



# Pot beetles

Ross Piper

The pot beetle *Cryptocephalus aureoles*. Ross Piper

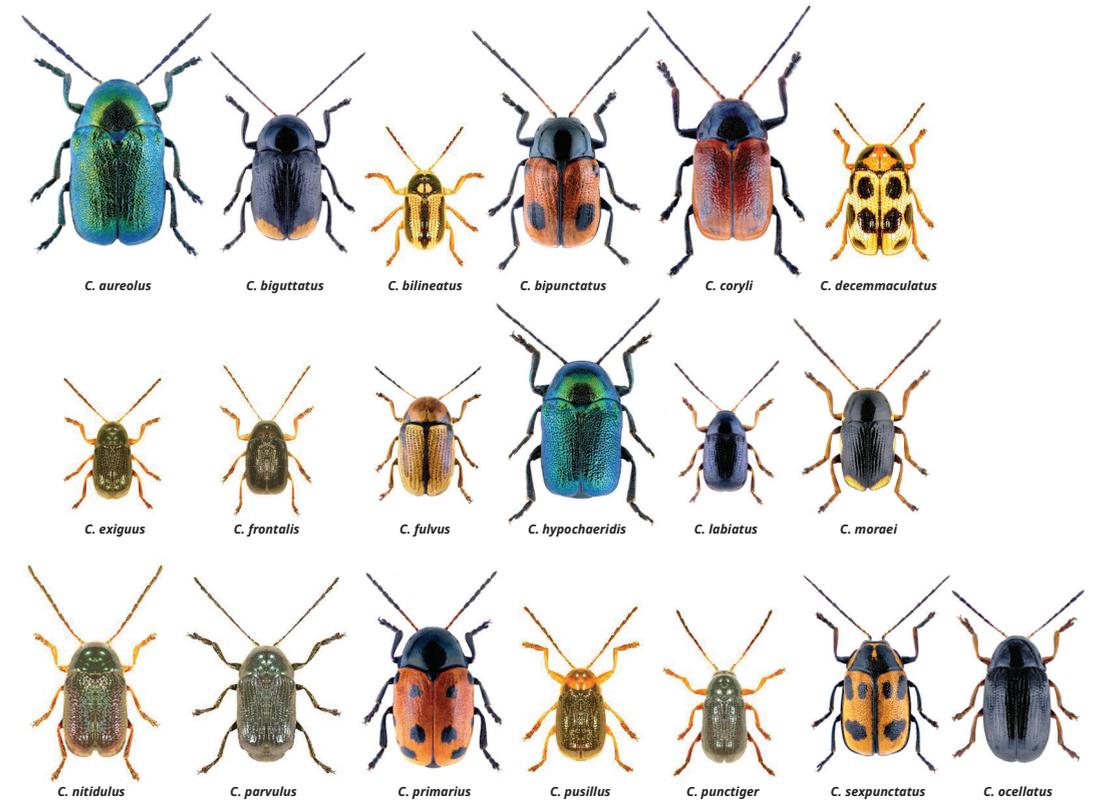
In a quiet corner of Cheshire, out of sight and out of time, lies Wybunbury Moss, a remarkable place for many reasons. Walking out onto this site feels like you are stepping into history – a veritable ecological time capsule preserving a wild essence that has been lost from so much of our landscape. If you were to have a good look around the site between May and July, you would be hard pressed not to notice the small yellow-and-black beetles sitting on the leaves of the willow and birch scrub. These look a bit like ladybirds, but they are much more unusual: these are Ten-spotted Pot Beetles *Cryptocephalus decemmaculatus*, and

Wybunbury Moss supports the only known English population of this attractive little insect.

As well as the Ten-spotted Pot Beetle, 20 other pot beetle species occur in Britain, which represents only the merest sliver of their global diversity. With more than 1,500 species worldwide, this is the one of the single largest animal genera out there. Such staggering diversity is only equalled by their extraordinary biology.

