthshire (Piper & Compton, 2013; Piper, 2013; Piper, 2015). Single specimens have previously been recorded from two other sites in Scotland: at Muir of Dinnet in Aberdeenshire in 1986, and within 'the Braemar area' in Aberdeenshire in 1959, however the exact locations of both sites are unknown (Littlewood & Stockan, 2013).

4.1. Camghouran and the Black Wood of Rannoch, Loch Rannoch

The Black Wood of Rannoch is an area of ancient woodland growing along the south shore of Loch Rannoch between Dall and Camghouran in Perthshire. This ancient forest holds some of the oldest pines in Scotland, with some estimated at over 400 years old (Anon., 2019a; Anon., 2019b). It is thought that woodland has been growing on this site virtually undisturbed since the end of the last Ice Age 10,000 years ago.

The various habitats within Black Wood of Rannoch support a diverse array of species. It is due to these diverse habitats that the site has been designated as a SSSI and a SAC, protecting the many special plants and animals that live among the pine trees and wetland areas (Anon., 2019a; Anon., 2019b). The site is particularly rich in lichens, fungi and rare vascular plants, and has been designated as an internationally Important Plant Area (IPA) (Anon., 2019b). In addition to Caledonian woodland, the area holds a mix of other habitats including bogs, fens, marsh, heath, scrub and dry grassland and riparian habitats, supporting a plethora of rare invertebrates (Anon., 2019a).

Within the Black Wood of Rannoch, a single larva of the Ten-spotted pot beetle was recorded in surveys in 2002 within an area of mixed broadleaved and coniferous woodland at grid reference NN5455 (Piper, 2002). This area lies to the west of the Allt Camghouran burn which cascades down the north-facing slope towards Loch Rannoch, passing the open area of hillside known as Camghouran. Piper (2002) described the area of suitable habitat for the beetle at this site as being ~60 m^2 in size with parts being dominated by birch with very few sallows present. It was in this area that seven adult beetles were found in July 2017 during year one of the Spotting Pot Beetles project.

During surveys in July 2018, a population was discovered in a new 1km square within a wayleave area at grid reference NN 5421 5672 (figure 10).

Figure 10. The area of wayleave that has suitable habitat for the Ten-spotted pot beetles with over 30 adults recorded here during this year's survey.

4.2. Ten-spotted pot beetle volunteer survey

During year three of the Spotting Pot Beetle protect we aimed to organise and run two survey days for the Ten-spotted pot beetle within the Black Wood of Loch Rannoch in Perthshire with volunteers to determine the size and health of the population. Permission for running the surveys was obtained from the landowner through SNH for the 3rd and 4th of July. Buglife organised the surveys with The Conservation Volunteers Wild Skills trainee scheme and six volunteers attended both days alongside the Buglife staff member.

On day one (3rd of July) we parked in a layby at grid reference NN 53637 56911 and headed into the woodlands to survey for pot beetles in the 1km square NN 5356 (Figure 11). The weather was dry, humid at times and with a slight breeze which helped keep the midges away for most of the afternoon. From here, the group walked east in the aim to get to the area where they were discovered in 2018.

Figure 11. The group of volunteers from TCV travelling east through a new 1km square at NN 5356 looking for Ten-spotted pot beetles.

Whilst walking through the area, small and medium sized willows, in particular Eared willow were observed for feeding activity and adults. Within the area at NN 53830 56819 several adults were recorded feeding on Eared willow (Figure 12). This is a new 1km square for the Ten-spotted pot beetle and appeared to be a healthy population (Figure 13 and 14); one other adult was recorded close by at NN 53873 56816. A number of other interesting species of invertebrate were recorded within this area including the Nationally Scarce Four-spot leaf beetle (*Clytra quadripunctata*) which is associated with ant nests (and is within the pot beetle subfamily Cryptocephalinae), the Nationally Scarce Deer bot-fly (*Cephenemyia auribarbis*) and the more common Black birch pot beetle. A list of all the species recorded during the surveys on the 3rd and 4th of July at Black Wood of Rannoch is in Appendix 2.

Figure 12. Volunteers looking for pot beetles in the new 1km square at NN 53830 56819, where several other interesting species of invertebrate were recorded.

