POPULATION SIZE AND DISPERSAL ABILITY OF *CRYPTOCEPHALUS NITIDULUS* (LINNAEUS, 1758) (COL.: CHRYSOMELIDAE)

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Abstract

Using mark-release-recapture, host plant marking and direct observations we obtained population size estimates and information on the dispersal ability of the Nationally Endangered beetle *Cryptocephalus nitidulus*. The studied sub-population was estimated to consist of 666 (±S.E. 281) adult beetles. It appears that *C. nitidulus* moves through its habitat by using suitable host-plants as 'stepping stones'. Sub-populations separated by relatively small areas of unsuitable habitat (e.g. open ground or dense woodland) are effectively isolated. The relatively small population sizes of this beetle and its association with transient, successional habitats makes it vulnerable to local extinctions. In addition, the limited dispersal ability of *Cryptocephalus nitidulus* means that other patches of suitable habitat are unlikely ever to be colonised naturally.

Introduction

Dispersal abilities of phytophagous insects range from less than 1km to more than 20km (Peterson and Denno, 1998; St Pierre and Hendrix, 2003) and in many ways the colonising insect is a slave to its environment (Loxdale and Lushai, 1999). Ideal colonists respond rapidly to habitat change, quickly locating suitable new habitats and proliferating once there (MacArthur & Wilson, 1967; Safriel and Ritte, 1980). Theoretically, habitats that are unpredictable in space and time should play host to those species which are adept at colonisation (Southwood, 1962), but the reverse has often been found (Thomas, 1984; Warren, 1987; Thomas, 1991). In western Europe, human activity has fragmented the natural environment to such an extent that species with a poor dispersal ability are no longer able to move through swathes of habitat. This feature predisposes them to local extinction even when the fragmentation of their habitat is minimal (Doak, 2000) and it these species that are often of conservation concern.

Site management and the implementation of recovery plans for rare insects, are often hampered by a lack of knowledge of their ecology (Bedick, 1999), a problem compounded by the difficulty in finding many rare insects in any numbers in the field, which makes acquisition of information difficult (Britton, 1994; New *et al.*, 1995). Without this basic information, habitat management can lead to the local extinction of the species, rather than its recovery (Ehrlich and Ehrlich, 1981).

The consequences of poor dispersal ability are compounded by the extreme habitat specialisation of some insects. This is particularly the case for species that rely on dynamic, early-successional habitats such as woody invasive scrub, which

only remains optimal for a few years. It appears counter-intuitive for these insects to be sedentary, because in order to persist in the landscape they need to be able to routinely disperse and populate new areas of suitable habitat as they become available. It has been shown, however, that insect species, which depend on dynamic habitats are surprisingly sessile often because habitats have been fragmented to such a degree that there is a negative selection pressure on traits that aid dispersal (Thomas, 1984; Warren, 1987; Thomas, 1991).

Rarity is often considered to be a consequence of an inability to colonise new habitat patches, but is not usually considered as a causal factor. However, sedentary but abundant species can potentially compensate for having poor dispersal abilities thanks to their large numbers, which mean that rare, long-distance dispersal events will take place periodically and are potentially sufficient to track changes within the landscape. In contrast, species which combine low dispersal ability and small population sizes are much less likely to be favoured by chance, long-distance dispersal.

Cryptocephalus beetles are a perfect example of this paradox as many of the species in this genus depend on short-lived ecotones, but their dispersal ability appears to be very poor. It has been shown that certain UK *Cryptocephalus* species exhibit considerable genetic differentiation between sub-populations that are separated by trivial distances (Piper and Compton, 2003). In the case of scrub transition species this may not have been a problem in the past, if the NW Europe woodland dynamic model is correct (woodland with numerous, open spaces, maintained by large ungulates, fire and poor soils) (Vera, 2000; Svenning, 2002).