In terms of classification, pot beetles belong in the Chrysomelidae – the leaf beetles – an enormous group of herbivorous insects that radiated along with the flowering plants. A typical leaf beetle lays

**A panorama of Wybunbury Moss in Cheshire, which supports the only known English population of Ten-spotted Pot Beetle *Cryptocephalus decemmaculatus*.** Ross Piper



**Twenty pot beetle species are known from Britain. *C. ocellatus* and *C. rufipes* (not shown here) have recently become established.** Ross Piper

its eggs on the foliage of the food plant and the larvae eat the plant tissue, eventually descending to the soil to pupate. The pot beetles, however, have gone on something of a remarkable evolutionary tangent. As larvae they dwell in the leaf-litter, equipped with a mobile shelter fashioned from their own faeces – the eponymous ‘pot’.

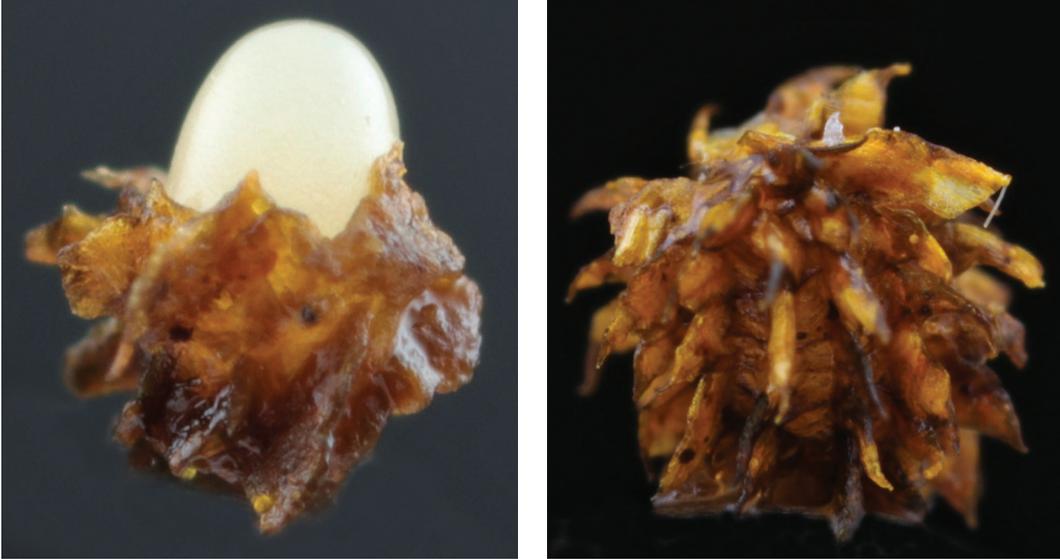
to rest in the leaf-litter somewhere beneath the female’s perch. Encasing each egg in this way takes between 15 and 20 minutes, a significant investment of time for an animal that lives only a few short weeks. Such elaborate behaviour also limits the

*Cryptocephalus aureolus* encasing an egg. Ross Piper



### An unusual life history

When a female pot beetle is laying an egg, she delicately cradles it in her back feet, holding it in a circular divot at the end of her abdomen. She then slowly and deftly rotates the egg, pressing minute plates of her faeces onto its surface until it is completely encased in what ends up looking like a tiny pinecone. The egg and its protective case of maternal faeces is then unceremoniously flicked away, eventually coming



Partially complete and complete egg case of *Cryptocephalus aureolus*. Ross Piper

number of eggs that a female can lay, although this is offset by the enhanced protection it provides for the offspring.

When the larva eventually hatches, rather than simply ditching the egg-case crafted by its mother, it uses it as a mobile shelter – the case is held aloft, covering most of the abdomen but leaving the armoured head and strong legs free. Even with this seemingly awkward encumbrance, the young larva can scuttle surprisingly fast, but at the first sign of danger it retreats fully into the case, its head forming a beautifully snug stopper. The case offers some protection from the many predators of the leaf-litter that would make a small snack of a soft larva, but it does not make them invulnerable, as we shall see later.