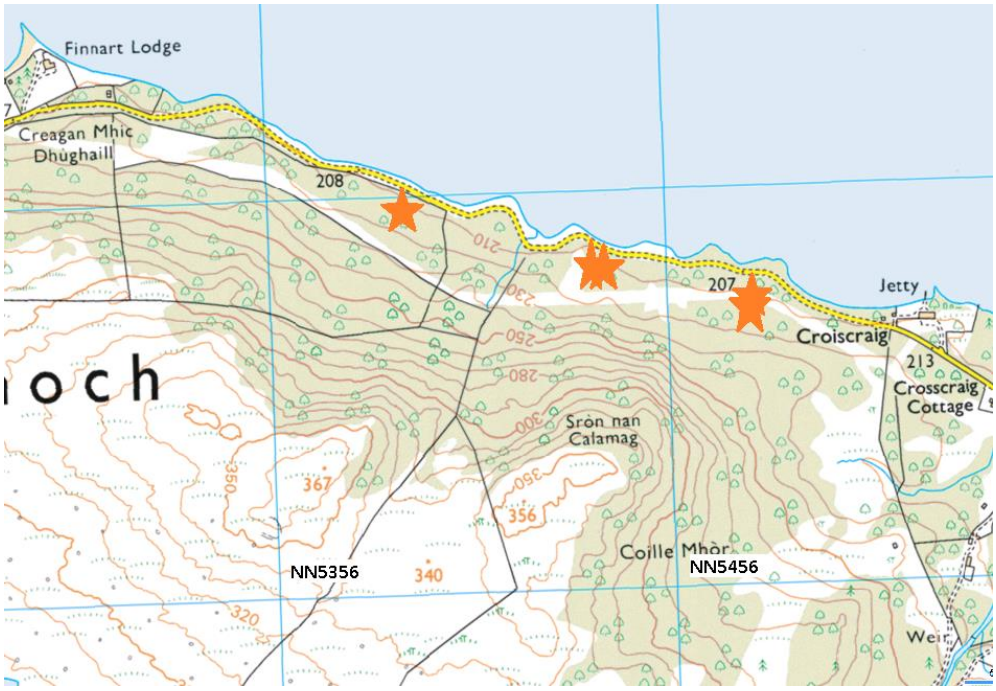

Figure 13. Ordnance Survey map with stars marking areas where Ten spotted pot beetles were recorded during this year's surveys in 1km squares NN 5356 and NN 5456. Ordnance Survey map © Bing Maps.

Figure 14. Aerial map showing location of pot beetles alongside grid references; red markers are from the survey on day one on the 3rd of July and the green marker is from the survey on day two on the 4th of July.

From this area we continued east looking for other populations of the pot beetle and aimed to get to the area where they were discovered during surveys in 2018 in the 1km square at NN 5456. When we arrived in this area at grid reference NN 54242 56738 several adults were observed (Figure 12 and 13). We then visited the wayleave at NN 54238 56715 and over 30 adults were recorded on Eared willow (Figure 10). This area appears to have done really well in 2019 with volunteers loosing count of the number of adults active over several Eared willow. The wayleave area appears to be regularly cut back due to the electricity pylons that pass through here and it is this clearing that provides an ideal habitat for the Ten-spotted pot beetle. From here the beetles may disperse to other suitable young saplings of Eared willow.

On day two (4th July) we started within the 1km square NN5356 to determine if there were any other populations present here. Another small population of three individuals was recorded at NN53345 56988 (Figure 12 and 13). We then ventured west to the next 1km square at NN5357 to look for further populations living close to the Loch. The morning of the 4th of July was dry although cloudy. There was rain at times that did affect the survey. Heading west through this square, the vegetation is denser and the terrain difficult to walk through. Fewer small and young Eared willows were observed in this area, although if they were present they could easily have been over looked due to the density of the habitat in places and how large the area is.

A total of 44 species of invertebrate were recorded during the two survey days, including two other species of pot beetle, the Black birch pot beetle and the Four spotted leaf beetle (Appendix 2).

4.3. Habitat management recommendations for Ten-spotted pot beetle

A considerable amount of habitat management has been carried out at Wybunbury Moss in England that appears to have significantly benefited the Ten-spotted pot beetles there and has led to large increases in the population at that site (Piper, 2013; Piper 2015). The following recommendations are therefore based on proven management techniques at this site that would benefit the pot beetle at Camghouran.

