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Oil palm expansion into rain forest greatly reduces ant biodiversity in canopy, epiphytes and leaf-litter

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Abstract

Oil palm cultivation is expanding rapidly into many of the world's most biodiverse tropical regions. One of the most functionally important and ecologically dominant animal groups in these environments is the ants. Here, we quantify the overall impacts of clear-felling lowland dipterocarp rainforest and conversion into oil palm plantation on ant diversity. At study sites in Sabah, Malaysia we collected ants from three microhabitats: 1 – the canopy, 2 – bird's nest ferns (*Asplenium nidus* complex, a common epiphyte in forest and oil palm), and 3 – leaf litter. We also measured temperature, humidity and light at collection sites to assess their impacts on ant community composition. Total ant species richness decreased from 309 to 110 (−64%) between forest and oil palm plantation. However, this impact was not the same across all microhabitats, with bird's nest ferns maintaining almost the same number of ant species in oil palm compared to forest (forest-oil palm, ferns: 36–35 (3% loss), canopy: 120–58 (52% loss), leaf litter: 216–56 (74% loss)). Relative abundance distributions remained the same for fern-dwelling ants, but became less even for oil palm ants in both the canopy and the leaf litter. These differences may be due in part to the ability of bird's nest ferns to provide a stable microclimate in hot, dry plantations. We also found that non-native ant species were more abundant in oil palm than in forest, and few forest ant species survived in plantations in any of the microhabitats. Only 59 of the 309 forest species persisted in oil palm plantations, corresponding to an 81% loss of forest species resulting from habitat conversion. Although oil palm supports many more ant species than has been previously reported, converting forest into plantation still leads to a dramatic reduction in species richness. The maintenance of forested areas is therefore vital for the conservation of ant biodiversity.

Zusammenfassung

Der Anbau von Ölpalmen expandiert in beschleunigtem Maße in viele tropische Regionen der Welt, die besonders hohe Biodiversitäten besitzen. Eine Tiergruppe, die in diesen Umwelten funktionell besonders wichtig und ökologisch dominant ist, sind die Ameisen. An dieser Stelle quantifizieren wir den gesamten Einfluss auf die Diversität der Ameisen, den der Kahlschlag von dipterokarpen Tieflandregenwäldern und die anschließende Verwandlung in Ölpalmenplantagen hat. Auf Untersuchungsflächen

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in Sabah, Malaysia, sammelten wir in drei Mikrohabitaten die Ameisen: (1) im Kronendach, (2) in Nestfarnen (*Asplenium nidus*-Komplex, einem verbreiteten Epiphyten im Wald und auf Ölpalmen) und (3) in der Streu. Wir maßen außerdem die Temperatur, die Luftfeuchte und das Licht an den Sammelorten, um den Einfluss auf die Zusammensetzung der Ameisengesellschaften zu bewerten. Die Gesamtartenzahl der Ameisen verringerte sich von 309 auf 110 (−64 %) vom Wald zur Ölpalmenplantage. Dieser Einfluss war jedoch nicht in allen Mikrohabitaten der gleiche, da in Nestfarnen fast die gleiche Anzahl von Ameisenarten in Ölpalmen wie im Wald erhalten blieben (Wald-Ölpalmen, Farne: 36–35 (3% Verlust), Kronendach: 120–58 (52% Verlust), Laubstreu: 216–56 (74% Verlust)). Die Verteilungen der relativen Abundanzen blieben für farnbewohnenden Ameisen bestehen, waren jedoch in Ölpalmen sowohl im Kronendach als auch in der Laubstreu weniger gleichverteilt. Diese Unterschiede können zum Teil darauf zurückgeführt werden, dass die Nestfarne in den heißen und staubigen Plantagen ein relativ stabiles Mikroklima zur Verfügung stellen können. Wir fanden außerdem heraus, dass nicht-einheimische Ameisenarten in den Ölpalmen häufiger als im Wald waren und dass nur wenige Waldameisenarten in sämtlichen Mikrohabitaten überlebten. Nur 59 der 309 Waldarten blieben in den Ölpalmenplantagen bestehen, so dass ein Verlust von 81% durch die Habitatumwandlung entstand. Auch wenn Ölpalmen sehr viel mehr Arten zulassen, als bisher berichtet wurde, führt die Umwandlung der Wälder in Plantagen immer noch zu dramatischen Verlusten im Artenreichtum. Der Erhalt bewaldeter Gebiete ist daher lebenswichtig für den Erhalt der Ameisenbiodiversität.