The larva gets to work eating leaf-litter and any fresh leaf material that it finds acceptable, but in order to grow it must enlarge its case. Using its mandibles, it makes a vertical slit in the underside of the case, filling the resultant gap with a mixture of saliva and faeces. During the lifetime of the larva – depending on the species, this may be the best part of one, two or even three years – this tailoring of the case needs to happen several times, eventually forming an exquisite, pot-shaped structure. The plump, fully grown larva now prepares for the rigours of pupation. Retreating into its case for the final time, it seals itself inside and turns around, so that its head now faces the broad end of the case. Once pupation is complete (it takes 7–10 days) the adult beetle must escape from the case, which it does by chewing a perfect lid from the broad end. The new adult then clambers up from the dark leaf-litter for its fleetingly short life in the light.

Adult pot beetles are typically sun-loving insects, dependent on microhabitats that offer warmth and shelter from the wind. When temperatures are sufficiently high they take to the air freely, although their flights are generally frenetic, short and arcing, often alighting very near to where they took off. They frequently sit conspicuously on their food plants. Depending on the species, they consume leaves, petioles, soft bark, flowers and pollen. Many of the pot beetle species possess bold, bright patterns that advertise chemical defences sequestered from their food. As well as their chemical defences, they also have a perhaps more comical means of avoiding enemies – a reflex known as thanatosis. When danger looms, their legs and antennae retract reflexively, and they tumble from their perch into the leaf-litter where they remain motionless for some time until the threat has passed. With a bit of practice, this reflex can be exploited to catch them, as a hand or tray can be surreptitiously edged under their perch before they tumble.

Many pot beetle species will eat a narrow range of host plants, while a smaller number are more selective, only consuming a single host-plant species. In Britain, May and June is the best time to see the adults, although they can linger on into August and early September. Males emerge first and mating occurs as soon as the female has exited her pot and clambered onto a perch on the host plant. The first few days after the adults emerge can be rather frantic, with males competing to mate and trying to disrupt mating couples. The males only live for about a month, but females, with the important business of egg-laying to get on with, can live for around two months.

### Pot beetles in Britain

Of the pot beetle species we have on these isles, many are rare, a couple exceedingly so. A large proportion of these rarities depend on scrub and sheltered woodland edges or glades and are only known from a handful of sites. This plight prompted Natural England to fund research into their conservation biology, which is how I found my way to them as a PhD student (Piper 2002). The species I focused on were those I could find in sufficient numbers in order to collect information on the important aspects of their ecology. At the time, only the Ten-spotted, the Hazel Pot Beetle *Cryptocephalus coryli* and *C. nitidulus* fitted the bill.

Studying these species in the field, captive-rearing of the larvae and genetic studies of the known populations has shone a light on their ecology and the factors responsible for their rarity.

### What we have learnt

#### Larval lives

It was once assumed that the larvae of these beetles were associated with ants, as is the case with the closely related beetles in the genus *Clytra*. Captive-rearing of pot beetles has shown that this is not so. It appears that they can all be reared in captivity, with varying degrees of success. The larvae will readily consume leaf-litter and fresh plant material from the adult food plants. Removing the element of predation yields large numbers of adults, which have subsequently been used in releases to

establish populations at new sites with suitable habitat. The larvae are susceptible to fungal attack and desiccation, though, so getting the humidity levels right is important. In the wild, the larvae can likely seek out optimal humidity levels and avoid extremes.

Searches for larvae in the field have also provided some interesting insights. Painstaking, hands-and-knees scrutiny of the ground, looking for 5mm-long, soil-coloured pots on the soil itself at the only known *C. nitidulus* site in the UK produced four larvae, two of which had been parasitised by wingless ichneumonids (*Gelis* or *Thaumtogelis* species) (Piper 2016). These wasps are considered to be generalist parasitoids of cocoon-forming insects and it is probably the case that larval pot beetles are attacked by a number of other parasitoid species too. A similar search of a Hazel Pot Beetle site in Lincolnshire turned up three larval cases, two of which were full size and partly buried, open-end down, in the sandy soil. One of these larvae had pupated successfully, the adult having chewed a lid from its case to escape. The other had also pupated, but the adult had died without exiting the case. Parasitoids, failed pupation and failure of the adult to escape the case may be responsible for considerable mortality in wild populations.