1.
Action - Ensure that existing patches of dwarf sallows in open sunny clearings are protected from deer browsing. Deer fence exclosures installed around small groups of sallows could help to stabilise, and increase the existing pot beetle population, which may be threatened by browsing by deer, especially in harsh winters. This could be particularly important in the wayleave at grid reference NN 54238 56715.
Reason - Browsing by deer may threaten remaining fragments of suitable Ten-spotted pot beetle habitat. Ten-spotted pot beetles depend on young sallow leaves, which are also favoured by deer. This can result in isolated pockets of sallows that support populations of beetles being heavily browsed and stripped of leaves before the adult beetles emerge. Creation of a stepping stone network of exclosures in sheltered sunny clearings may help stabilise the beetle population and help fragmented populations within the Black Wood of Rannoch to reconnect.

2.
Action - Ensure areas currently supporting the beetle are open to the maximum amount of sunlight, without exposure to excessive winds. Create open clearings around existing sallows by removing tall birch scrub shading them, but don't completely remove scrub as this offers shelter.
Reason - Adult beetles are often found basking on willow trees in open, sunny, but sheltered locations. Larvae develop in the fallen leaves beneath the food plant. In the wet boggy habitats where this beetle is found, basking locations are likely to be important to increase body temperature above a threshold required for various activities such as mating, egg development, escape from predators, and for larval development.

3.
Action - Attempt to expand the area of suitable habitat by planting preferred host plants of the Ten-spotted pot beetle including Eared willow and/or Grey willow and remove potential barriers to dispersal, such as tall birch scrub. Volunteers helped to map the distribution of sallows at the core area in 2018 (Lemon & Shanks, 2019).
Reason - The number of suitable sallows in this 1 km square appeared to be very low and is likely a major population-limiting factor. Increasing the density and choice of food plants for the adults and larvae is a good strategy for increasing the beetle population.

4.
Action - Minimise ground disturbance during the spring and when adults are seen.
Reason - Fully-grown larvae may be in the leaf litter at this time and may be more sensitive to trampling if there is very heavy disturbance. Any planting or habitat work in the area should be carried out in autumn or winter and avoid trampling and disturbance of

sphagnum and leaf litter around existing sallows. This includes the clearance of vegetation under the electricity pylons. By completing this work in late autumn, early winter there will be less disruption to the beetles, but also to other species in the area.

5.
Action - Scallop woodland edges to create sheltered micro-climates for Ten-spotted pot beetle.
Reason - Cutting back birch and other trees and shrubs, including non-sallows, Bog myrtle (*Myrica gale*) and Bracken (*Pteridium aquilinum*), to create sunny south-facing scallops or small clearings around favoured food plants would open them up to sunshine, while protecting them from too much wind.

5. Further recommendations

As well as the suggested habitat management recommendations described above for both the Six-spotted pot beetle and Ten-spotted pot beetle, there are several other considerations for both species.

1.
Action - Monitor beetles at Black Wood of Rannoch (Ten-spotted pot beetle) and Kirkconnell Flow SSSI (Six-spotted pot beetle) to establish population size and health.
Reason - 2017 was the first year that Six-spotted pot beetles had been recorded at Kirkconnell Flow SSSI since the late 1990s and Ten-spotted pot beetles hadn't been recorded at Black Wood of Rannoch since 2002, when only a larva was recorded. Although the highest number of adults of both species were recorded during surveys in 2019, it is important to continue to survey and monitor for both species at both sites. Due to the likelihood of a two year lifespan it is strongly recommended that monitoring continues in order to establish the size and health of the population. Continued surveys to monitor population size and health are also recommended every three years for the Six-spotted pot beetle and five years for the Ten-spotted pot beetle by Littlewood & Stockan (2013).

2.
Action - Expand searches for suitable habitat to surrounding 1 km squares and attempt to find further sub-populations in the local area of Dumfriesshire for the Six-spotted pot beetle and Loch Rannoch for the Ten-spotted pot beetle.
Reason - Checking for suitable habitat in surrounding areas should be attempted to assess how localised the population is within Kirkconnell Flow SSSI (Six-spotted pot beetle) and Camghouran and Loch Rannoch (Ten-spotted pot beetle) and the surrounding areas. Initially we planned to visit Mabie Forest during surveys in 2019 but due to poor success on day one of the surveys (only finding two adults on Friday 21st 2019) it was decided to spend all of day two surveying a new area to determine if the beetles were elsewhere on the site.