This study describes field studies of wild populations of *C. nitidulus* addressing the questions of 'how many individuals live in an area of suitable habitat and how mobile is *this beetle*?' The answers are used to suggest steps that can be taken to safeguard the remaining populations of this beetle and other insects with similar characteristics.

Study Sites

Data was collected from a small area on the White Downs, Surrey, England (N51º:13':53"; W0º:23':37") where there is a strong sub-population of *C. nitidulus*. This area is situated on the south-facing escarpment of the North Downs. The steep slopes are heavily rabbit-grazed leaving a short, floristically diverse scrub. Several tree species form a scrub ecotone between the grassland habitat and the surrounding woodland, with *Betula pendula* and *Crateagus monogyna* predominant.

Materials and methods

Population sizes and dispersal ability were assessed in 2000 by marking and recapturing *C. nitidulus* adults in a small area on the White Downs (Figure 1). To provide data on dispersal every host tree in Area B was marked with a numbered
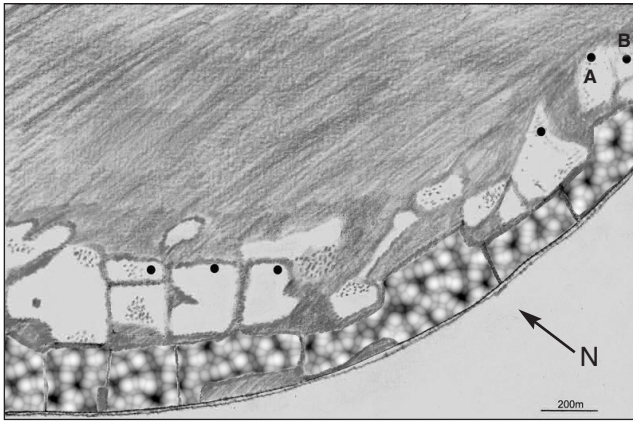
Figure 1. *Cryptocephalus nitidulus* sub-populations on the White Downs and Hackhurst Downs. Area B is the site of the strongest *Cryptocephalus nitidulus* population identified during surveys where data were collected. The other spots indicate other, much smaller sub-populations. Grey indicates more-or-less unbroken woodland and the marbled areas indicate arable land in the bottom of the Mole Valley. The white areas in between the woodland and the arable land are tracts of calcareous grasslands on the south-facing escarpment of the North Downs. Birch and hawthorn are very common in these tracts of grassland and areas with particularly advanced scrub are indicated by the grey stippling.

Figure 2. Location of *Betula pendula* trees in Area B supporting a *Cryptocephalus nitidulus* sub-population and movements of released individuals. (Scale bar = 10 metres). Open square = release *B. pendula* tree, filled circle = *B. pendula* tree with recaptures, open circle = *B. pendula* tree with no recaptures. *n* released = 72 (49 males; 23 females); *n* recaptured = 7 (5 males, 2 females). Solid line boundary = woodland border; Dashed line boundary = scrubless habitat border.

waterproof tape tag. These trees were then mapped on X and Y co-ordinates by laying two 50m measuring tapes at right angles to one another to form axes (Figure 2).

This was carried out at the beginning of June – the time of year when the adult beetles are at their peak. All potentially suitable habitat in the highlighted area of Figure 1 was sampled for adults using beating and visual searching of host trees. Area B in Figure 1 supported a strong sub-population concentrated in a small patch of habitat no more than 30m x 50m (Figure 2). In addition a very small sub-population (Area A in Figure 1) was also located. All beetles were marked using a very small spot of typing correction fluid. Individuals from the Area B sub-population form the basis of this study and they were differentiated from the Area A sub-population by a mark on the right elytron rather than the left in order to detect any interchange between these two sub-populations, which were separated by around 150m of unsuitable habitat. Following marking, the beetles were retained over-night in large storage boxes replete with food plants.

The Lincoln index (Lincoln, 1930) was used to estimate the population size of the adults, with Bailey's Correction (Bailey, 1952) because of the small sample sizes.

