Global Ecology and Conservation 2 (2014) 385–394

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: www.elsevier.com/locate/gecco

Original research article

From rainforest to oil palm plantations: Shifts in predator population and prey communities, but resistant interactions

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ARTICLE INFO

Article history:
Received 8 September 2014
Received in revised form 22 October 2014
Accepted 22 October 2014
Available online 25 October 2014

Keywords:
Southeast Asia
Riparian reserves
Invasive species
Deforestation
Amphibia

ABSTRACT

Anthropogenic habitat change can dramatically alter biotic communities in tropical landscapes. Species that persist in human dominated landscapes are therefore likely to modify the way they interact. Although human impacts on community composition are relatively well studied, changes in species interactions are less well documented. Here we assess how logging of rainforest and conversion to oil palm plantations affects the populations of the ant-specialist giant river toad (*Phrynoidis juxtaspera*), and the availability and composition of its ant prey. We measured canopy cover as an estimate for the degree of disturbance and found that toad abundance decreased with increasing disturbance, and that retaining riparian vegetation should therefore help conserve this species. Both abundance and species richness of local ground-foraging ants increased with disturbance, and ant community composition was altered. Despite these changes, composition of ants consumed by toads was only weakly affected by habitat change, with the exception of the invasive yellow crazy ant (*Anoplolepis gracilipes*), which was positively selected in oil palm plantations. This suggests that predator–prey interactions can be mostly maintained with habitat disturbance despite shifts in the community composition of potential prey, and even that some predators are capable of exploiting new prey sources in novel ecosystems.

1. Introduction

The negative impacts of habitat loss and land conversion on a wide range of species are increasingly well documented (Hoekstra et al., 2004; Sala et al., 2000). However, our understanding of the impact of human activity on species interactions remains poor. Mutualisms and trophic interactions influence the structure of animal and plant communities, and affect the stability and function of ecosystems (Ives and Cardinale, 2004). Species interactions play essential roles in both natural and human-dominated ecosystems, providing services such as pollination (Klein et al., 2007) and pest control

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http://dx.doi.org/10.1016/j.gecco.2014.10.011
2351-9894/

(Bianchi et al., 2006). Given the ecological and economic importance of ecological processes and associated ecosystem services, documenting the impact of human activity on interactions between species is a priority (Herrera and Doblas-Miranda, 2013). We need to understand the causes and consequences of changes in networks of interactions if we are to properly predict and manage human impacts on ecosystems (Morris, 2010; Tylianakis et al., 2010).

The complexity of ecological interactions may make it challenging to generate general rules for predicting the impacts of such changes (Tylianakis et al., 2008). For example, shifts in resource consumption following habitat fragmentation are likely to differ between generalists and specialists (Martinson and Fagan, 2014). Similarly, the removal of top predators can have a range of cascading effects on lower trophic levels (Ripple et al., 2014). Nevertheless, there is an increasing body of evidence indicating that resource extraction and land use change alter species interactions. For example, modification of tropical habitats reduces the diversity and breadth of host–parasitoid food webs (Tylianakis et al., 2007), alters the trophic position and narrows the niche breadth of bird communities (Edwards et al., 2013), and alters the trophic position of leaf-litter ant species (Senior et al., 2013; Woodcock et al., 2013). Understanding the variation in responses of different species interactions to habitat modification is potentially a greater challenge than documenting the changes in the communities themselves.

Our knowledge of how trophic interactions are altered by anthropogenic disturbance is particularly poor for tropical systems (Morris, 2010). This is a particular concern because tropical ecosystems exhibit high levels of biodiversity and are particularly vulnerable to on-going anthropogenic threats (Brooks et al., 2002). Southeast Asia, and Sundaland in particular, is an important biodiversity hotspot (Myers et al., 2000) threatened by habitat loss (Sodhi et al., 2004). In this region, the important drivers of changes in community structure and function are logging and subsequent conversion of degraded forest to oil palm plantation (Wilcove et al., 2013). There is a substantial body of evidence showing that the community composition of many species in Southeast Asian rainforest changes with logging and conversion to oil palm dominated landscapes (Danielsen et al., 2009; Fitzherbert et al., 2008; Foster et al., 2011), including abundant tropical meso-predators such as anurans (Faruk et al., 2013). Furthermore, there is some evidence that interactions of other ecologically important groups such as ants are altered by conversion to oil palm plantations (Fayle et al., 2013). However, the impact of oil palm expansion on species interactions and in particular on trophic interactions remains mostly unknown.

Habitat conversion is often accompanied by the introduction of non-native species (Ricciardi, 2007) and these invasions can also alter or inhibit interactions between native species (Traveset and Richardson, 2006). Understanding the effects of non-native species on food webs and trophic interactions is therefore of particular interest. We need to enhance our understanding of the interaction between land conversion and invasive species if we are to predict and manage species' responses to anthropogenic change. Knowing the extent to which native species can respond to the ecological changes caused by the presence of these introduced groups will help with predicting the resilience of communities and targeting conservation efforts (Didham et al., 2007).

The impact of habitat degradation on the trophic interaction between ants and is currently unknown. However, ants are an important part of the diet of some tropical anuran communities (e.g. Inger, 2009; Konopik et al., 2014; Toft, 1980). Here we assess the variation in the interaction between a common anuran predator, the giant river toad (*P. juxtaspera*) and the ground dwelling ants on which it feeds. We quantify changes in toad populations, ant communities, and predator–prey interactions across different land uses in Malaysian Borneo. Specifically, we ask the following questions:

(1) How does the abundance of the toad *P. juxtaspera* vary with degree of disturbance and stream characteristics?
(2) How does the abundance and species richness of ground dwelling ants vary with degree of disturbance and stream characteristics?
(3) How do the predator–prey interactions between the toad and ant communities change with degree of disturbance and stream characteristics?

2. Materials and methods

2.1. Study sites

The study was conducted in northern Borneo in the state of Sabah, Malaysia from April to June 2011. We sampled the abundance and diet of the giant river toad (*P. juxtaspera*) and corresponding ground-dwelling ant communities along streams in primary lowland dipterocarp rainforest, continuous logged forest and in oil palm plantations under the framework of the SAFE project (Stability of Altered Forest Ecosystems; Ewers et al., 2011).

Primary forest sites were located within the Maliau Basin Conservation Area (MBCA, 58,840 ha) and a patch (2200 ha) of mainly unlogged forest (lightly logged along its edges), which is continuous with both the SAFE project area and a major forest block (>1 million ha) of both logged and unlogged forest (Reynolds et al., 2011). Logged forest sites were located in the SAFE project area, which has undergone two rounds of selective logging. The forest structure in the SAFE project area is highly variable, ranging from open areas to those with closed canopies (Ewers et al., 2011). The oil palm plantation sites and their catchments were isolated by 1–5 km from the logged forests. All plantation streams were managed by the same company (Benta Wawasan Sdn Bhd) but had riparian reserves of differing vegetation and quality. These ranged from forested riparian strips shading the streams to shrubby and grassy, heavily degraded streamside vegetation. To standardise stream size, all data were collected at the outlets of 2.5 km^2 stream catchments, which were 1.5–9 km apart from each other.