3.
Action - Carry out searches for suitable habitat and the species at known historic locations across Scotland.

Reason - Checking for suitable habitat at locations where the species has been recorded in the past may enable remnant populations to be rediscovered. For example there is a record on the NBN Atlas for a single individual of Six-spotted pot beetle recorded by the Royal Horticultural Society within their insect reference collection from 2008 at Grantown-on-Spey at grid reference NJ0326. The Ten-spotted pot beetle has previously been recorded near Braemar and Muir of Dinnet in the Cairngorms. Visits in June and early July would be recommended for both species, and as well as searching for the beetles themselves the surveys could also focus on searching for preferred host plants and the condition of habitat. Searching an area with trained volunteers has proven to be very successful in the current survey.

4.
Action - Potential captive breeding of both species for re-introduction to known sites and potential historically known sites.
Reason - Captive rearing of the Ten-spotted pot beetle was undertaken in the past by Piper (2002). A captive breeding programme could help to boost numbers of both the Six-spotted pot beetle and Ten-spotted pot beetle from the incredibly low population size at present, while habitat management work is taking place. The Royal Zoological Society of Scotland's Native Species Conservation Programme has expressed interest in working with this species. If successful, adults or mature larvae could be returned to the site to help strengthen the local population, and potentially help recolonise other sites.

6. Conclusions

Pot beetles are fascinating insects with an interesting life cycle that involves females protecting each egg they lay by covering them with their faeces, and the larvae living and developing in these pots.

The Ten-spotted pot beetle and Six-spotted pot beetle are both very rare in the UK and are on the Scottish Biodiversity list. They are only known from one site each in Scotland. Due to their rarity it is important that surveys, such as within this project, are completed to determine the distribution of the current population and if management of habitat is required to ensure their long-term survival in Britain.

With the help of volunteers, surveys for both the Six-spotted pot beetle and Ten-spotted pot beetle during all three years of the Spotting Pot Beetle project have been successful. This year, a new area for Six-spotted pot beetles was discovered at Kirkconnell Flow and Ten-spotted pot beetles were recorded in two areas of a new 1km square. The area where Ten-spotted pot beetles were recorded at last year appeared to be doing really well this year with volunteers losing count of the number of adults in this area (at grid reference NN 54238 56715) (Figure 12 and 13). Through these surveys it has been identified that both the Six-spot and Ten-spot pot beetle appear to be doing well at the known sites in Scotland.

Two other species of pot beetle were recorded during the surveys, the Black birch pot beetle was recorded at both sites and is a very common species found across Scotland, and the Four spotted leaf beetle (in the pot beetle subfamily) was recorded at Black Wood of

Rannoch. The Four spotted leaf beetle is Nationally Scarce in Great Britain and is associated with ant nests. There are no recent records of this species for this area on the NBN Atlas.

Both species are currently only known from one site each but there are records at other historic sites and other potential sites that would be worth surveying in the future. Although these surveys have been successful, it is important that the populations are monitored at both sites and the habitat managed appropriately to ensure the long-term survival of both species in Scotland.

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Appendix 1. Species of invertebrate recorded during the surveys at Kirkconnell Flow SSSI on 21st and 22nd of June 2019.

Order	Scientific name	Common Name
Aranaea	*Araniella cucurbitina*	Cucumber spider
	Xysticus cristatus	Crab spider
Coleoptera	*Calvia quatuordecimguttata*	Cream spot ladybird
	Cantharis nigra	Soldier beetle
	Coccinella septempunctata	7 spot ladybird
	Cryptocephalus labiatus	Black birch pot beetle
	Cryptocephalus sexpunctatus	Six-spotted pot beetle
	Dalopius marginatus	Click beetle
	Lochmaea caprea	Willow leaf beetle
	Luperus longicornis	Leaf beetle
	Plateumaris species	Reed beetle
	Polydrusus species	Weevil
	Silphidae (Family)	Carrion Beetle larva
Hemiptera	*Elasmostethus interstinctus*	Birch Shieldbug
	Elasmucha grisea	Parent bug
	Miridae (Family)	Capsid bug
	Pentatoma rufipes	Red-legged Shieldbug
Hymenoptera	*Croesus latipes*	Sawfly larvae
Lepidoptera	*Aphantopus hyperantus*	Ringlet butterfly
	Argyresthia brockeella	A micro moth
	Crambus lathoniellus	Grass Moth
	Diacrisia sannio	Clouded buff moth
	Ematurga atomaria	Common heath moth
	Eulithis populata	Northern spinach moth
	Euthrix potatoria	Drinker moth caterpillar
	Heliozela hammoniella	A micro moth
	Nemophora degeerella	Yellow barred long-horn moth
	Noctua pronuba	Large yellow underwing moth
	Phymatopus hecta	Gold Swift
	Scoparia ambigualis	Grass Moth
	Tyria jacobaeae	Cinnabar moth
Mecoptera	*Panorpa* species	Scorpion fly
Neuroptera	*Chrysopa perla*	Green lacewing
Odonata	*Pyrrhosoma nymphula*	Large red damselfly

