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Effects of monoculture and polyculture practices in oil palm smallholdings on tropical farmland birds

Badrul Azhar[a,*], Chong Leong Puan[b], Mohamed Zakaria[b], Nuraishah Hassan[b], Mohd Arif[c]

[a]*Biodiversity Unit, Institute of Bioscience, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*
[b]*Department of Forest Management, Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*
[c]*Department of Wildlife and National Parks, Km 10, Jalan Cheras, 56100 Kuala Lumpur, Malaysia*

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Abstract

Industrial oil palm expansion has led to dramatic landscape changes that have negatively affected forest biodiversity in the tropics. In contrast to large-scale plantations, oil palm smallholdings may support greater levels of biodiversity through the implementation of multi-cropping system or polyculture. We examined bird species richness, together with community structure, conservation status, and feeding guild of existing smallholdings in Peninsular Malaysia. Based on point transect sampling, we sampled birds in 100 smallholdings that practiced either monoculture or polyculture farming. Our results revealed that bird species richness was significantly greater in monoculture smallholdings than in polyculture smallholdings, but the opposite was true for bird abundance. Non-forest birds constituted the major species of bird communities in oil palm smallholdings. However, we found that the abundances of insectivores and frugivores were greater in polyculture smallholdings than in monoculture smallholdings. In the monoculture models, predictor variables explained 11.31–19.98% of the variation in bird species richness. When polyculture was being practiced, bird species richness increased significantly with the height of ground vegetation cover, distance to major roads, and distance to rice fields. In the polyculture models, predictor variables accounted for 11.71–24.85% of the variation in bird species richness. We also found that bird species richness increased significantly with height of ground vegetation, but it decreased with ground vegetation cover and distance to rivers. The evidence from this study suggests that monoculture and polyculture farming were able to maintain farmland biodiversity in smallholdings, at least for birds, but differed in richness, population, and feeding guild.

Zusammenfassung

Die Ausweitung industrieller Ölpalmennutzung hat zu dramatischen Landschaftsveränderungen geführt, die die Biodiversität von Wäldern in den Tropen negativ beeinflusst haben. Im Gegensatz zu großen Plantagen könnte der kleinbäuerliche Ölpalmenanbau einen höheren Grad der Biodiversität unterstützen, indem Polykultursysteme etabliert werden. Wir untersuchten den Artenreichtum von Vögeln, ihre Gemeinschaftsstruktur, ihren Gefährdungsstatus und Nahrungsgilden in bestehenden kleinbäuerlichen Betrieben auf der malayischen Halbinsel. Mithilfe von point-transect-Probenahmen registrierten wir die Vögel in 100 Kleinbetrieben, die entweder Monokultur oder Polykultur praktizierten. Unsere Ergebnisse zeigten, dass der Artenreichtum

*Corresponding author. Tel.: +60 389467206; fax: +60 389432514.
E-mail addresses: b_azhar@upm.edu.my, badrulazhar@yahoo.com (B. Azhar).

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der Vögel bei Monokultur signifikant höher war als bei Polykultur, aber das Gegenteil traf auf die Abundanz der Vögel zu. Offenlandarten waren die wichtigsten Arten in den Vogelgemeinschaften der Ölpalmenkleinbetriebe. Indessen fanden wir, dass die Abundanzen von Insektenfressern und Fruchtfressern auf Polykulturbetrieben höher als bei Monokultur waren. Bei den Monokultur-Modellen erklärten die bestimmenden Variablen 11,31% bis 19,98% der Variation des Vogelartenreichtums. Bei Polykultur stieg der Artenreichtum der Vögel mit der Höhe der Bodenvegetation, der Entfernung zu Hauptverkehrsstraßen und der Entfernung zu Reisfeldern. Bei den Polykultur-Modellen erklärten die bestimmenden Variablen 11,71% bis 24,85% der Variation des Vogelartenreichtums. Wir fanden ebenfalls, dass der Artenreichtum mit der Höhe der Bodenvegetation signifikant anstieg, aber er nahm mit dem Deckungsgrad der Vegetation und der Entfernung zu Wasserläufen ab. Die Ergebnisse dieser Studie legen nahe, dass -wenigstens für Vögel- sowohl Monokultur als auch Polykultur in der Lage waren, die Biodiversität in der Agrarlandschaft von Kleinbetrieben aufrecht zu erhalten, aber dass sie sich hinsichtlich Artenreichtum, Populationsdicht und Nahrungsgilden unterschieden.