In the early morning of 2 June 2000, the boxes containing the marked adults from Area B were placed beneath a host tree in the core of their habitat. After four days a recapture was conducted and the sex and location (tree number) were recorded for any marked beetles recaptured. Relocated beetles were retained until the whole study area had been searched. The weather over the four-day release periods was warm and dry.

Results

Estimation of population sizes

Seventy-two *C. nitidulus* adults were marked in Area B. The recapture rate was very low (just 4.2%), reducing the accuracy of the population estimate. Using the Lincoln index with Baileys Correction it was estimated that the population size in this area was 666 ± S.E. 281 adult beetles. This sub-population is one of several along the south facing escarpments of the White Downs, although it is probably the largest current sub-population.

Adult movements

Very few marked *C. nitidulus* adults were recaptured. The dispersal of these recaptured adults was limited, with no marked adults being found more than 10 m away from the release tree. The low recapture rate is more than likely a consequence of the large host trees (4-5m in height) and the difficulty with sampling them effectively rather than the beetles leaving this island of suitable habitat. Dispersal of *C. nitidulus* in suitable habitat is facilitated by a network of loosely grouped host plants that appear to act as 'stepping stones'. No interchange of individuals was detected between Areas A and B.

Discussion

The UK range of *C. nitidulus* is not as restricted as some of its congeners, as it occupies at least seven patches along a two kilometre long arc of the White Downs as well as being found elsewhere. Our estimate of the size of one sub-population of this species has a considerable degree of error because of the low recapture rates (probably the result of adults sheltering higher up in tall host trees), but it is clearly more abundant and widespread than some other *Cryptocephalus* species that have a lesser conservation status. Nonetheless, its sub-populations are further apart than some of these congeners and separated from each other by large tracts of mature woodland or areas of scrub-free habitat. Movements between its sub-populations are therefore probably exceedingly rare – the dispersal of even mobile insects can be inhibited by barriers such as hedgerows or tracts of woodland (Wratten *et al.*, 2003). Direct observations of the flight behaviour *C. nitidulus* and *C. decemmaculatus* demonstrate that in suitably hot weather these beetles are quick to take to the wing, but the flights are typically short (mean of 3.9m in *C. decemmaculatus* – unpublished data). Typically, the beetles take to the air steeply then fly rapidly towards the ground until they are intercepted by another tree. Movements through suitable habitat (only possible in warm weather) is accomplished by lots of these short flights using host plants as 'stepping stones' from one area to another.

The poor dispersal abilities of *Cryptocephalus* species are supported by genetic studies. Mitochondrial DNA markers demonstrated complex population structure at the micro-geographical scale in these and other rare UK *Cryptocephalus* species, with evidence of genetic differentiation present between populations separated by distances less than one kilometre (Piper and Compton, 2003). In these beetles it seems that a small barrier of unsuitable habitat is as effective as large geographic distances at isolating populations. In addition to these genetic differences there also appears to be nascent ecological differences between sub-populations, such as subtle changes in host-plant preferences (R. Piper, unpublished data). The poor dispersal ability of these beetles coupled with their habitat requirements can be viewed as drivers of speciation, which is supported by the fact that, globally, the genus *Cryptocephalus* is one of the most speciose beetle genera (Erber, 1988). Similar local genetic differentiation has also been found in some other phytophagous beetle species (McCauley *et al.*, 1988; McCauley, 1991; Rank, 1992).

C. nitidulus depends on mid-successional, transitional habitats. Such habitats would have a short natural life span with any particular location quickly changing to dense scrub and then woodland (T. Coleshaw, pers. comm., J. Cranham, pers. comm). Good dispersal ability would therefore appear to be a prerequisite for any species inhabiting this type of habitat, yet the converse seems to be the case, not only for *Cryptocephalus* species, but also many other insects associated with transitional habitats (Thomas, 1984; Warren, 1987; Thomas, 1991). The clear

implication from this is that for these species to have persisted the previous landscapes must either have had succession routinely inhibited by large mammals or other factors (Vera, 2000) and were more dynamic, routinely offering mid-successional habitats in close proximity to each other.