Appendix 2. Species of invertebrate recorded during the surveys at Black Wood of Rannoch on the 3rd and 4th of July 2019.

Order	Common Name	Scientific Name	Grid reference
Aranaea	Cucumber spider	*Araniella cucurbitina*	NN5362956937
	Candy stripe spider	*Enoplognatha ovata*	NN5387356816
Coleoptera	Click beetle	*Agriotes* species	NN5387356816
	Kidney spot ladybird	*Chilocorus renipustulatus*	NN5336856981
	Four spotted leaf beetle	*Clytra quadripunctata*	NN5382956821
	Seven spot ladybird	*Coccinella septempunctata*	NN5362956937
	Flea beetle	*Crepidodera fulvicornis*	NN5382956821
	Ten-spotted pot beetle	*Cryptocephalus decemmaculatus*	NN5382956821
	Ten-spotted pot beetle	*Cryptocephalus decemmaculatus*	NN5387356816
	Ten-spotted pot beetle	*Cryptocephalus decemmaculatus*	NN5334556988
	Ten-spotted pot beetle	*Cryptocephalus decemmaculatus*	NN5423856715
	Ten-spotted pot beetle	*Cryptocephalus decemmaculatus*	NN5423956756
	Black birch pot beetle	*Cryptocephalus labiatus*	NN5382956821
	Black birch pot beetle	*Cryptocephalus labiatus*	NN53863 56813
	Ground beetle	*Cychrus caraboides*	NN5387356816
	Click beetle	*Dalopius marginatus*	NN5382956821
	Dor beetle	*Geotrupes* species	NN5387356816
	Leaf beetle	*Lochmaea suturalis*	NN5387356816
	Long horn leaf beetle	*Luperus longicornis*	NN5387356816
	Soldier beetle	*Podabrus alpinus*	NN5382956821
	Two banded longhorn	*Rhagium bifasciatum*	NN5362956937
Dermaptera	Common earwig	*Forficula auricularia*	NN5387356816
Diptera	Deer botfly	*Cephenemyia auribarbis*	NN5377456764
	Black snipefly	*Chrysopilus cristatus*	NN5387356816
	Marmalade hoverfly	*Episyrphus balteatus*	NN5362956937
	Hoverfly	*Melanostoma scalare*	NN5362956937
	Cranefly	*Pedicia rivosa*	NN5387356816
	Snipe fly	*Rhagio scolopaceus*	NN5362956937
Ephemeroptera	Green drake mayfly	*Ephemera danica*	NN5382956821
Hymenoptera	Honeybee	*Apis mellifera*	NN5362956937
	White tailed bee	*Bombus lucorum*	NN5362956937
	Common carder bee	*Bombus pascuorum*	NN5362956937
	Buff tailed bee	*Bombus terrestris*	NN5362956937
	Black ant	*Formica lemani*	NN5382956821
	Red ant	*Myrmica scabrinodis*	NN5382956821
	Sawfly	*Rhogogaster* species	NN5387356816
Lepidoptera	Cypress tip moth	*Argyresthia brockeella*	NN5382956821
	Common wave	*Cabera exanthemata*	NN5382956821
	Light emerald	*Campaea margaritata*	NN5382956821
	Northern eggar	*Lasiocampa quercus*	NN5387356816
	Clouded border	*Lomaspilis marginata*	NN5387356816
	Chimney sweeper moth	*Odezia atrata*	NN5362956937

	Willow beauty	*Peribatodes rhomboidaria*	NN5382956821
	Map winged swift	*Pharmacis fusconebulosa*	NN5387356816
	Common blue butterfly	*Polyommatus icarus*	NN5362956937
	Painted lady	*Vanessa cardui*	NN5387356816
Mecoptera	Scorpion fly	*Panorpa* species	NN5387356816
Odonata	Common hawker	*Aeshna juncea*	NN 5423956756

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