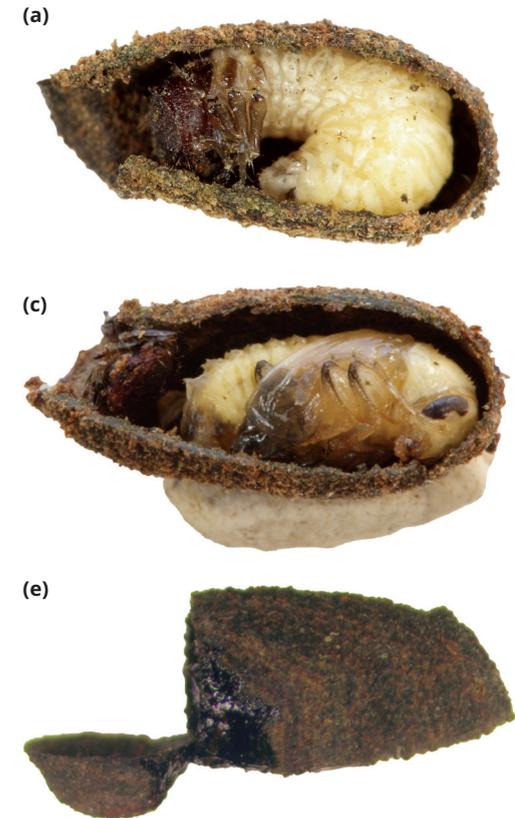
Using an extremely sensitive metal detector and released, captive-reared larvae tagged with tiny pieces of ferrous metal, I was able to study the overwintering success of the larvae. A significant number were consumed by rodents, who gnawed through the cases like they were a seed or nut.

**These two images illustrate a mature larva of the Ten-spotted Pot Beetle *Cryptocephalus decemmaculatus* showing its armoured head, well-developed legs and case.** Ross Piper



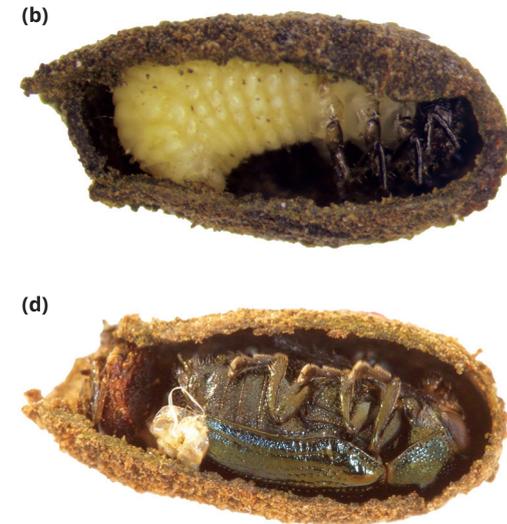
Predation by rodents was much lower in areas where there was more bare ground, possibly because these places lacked the cover that rodents need to forage while at the same time being safely concealed from their own predators (Piper *et al.* 2014a). It is likely that rodents predate a considerable proportion of wild pot beetle larvae, especially of the larger species.

During searches of the Ten-spotted Pot Beetle site in Cheshire, 25 larvae were found among the aerial parts of the adult food plants, principally small Grey Willow *Salix cinerea* bushes (Piper 2014b). Ranging in position from 20cm to 75cm above the ground, these larvae were observed clinging to leaves and petioles, and anchoring themselves in withered leaves or the holes they had chewed. A cluster of three larvae was even discovered among the outer threads of a spider's nest (*Theridion pictum*) (Piper 2014b). These observations go to show that pot beetle larvae are not just animals of the leaf-litter. They can also survive and thrive in the aerial parts of their food plants, especially during the growing season.