Keywords: Agriculture; Oil palm; Biodiversity; Bird species richness; Conservation; Feeding guild

Introduction

Over the past decades, industrial oil palm cultivation has replaced large tracts of natural vegetation cover in the tropical regions (e.g. Southeast Asia, Amazon, and western Africa). In countries in which oil palms are extensively planted, the loss and alteration of natural habitats have led to local species extinction (Donald 2004; Fitzherbert et al. 2008; Immerzeel, Verweij, Hilst, & Faaij 2013). Previous studies have consistently shown that oil palm agriculture supports a lower number of species than native forests do (Koh 2008; Gillespie et al. 2012). Therefore, preservation of large tracts of primary forests should remain the principal conservation strategy in the tropical countries (Sodhi et al. 2010). However, protecting forests from deforestation is often constrained by various socio-economic issues (e.g. limited funding, lack of political will, poverty and corruption) (Laurance 2004; Barrett, Gibson, Hoffman, & Mccubbins 2006).

Agricultural landscapes can be managed for conservation outcomes even though this approach may support a small number of high conservation value species (Vandermeer & Perfecto 2007; Norris 2008). A study has suggested that wildlife-friendly oil palm plantations fail to protect forest biodiversity effectively (Edwards et al. 2010). However, protecting biodiversity in oil palm agro-ecosystems may benefit stakeholders in terms of ecosystem services (e.g. pest control) offered by insectivorous birds (Altieri 1999; Najera & Simonetti 2010).

Studies in commodity crops (e.g. coffee and cacao) have demonstrated the importance of tropical farmlands in biodiversity conservation (Perfecto, Mas, Dietsch, & Vandermeer 2003; Clough, Faust, & Tscharntke 2009). This has further sparked a debate whether to employ land sparing or land sharing (Fischer et al. 2008; Tscharntke et al. 2012) in palm-oil producing countries. Land sparing allocates a certain portion of an area to crop production, whereas the rest of the area is dedicated to biodiversity conservation (Balmford, Green, & Scharlemann 2005; Fischer et al. 2008). In order to maximize agricultural yield, intensive management application is being implemented on the former. On the other hand, land sharing merges crop production and biodiversity conservation, through the implementation of wildlife-friendly farming approaches (Balmford, Green, & Phalan 2012).

Large-scale oil palm plantations form the dominant agricultural matrixes in Southeast Asia (Azhar et al. 2011; Lee et al. 2013). In 2012, the plantation sector accounted for 86% of the total planted oil palm area (5,076,929 ha) in Malaysia, as the second biggest palm oil producer in the world (Malaysia Palm Oil Board 2012). Apart from large-scale plantations (i.e. planted area of 50 ha or larger), smallholdings are another form of oil palm agriculture that can be differentiated from the former. In Malaysia, oil palm smallholdings accounted for 681,267 ha (Malaysia Palm Oil Board 2012). Large-scale plantations produce greater levels of yield per harvest than smallholdings. Large-scale plantations are operated by major oil palm corporations. Unlike large-scale oil palm plantations, there is a lack of modern infrastructure (e.g. perimeter fences and trenches, palm oil mills, plantation housing settlements, and paved roads) in smallholdings (Turner & Gillbanks 1974; Piggott 1990).

Driven by stable income opportunity and government incentives, small-scale farmers or smallholders have opted for oil palm over other commodity crops (Feintrenie, Chong, & Levang 2010; Rist, Feintrenie, & Levang 2010). Some farmers have integrated multiple crops with oil palms to increase the income or produce food for domestic consumption, which rarely takes place in large-scale oil palm plantations. These integrated schemes may unintentionally create habitat heterogeneity and enhance biodiversity (Benton, Vickery, & Wilson 2003). Because of habitat complexity at local level, oil palm smallholdings have been demonstrated to support a higher level of bird species richness and more diverse bird community than plantations that are characterized by homogenized vegetation structure (Azhar et al. 2011). Besides local level characteristics, landscape factors such as distance to species rich habitats, such as forests, are also important drivers of species richness in oil palm agriculture. Both local and landscape factors have been investigated to identify