The very limited dispersal ability of *C. nitidulus* is compounded by the fact that host plants for *Cryptocephalus* adults need to have a clear south facing aspect and shelter from the wind. A complex ecotone with scrub invading grassland with many discrete 'pockets' where temperatures may be significantly higher than around exposed trees (Greatorex-Davies, 1992) is required. An ovipositing female *Cryptocephalus* makes no obvious selection of where her eggs will be dropped. *C. nitidulus* females that disperse away from the natal site will be leaving an area that has been successfully used for many generations due to the juxta-position of suitable adult and larval habitat effectively selecting against individuals with better dispersal ability. It could be reasoned that teneral adults which have developed as larvae in an optimal habitat are found on the tree that their mother oviposited from. This pattern was observed in *Yponomeuta padellus* (Brookes and Butlin, 1994). Successive generations of beetle will develop beneath the tree and lay some of their eggs from its branches. Consequently, the integrity of the population of this beetle at any one site may be dependent on an extremely limited number of trees that provide optimal conditions for the adults and larvae.

The fragmentation of habitats is suggested to be one of the major causes for species extinction (Morris, 1995). The remaining populations of *C. nitidulus* have probably been isolated for a very long time. All the current sites of the two species are areas where habitat management is routinely carried out and it has often been the case where management aimed at the conservation of a species has led to its extinction (Ehrlich and Ehrlich, 1981). The autecological information in this paper provides valuable information for the conservation of *C. nitidulus* and other insects with similar requirements. The preservation and enhancement of this species at its last known sites can be assisted by: (i) altering the structure of the vegetation between the sub-populations by providing 'stepping stones' of bushes in suitable microclimatic conditions; (ii) maintaining the presence of a complex scrub where the sub-populations are presently found, but controlling scrub maturation; (iii) planting and maintenance of host trees between sub-populations to provide artificially positioned host plants to facilitate movement between sub-populations. The above proposals take into account the needs of the adults, but any management carried out should be undertaken with equal consideration for the requirements of larvae.

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The Scarlet Tiger *Callimorpha dominula* (L.) in Hertfordshire and Middlesex

A single specimen of *Callimorpha dominula* was taken at mv light in a garden in Letchworth, Hertfordshire (VC 20), at approximately 23.30 hours on 22 June 2010. The captor, Randy Drew, immediately recognised the significance of the discovery and noted that the weather conditions were very warm, in spite of the clear sky and with hardly any breeze.

About a week later Geoff Geiger was equally surprised and delighted to find another example of this species in his garden at Wembley, Middlesex (VC 21) in the morning of 3 July; it was near to, though not inside, one of the moth traps and so is entered into the database as being attracted on 2 July.

There are no previous records for Middlesex; the open-circle in grid square TQ 28 shown in the distribution map for this species in Heath & Emmet (1979. *Moths and Butterflies of Great Britain and Ireland* volume 9, page 109) seems to be in error. In Hertfordshire, there are five previous records, from Hitchin in the north and the Tring/Berkhamsted area in the south-west, between 1872 and 1953; these are summarised and discussed in Plant (2008. *The Moths of Hertfordshire*. HNHS). The moth is well-established in the south-west, in Carmarethenshire and Pembrokeshire and from Cornwall to Hampshire and is found locally east of here in Berkshire, Oxfordshire and Gloucestershire and also in south-east Kent where it maintains a precarious existence (Skinner, 2009. Colour *Identification Guide to the Moths of the British Isles*. 3rd revised and updated edition. Apollo Books). There are late nineteenth century records from north-west Kent at Darenth, Woolwich, Erith, Dartford and Blackheath (Plant, 1993. *Larger Moths of the London Area*. LNHS) and this area also generates one of the oldest records of this