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Ecological characteristics associated with high mobility in night-active moths

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Abstract

Mobility is an important factor influencing the range and persistence of local populations. However, mobility is very difficult to measure empirically and thus is poorly known in most taxa. Since ecological characteristics have been suggested as good estimators of mobility, we here explore the association between ecological characteristics and mobility. We surveyed night-active moths on a Swedish island, situated 16 km from the mainland, and compared ecological characteristics of the non-resident moths found on the island with those of a species pool of assumed potential vagrants from the neighbouring mainland. Species associated with high mobility were characterised by a large range, a high population density, an activity period during warm temperatures and by being habitat generalists or preferring open habitats. The generally assumed view of poly- and oligophagous species being more mobile than monophagous species was obscured by the effect of population density. Poly- and oligophagous species had higher population densities than did monophagous species, which probably explain their higher mobility found in this study. Our result highlights the need to consider the influence of ecological characteristics on mobility. This in turn will have implications for an increased understanding of distribution patterns, population persistence and how to prioritise conservation actions, especially since habitats and climate are under dramatic changes. In taxa where data on mobility are poor, ecological characteristics can be used as a proxy for mobility.

Zusammenfassung

Die Mobilität ist ein wichtiger Faktor, der die Ausdehnung und den Bestand lokaler Populationen beeinflusst. Die Mobilität empirisch zu messen ist jedoch sehr schwierig und daher ist sie bei den meisten Taxa kaum bekannt. Da vermutet wird, dass ökologische Eigenschaften gute Indikatoren für die Mobilität sind, untersuchten wir die Beziehung zwischen ökologischen Eigenschaften und der Mobilität. Wir untersuchten nachtaktive Falter auf einer schwedischen Insel, die 16 km vom Festland entfernt gelegen ist, und verglichen die ökologischen Eigenschaften von Faltern, die auf der Insel gefunden wurden aber dort nicht heimisch sind, mit denen eines Artenpools von vermutlich wandernden Faltern des benachbarten Festlands. Arten, die mit einer hohen Mobilität assoziiert sind, waren durch ein großes Verbreitungsgebiet, eine hohe Populationsdichte und eine Aktivitätsperiode bei warmen Temperaturen charakterisiert, und sie waren Habitatgeneralisten oder bevorzugten offene Habitate. Die generell angenommene Sichtweise, dass poly- und oligophage Arten mobiler als monophage Arten sind, wurde durch den Effekt der Populationsdichte verschleiert. Poly- und oligophage Arten hatten höhere Populationsdichten als monophage Arten und dies erklärt wahrscheinlich ihre höhere Mobilität, die in dieser Untersuchung gefunden wurde. Unsere Ergebnisse betonen die Notwendigkeit, den Einfluss der ökologischen Eigenschaften auf die Mobilität zu berücksichtigen. Dies wird dann

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Konsequenzenen für ein zunehmendes Verständnis der Verbreitungsmuster und des Bestandes von Populationen haben, und dafür, welche Schutzaktivitäten Priorität haben werden, insbesondere weil Habitate und das Klima sich dramatisch verändern. Bei den Taxa, bei denen die Daten zur Mobiliät lückenhaft sind, können ökologische Eigenschaften als eine Näherung für die Mobilität genutzt werden.

Keywords: Dispersal; Island; Lepidoptera; Life-history trait; Light-trap; Migration; Moth; Species trait; Sweden

Introduction

Mobility is an important factor influencing the range and persistence of local populations (Dennis, Donato, Sparks, & Pollard, 2000; Thomas & Hanski, 1997). Highly mobile species are associated with low extinction risks and have greater potential to extend their ranges when habitats become suitable, compared to sedentary species where mobility limits their range (Cowley, Thomas, Thomas, & Warren, 1999; Ovaskainen and Hanski 2004; Schweiger et al., 2005). Mobility also is a fundamental parameter in many ecological concepts, e.g. in metapopulation theory (Hanski, 1999), source-sink dynamics (Liu, Hull, Morzillo, & Wiens, 2011) and resource-based approaches (Dennis, Shreeve, & van Dyck, 2003). However, mobility is notoriously difficult to measure empirically in most taxa and several different methods have been applied to study it (overview in Burke, Fitzsimmons, & Kerr, 2011), including indirect measures such as expert evaluations and rankings. Therefore, to develop suitable methods for exploring mobility is one great challenge for applications in ecology and conservation (Cook, Dennis, & Hardy, 2001; Van Dyck & Baguette, 2005).

In this study we use mobility as referring to long-distance movements. This is important because ecological characteristics associated with long-distance movements probably depend on different selection pressures than movements within a habitat, because the latter could be seen as routine movements performed in order to explore different resources (Van Dyck & Baguette, 2005). Body size and ambient temperature are directly linked to mobility, while habitat and host plant availability indirectly may force individuals to move at larger scales. Also characteristics related to the temporal dynamics of a population, such as population density and range size could potentially influence mobility (Gaston et al., 2000).

Moths represent a significant part of biodiversity and there is a wide variety in their feeding spectrum. There is also a solid and robust knowledge on their distribution and ecology, especially in northern Europe. However, systematic comparative analyses of the relative importance of ecological characteristics for mobility in Lepidoptera are still rare (Sekar, 2012; Stevens, Trochet, van Dyck, Clobert, & Baguette, 2012). Generally widely distributed generalist species (Warren et al., 2001), species with large body size (Öckinger et al., 2010; Sekar, 2012) and species with high population density (Cook et al., 2001; Stevens, Turlure, & Baguette, 2010), are considered to be more mobile than species with other characteristics. The length of the adult flight period could also influence mobility, because this increases the probability of encountering conditions suitable for long-distance dispersal of adults (Betzholtz & Franzén, 2011; Sparks, Dennis, Croxton, & Cade, 2007).

Generally applied methods for exploring mobility among insect species such as mark-release-recapture (MRR) and population genetics using allozymes (Stevens et al., 2012) are very difficult to carry out for night-active moth species and the number of studies is few (but see Merckx et al., 2009; Nieminen, Rita, & Uuvana, 1999). Here we used an alternative approach, especially suitable for exploring mobility of this group. We recorded non-resident night-active moths on an island 16 km out in the sea by the use of a light-trap, and explored if there was a general pattern among ecological characteristics and mobility. We predicted that the following ecological characteristics are associated with high mobility: generalist with regard to habitat and larval diet breadth, high population density, large range and body size, long adult activity period and adult activity period during warm conditions.

Materials and methods

Study area

Utklippan is a small island (9 ha) of primary rocks, situated at the southeast corner of the Karlskrona archipelago in southeast Sweden (Fig. 1). The island is situated 8 km from the nearest island in the archipelago and 16 km from the Swedish mainland, the province Blekinge. The vegetation on Utklippan is very sparse, restricted to crevices in the rocks, with only a few isolated bushes and trees. The local climate is harsh, characterised by lower summer temperatures, stronger winds and salt spray, compared to the mainland of Sweden (province Blekinge) or more sheltered islands in the Karlskrona archipelago. Few moth species reproduce on Utklippan, thus most species recorded on the island represent highly mobile species capable to move several km over open sea. The province Blekinge (ca. 29.000 km^2) is dominated by deciduous forest, semi-natural grasslands and arable fields, while coniferous forest have a more scattered distribution. The coastline bordering the Baltic Sea consists of primary rocks.