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Ground-foraging ant communities vary with oil palm age

Wendy Y. Wang[a,*], William A. Foster[b]

[a]Evolutionary Biology Lab, Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, Block S1A 05-16, Singapore 117543, Singapore
[b]Insect Ecology Group, Department of Zoology, University of Cambridge, Downing Street, CB2 3EJ Cambridge, United Kingdom

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Abstract

The conversion of natural habitats to croplands is a major cause of the global loss of species diversity and ecosystem services. One potentially effective method for enhancing the biodiversity of important groups such as insects, and their associated ecosystem services within croplands, is to increase the environmental complexity of the agricultural matrix. This can be achieved in perennial tree crops by planting mixed-age stands. There is, however, very little evidence for the effects of stand age on biodiversity in tropical tree crops. In this study, we assess how ground-foraging ant communities differ in relation to oil palm stand age, currently the dominant tree crop across tropical Southeast Asia. Oil palm age did not affect overall ant species richness. However, the numbers of species that were either common or numerically-dominant decreased with increases in canopy cover, which positively correlated with oil palm age, suggesting greater species evenness in older oil palm. In mature, but not young, oil palm, ant species co-occurred non-randomly, suggesting competitive exclusion and species segregation. Species responses to variables associated with oil palm age depended on their functional group. Generally, opportunists and generalized myrmicines were less abundant and less diverse, whereas specialist predators were more abundant and diverse, in older oil palm. Our results show that ground-foraging ant communities in oil palm change significantly in composition, but not in species richness, with crop age. These results suggest that mixed-age stands could support compositionally variable communities and help boost insect diversity in otherwise homogeneous perennial monocultures.

Zusammenfassung

Die Umwandlung von natürlichen Lebensräumen in Ackerland ist ein Hauptgrund für den globalen Rückgang von Artendiversität und Ökosystemdienstleistungen. Eine potentiell wirkungsvolle Methode zur Stärkung der Biodiversität von wichtigen Gruppen, z.B. der Insekten, und der mit ihnen verbundenen Ökosystemdienstleistungen in Ackerland ist, die Umweltkomplexität der landwirtschaftlichen Matrix zu erhöhen. Bei ausdauernden Nutzbäumen kann dies durch die Anlage von Beständen unterschiedlichen Alters erreicht werden. Es gibt indessen sehr wenige Belege für einen Effekt des Bestandsalters auf die Biodiversität in tropischen Fruchtbaumbeständen. Wir untersuchen, wie sich die Gemeinschaften von am Boden Futter suchenden Ameisen im Zusammenhang mit dem Bestandsalter der Ölpalme unterscheiden, die gegenwärtig der dominante Fruchtbaum im tropischen Südostasien ist. Das Alter der Ölpalmen beeinflusste nicht die Gesamtartenzahl der Ameisen. Es ging aber die Anzahl der Arten, die entweder weit verbreitet oder zahlenmäßig dominant waren, mit der Zunahme des Kronenschlusses (seinerseits positiv

*Corresponding author. Tel.: +65 6516 2968.
E-mail addresses: wywang24@gmail.com (W.Y. Wang), waf1@cam.ac.uk (W.A. Foster).

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korreliert mit dem Bestandsalter) zurück, was eine höhere Evenness in alten Beständen nahelegt. In reifen (aber nicht in jungen) Ölpalmenbeständen waren die Ameisenarten nicht-zufällig miteinander vergesellschaftet, was Konkurrenzausschluss und räumliche Trennung der Arten nahelegt. Die Reaktionen der Arten auf mit dem Alter der Ölpalmen assoziierte Faktoren hingen von ihrer funktionellen Gruppe ab. Generell waren in älteren Beständen Opportunisten und generalistische Myrmecinae weniger abundant und weniger divers, während spezialisierte Räuber häufiger und diverser waren. Unsere Ergebnisse zeigen, dass die Gemeinschaften der am Boden fouragierenden Ameisen sich in Ölpalmenbeständen unterschiedlichen Alters signifikant hinsichtlich der Zusammensetzung, nicht aber des Artenreichtums unterscheiden. Diese Ergebnisse legen nahe, dass Bestände unterschiedlichen Alters Gemeinschaften unterschiedlicher Zusammensetzung unterstützen und dazu beitragen könnten, die Diversität der Insekten in ansonsten homogenen ausdauernden Monokulturen zu steigern.