**Adult lives**

The adults are easier to find than the larvae, but they still pose a challenge. During my time working on scarce pot beetles, the only species that could be located in reliably substantial numbers was the Ten-spotted. This allowed me to estimate the population size over a period of years, and to study the way in which these insects disperse through suitable habitat and what prevents them from doing so (Piper and Compton 2013). The population at this Cheshire site was actually fragmented into four or five subpopulations, some of which were very small – numbering only in the tens of individuals and separated by as little as 20–30m of sub-optimal habitat (treeless bog or small areas of mature woodland). By marking the adult beetles with miniscule, judiciously placed spots of Tipp-Ex, I was able to assess if there was mixing between the subpopulations. Worryingly, I encountered no evidence of mixing – but that does not mean it never happens. To look at how this species disperses through suitable habitat, I tagged and plotted all of the host plants in one of the subpopulations and got out my trusty Tipp-Ex pen



**These images show the stages in the pupation of *Cryptocephalus parvulus*.** Using a scalpel, the case of a mature larva can be carefully cut open to document the sequence of events, covering the open case with damp tissue paper in the meantime. The photos show: (a) fully developed larva; (b) a larva turned around to face the broad end of the case, becoming a pre-pupa; (c) the pupa; (d) a freshly enclosed adult beetle; (e) an empty case, from which the adult has emerged by chewing a hole in the broad end. Ross Piper



**Many adult pot beetles, such as the Ten-spotted, are brightly coloured, broadcasting awareness of their chemical defences. Here, a lone male looks on as another pair mate.** Ross Piper



**Pot beetles are not above spoiling tactics, with lone males trying to disrupt mating pairs. Here, a male *C. labiatus* attempts to disrupt a mating pair.** Ross Piper

to mark more individuals. As previously mentioned, in calm, warm weather these are very active little beetles, scampering over the leaves of willows and birches and frequently taking to the air. Most of the flights are very short and quite erratic – pitching up and away from a host tree and typically back onto it or alighting on a nearby host tree. If the host tree is isolated, the beetles are rather marooned. Indeed, they are only able to disperse through the landscape in a stepping-stone fashion using networks of scrub growing in warm, sheltered conditions. Scrub-free areas of the site are effective barriers to dispersal, serving to divide the subpopulations as effectively as

tall woodland. This finding was further supported by studying the genetics of populations of several other rare pot beetle species, which implies limited gene-flow even between subpopulations separated by seemingly trivial distances (Piper & Compton 2003).

The Hazel Pot Beetle and *C. nitidulus* were thought to have a similar predilection for scrub, but studies in Lincolnshire and Nottinghamshire have demonstrated that certainly the Hazel Pot Beetle has a preference for the higher parts of mature host trees (normally Silver Birch *Betula pendula*), out of range of normal sampling methods such as beating trays (Pendleton and Pendleton 2024). This also seems to be the case for *C. nitidulus*. Another very scarce species, *C. querceti*, is assumed to be associated with low-growing ‘epicormic’ growth on mature and veteran oaks *Quercus*. However, this may be yet more sampling bias, as entomologists in Poland have found large numbers of this species during canopy surveys of oaks (Sprick and Floren 2007). Dislodged from the canopy by wind or rain, they might end up in epicormic growth around the base of the trunks, but this is

probably not their favoured microhabitat. The same is likely true for several other scarce members of this genus, including *C. punctiger*, *C. frontalis* and possibly *C. sexpunctatus* in the southern part of its British range, which may prefer higher reaches of mature host trees.

**The outlook for rare pot beetles**

The work on these beetles has increased our knowledge, specifically regarding habitat requirements and the factors responsible for their rarity. This research has guided sympathetic habitat management and targeted surveys to provide us

with more current distribution data.