Keywords: *Asplenium*; Bird's nest fern; Deforestation; *Elaeis guineensis*; Formicidae; Malaysia; Microclimate; Plantation; Sabah; SE Asia

Introduction

The extraction of resources and the continuing expansion of agriculture is an ongoing cause of many species extinctions (Tilman et al. 2001). Oil palm (*Elaeis guineensis* Jacq.) gives high vegetable oil yields relatively cheaply (Carter, Finley, Fry, Jackson, & Willis 2007; Corley 2009) and consequently is one of the most widespread and rapidly expanding crops. Since the majority of terrestrial biodiversity is supported in the tropical environments in which oil palm grows best (Fitzherbert et al. 2008; Turner, Snaddon, Fayle, & Foster 2008) and much oil palm expansion is into forested areas (Koh & Wilcove 2008), this trend is a major cause for concern.

While the overall impacts of converting forest into oil palm plantation on biodiversity are negative (Fitzherbert et al. 2008), relatively little research on this subject has been carried out (Turner et al. 2008), and some groups have similar, or even higher species richness in plantations (Chang, Hii, Buttner, & Mansoor 1997; Liow, Sodhi, & Elmqvist 2001). Consequently, it is vital that these impacts are properly documented for all ecologically important taxa, in particular those that carry out ecosystem services (e.g. Koh 2008a).

One of the most ecologically dominant groups of animals in tropical environments is the ants (Hölldobler & Wilson 1990). They comprise a large proportion of animal biomass and perform important ecosystem functions such as predation, soil turnover, nutrient cycling and seed dispersal (Alonso & Agosti 2000; Fayle et al. 2010). Ants also form mutualistic relationships with a diverse range of other animals (e.g. Dill et al. 2002) and plants (e.g. Edwards et al. 2010). To date, three studies have directly compared forest ant communities with those in oil palm plantations, using the same sampling techniques in both habitats (Brühl & Eltz 2010; Room 1975; Taylor 1977). These all documented reductions in species richness in plantations compared to forest. However, all three used methods that sample a single microhabitat (tuna baiting and hand collecting; hand collecting; visual identification) and this is reflected in the low species richness of the forest sites in these three studies (26, 50 and 24, respectively). Two other collections have been made of ants from oil palm plantations, both of which found low ant species richness, although neither included ants from forested areas (Dejean, Djieto-Lordon, & Durand 1997; Pfeiffer, Tuck, & Lay 2008). Consequently, the impacts of conversion of forest to oil palm plantation on whole ant communities are not clear.

Most studies on the biodiversity impacts of habitat conversion do not distinguish between effects on animal communities in different parts of a habitat, such as those inhabiting the canopy, epiphytes and the leaf litter layer, referred to here as microhabitats. Such heterogeneity is important for smaller animals, which may be found exclusively in a particular microhabitat. This has been shown in oil palm plantations, where the impact of forest conversion on abundance of arthropod orders differs between microhabitats (Turner & Foster 2009), and for butterflies and birds, where habitat complexity explains some of the variation in species composition (Koh 2008b).

Although rarely sampled in studies of the impacts of habitat conversion, epiphytes are a microhabitat that can be of particular importance for ants, which often use them as a nesting substrate (Ellwood & Foster 2004; Ellwood, Jones, & Foster 2002; Stuntz, Linder, Linsenmair, Simon, & Zotz 2003). One of the most abundant of these in SE Asian forests and plantations is the bird's nest fern (*Asplenium nidus* complex), a litter basket epiphyte (forest: up to 180/ha; plantation: up to 112/ha; Fayle, Chung, Dumbrell, Eggleton, & Foster 2009; Turner & Foster 2009). The accumulations of aerial leaf litter in these plants provide a buffered microclimate away from the hot dry conditions prevalent in oil palm plantations (Turner & Foster 2006), and consequently are an ideal habitat for many groups of litter-dependent arthropods (Turner & Foster 2009).