Keywords: Ant diversity; Mixed-age stands; Environmental heterogeneity; Tropical agriculture; Community changes

Introduction

Reduced biodiversity in ecologically uniform agricultural habitats may undermine critical ecosystem processes (Loreau et al. 2001; Prévot-Julliard, Clavel, Teillac-Deschamps, & Julliard 2011). Insect diversity, in particular, is important in preserving ecosystem integrity, because insects perform important functional roles enhancing various ecological processes such as nutrient cycling, seed dispersal, bioturbation, pollination, and pest control (Weisser & Siemann 2004). Enhanced insect diversity positively influences ecosystem functions, promoting more sustainable ecosystems over time (Loreau et al. 2001; Hooper et al. 2005; Garibaldi et al. 2011). One way to mitigate the negative impacts of agriculture conversion on biodiversity is to generate spatial heterogeneity in an otherwise homogeneous agricultural matrix (Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies 2005; Brockerhoff et al. 2008; Jackson et al. 2010). In long-lived perennial crops, this may be achieved by having stands of different ages within a single crop. Perennial crops tend to develop temporally distinct physical features over time (Vasseur et al. 2013), and therefore an agricultural habitat with mixed-age stands can potentially support combinations of disparate communities whose resource requirements are satisfied only by crops at specific ages (Kone, Konate, Yeo, Kouassi, & Linsenmair 2012). The growing popularity of perennial cropping systems in modern agriculture and biofuel production (Glover et al. 2010) potentially enhances the utility of mixed-age stands in bolstering biodiversity, and maintaining healthier ecosystems in agricultural landscapes.

Faunal changes with crop age-related environmental differences often depend on the specific habitat or host plant requirements of focal insect taxa (Jeffries, Marquis, & Forkner 2006). The diversity of insect herbivores, for example, has been established to be positively related to increasing plant architectural complexity (e.g. Haysom & Coulson 1998; Espírito-Santo, Neves, Andrade-Neto, & Fernandes 2007), and therefore should be expected to increase in older crops, which are generally associated with increased structural heterogeneity (Brockerhoff et al. 2008). Further, species composition of assemblages may change with crop age in response to the availability of preferred food resources. Taki et al. (2010), for example, found that lepidopteran communities in mature conifer plantations were dominated by species that fed on woody plants and lichens, which were more abundant in older plantation forests.

Crop age may also affect ambient species diversity via interspecific interactions. Young crops may be considered early disturbance systems, which provide rudimentary conditions advantageous only for the colonization of generalized species with broad environmental tolerances (Hoffmann & Andersen 2003). In contrast, the increased presence of late-succession species with competing resource needs in older crop systems may result in a more competitive environment, where diversity is potentially regulated through stronger deterministic forces such as competitive exclusion (Fukami 2010). However, young stands may nevertheless have low diversity because few species have accumulated in the short time available for colonization (Jeffries et al. 2006).

The growing global dominance of perennial agriculture is exemplified in the massive expansion and intensification of one crop – the oil palm (*Elaeis guineensis* Jacq.); land converted to oil palm worldwide quadrupled to 13.9 million ha from 1961 to 2007, and has been projected to keep increasing (Wilcove & Koh 2010). Oil palm is productively long-lived, and often allowed to grow for up to 30 years before replanting, conferring much potential for the development of temporally distinct communities (Foster et al. 2011). Despite this potential, there are few studies that document how communities change during the growth of oil palm (Turner, Snaddon, Ewers, Fayle, & Foster 2011) (e.g. ground-dwelling ants: Brühl & Eltz 2010, arboreal ants: Pfeiffer, Ho, & Teh 2008). Young and old oil palm plantations are known to be quite different in microclimate conditions and other physical habitat characteristics; older oil palm generally has a more stable microclimate, with more leaf litter and epiphytes than younger oil palm, but conditions depend on management practices in individual estates (Luskin & Potts 2011).