Habitat management for the Ten-spotted Pot Beetle at Wybunbury Moss has benefitted the population enormously. From a few hundred at the outset in 1999 the population is now several thousand strong, responding to a more nuanced approach to management, allowing the formation of scrub corridors between subpopulations and more areas of scrub in warm, sheltered spots (Piper 2014b, 2015). This includes the ‘scalping’ of the woodland edge at the periphery of the site to foster the perfect conditions for the beetles. Even though the population is now much stronger than previously, it is still acutely vulnerable until populations can be established in suitable habitats elsewhere. In Scotland, surveys organised by Buglife have discovered previously unknown populations of this species and there are probably many more to be found (Burgess and Shanks 2017; Burgess and Lindsay 2019; Burgess 2020).

Thanks to eagle-eyed entomologists, the Hazel Pot Beetle was rediscovered after at least 70 years in Sherwood Forest. Innovative survey techniques at this location have revealed this beetle has a preference for the higher reaches of mature birch *Betula* trees (Pendleton and Pendleton 2024a). Captive-rearing from this population and others has also been extremely successful, allowing further insights into its larval ecology and providing large numbers of adults for releases (Binding *et al.* 2011; Piper and Hodge 2002b,c; Pendleton and Pendleton 2024b). Releases of



**This sequence of images shows wild Ten-spotted Pot Beetle larvae in the aerial parts of their host plant. A cluster were found in a spider web, perhaps feeding on the silk. The larvae are strong climbers and not restricted to the leaf-litter.** Ross Piper

captive-reared individuals at a site in Lincolnshire appear to have established a population that has persisted for 23 years..

The Rock-rose Pot Beetle *C. primarius* was once considered to be among the rarest of the rare in this genus and certainly the species that elicited most excitement from beetle collectors in days gone by (Wiltshire and Owen 2004). Associated with Common Rock-rose *Helianthemum nummularium* growing on south-facing calcareous slopes, surveys of likely-looking sites and old haunts have turned up new populations and rediscovered some lost ones (Olds 2021).

Singletons and small numbers of individuals of the Six-spotted Pot Beetle *C. sexpunctatus* pop up fairly regularly, with hotspots in Lincolnshire, Worcestershire, and Kent. However if old accounts are anything to go by, this species could sometimes be encountered in profusion. Beetle collectors recount taking large numbers of this species from Darenth Wood, Kent in the 1920s and 1940s (Massee 1947). A favourite place of insect collectors in days gone by, Darenth Wood has since been degraded and fragmented by house construction and road building, and the Six-spotted has not been seen here in decades. It is likely that this species benefitted from Hazel *Corylus avellana* coppicing, a practice that was once commonplace in many woodlands. In Scotland Buglife's efforts have uncovered new populations and refound old ones (Burgess and Shanks 2017; Burgess and Lindsay 2019; Burgess 2020). These northern examples are associated with small birches growing in sheltered areas on blanket bog sites – although it remains to be seen if they too have a liking for the higher parts of mature birches.

Our rarest pot beetle is also the smallest: the diminutive *C. exiguus*. At present, it is clinging on, just, at a single site in Suffolk and it would not take much for this population to blink out of existence. The adults are thought to be associated with Common Sorrel *Rumex acetosa* growing in damp meadows, but the species' exact requirements are poorly understood. Freshney Bog near Grimsby is the only site where it appears to have been fairly abundant, but this was turned into a rubbish dump during the Second World War. Easily overlooked and rather similar to *C. labiatus*, a much commoner species, it is likely that there are other populations out there waiting to be found.

*C. nitidulus* is now known only from the North Downs, in particular a fairly long stretch of the south-facing escarpment managed by the National Trust. As yet, no new populations of this species have been discovered, nor have any old populations been rediscovered. Marking and recapturing of adults suggest that it may have a preference for the upper parts of mature birches (Piper and Compton 2004).

As well as the abovementioned species, *C. biguttatus*, *C. frontalis* and *C. punctiger* are also very rare, but even less is known about them and I have only seen them once each. *C. biguttatus* is the largest and most distinctive of these three. Associated with Cross-leaved Heath *Erica tetralix* growing in wet heath, bogs, moors and commons, the heaths of Dorset, North Hampshire and West Sussex are its current strongholds (Mann and Barclay 2009), but individuals turn up in other locations. My sole brush with this species was finding an individual attached to my leg, cocooned in spider silk, while sweeping wet heath on Hartland Moor in Dorset. *C. frontalis* appears to be associated with old hedgerows, but it is probably a species of woodland edges and again might have a liking for the higher parts of hawthorns and other potential host trees, out of

**To study the population size and dispersal abilities of Ten-spotted Pot Beetles, adults were carefully marked with small spots of Tipp-Ex. As the beetles are only 4mm long, this requires practice and patience.** Ross Piper



## Pot beetles

range of beating trays and sweep nets. The same may be true as well for *C. punctiger*, which is also small and can be confused with more common species. It is very likely that there are Scottish populations of this species to discover and rediscover. The Surrey Heaths were the stronghold for *C. punctiger*, but overzealous scrub-bashing to benefit reptiles has not done it any favours. This captures in a nutshell the key challenge that confronts conservation in Britain: namely, the competing requirements of different species in small, fragmented areas of habitat.

### Broader ecological insights from pot beetles

Looking at the distribution maps of the rare pot beetle species, I have always been struck by the unusual pattern exhibited by many of them: a smattering of populations in the south and then a few in Scotland. The more I have thought about this, the more I believe that it can add to what we know about the landscape of Britain following the retreat of the glaciers at the end of the last ice age. It was assumed for a long time that, as tundra gave way to a northward procession of woodland, Britain was very nearly completely wooded. The pollen record, microfossils and numerous other lines of evidence have revealed that this was probably not the case. Rather, we can picture the post-glacial

**Area of suitable habitat for Ten-spotted Pot Beetle at Wybunbury Moss – Grey Willow *Salix cinerea* and Downy Birch *Betula pubescens* bushes in a small clearing.** Ross Piper



British Isles as a dynamic mosaic of woodlands, scrublands, grasslands and wetlands, all teeming with life. Soil type, inundation, large-animal activity, storms, tree diseases and pests would have created and maintained this mosaic. The dynamic, rapidly changing habitats on which many of the rare pot beetle species depend must have been sufficiently common and well connected to allow them to colonise a large swathe of Britain in the millennia following the melting of the glaciers. As humans altered more and more of the land for their own requirements, the populations of these beetles dwindled, leaving the outposts we know today.

As well as what they can tell us about prehistoric ecology and landscapes, pot beetles are an excellent model for the study of speciation. The main drivers in the explosive speciation we see in this genus are limited dispersal ability and metabolic plasticity. The former means that populations can rather quickly become fragmented and genetically divergent, while the latter allows them to make the leap to new host plants, reinforcing the separation imposed by geographical distance. In several species, early divergence between populations is evident, such as different habitat preferences and subtle morphological changes.

As with many insect species, pot beetles are also useful for studying and tracking climate change. In the time that I have been looking at this genus, two continental species have become established on our shores in recent years: *C. rufipes* and *C. ocellatus*. It is likely that other species will appear too as the climate continues to warm.

### Further work

There is still much to learn about these captivating little beetles, especially the precise micro-habitat requirements of the very elusive species and the ecology of wild larvae of all the species. One thing that I have always found very perplexing is that the success of any one population seems to depend on the chance juxtaposition of suitable adult and larval habitat. As far as I can



***C. rufipes* has recently become established in Britain and we can expect more pot beetle species in the coming years as the climate continues to warm.** Ross Piper

work out, a gravid female makes no obvious choice of egg-laying site, never venturing into the leaf-litter to assess its suitability for her offspring. Perhaps she is directed by cues such as temperature, humidity or polarised light?

It would also be interesting to look in greater detail at the population genetics of the rare species, as well as their physiology, distribution, dispersal abilities and how they cope with the impacts of habitat fragmentation and small population size.

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