Global Ecology and Conservation 11 (2017) 188–195

Contents lists available at ScienceDirect

Global Ecology and Conservation

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

Original Research Article

A pantropical assessment of vertebrate physical damage to forest seedlings and the effects of defaunation

Cooper Rosin [a, *], John R. Poulsen [a], Varun Swamy [b], Alys Granados [c]

[a] Nicholas School of the Environment, Duke University, Durham, NC, USA
[b] San Diego Zoo Institute for Conservation Research, Escondido, CA, USA
[c] Department of Zoology and Biodiversity Research Centre, University of British Columbia, Vancouver, BC, Canada

ARTICLE INFO

Article history:
Received 13 June 2017
Accepted 14 June 2017
Available online 3 July 2017

Keywords:
Defaunation
Hunting
Logging
Plant–animal interactions
Trampling
Tropical forest

ABSTRACT

Many of the forces that shape tropical forest plant communities are facilitated by interactions with animals, which can either promote or inhibit plant reproduction and survival across ontogenetic stages. Hunting-induced defaunation can disrupt these interactions, altering tree recruitment, forest structure, and carbon storage, with strong effects at the seed and seedling stages. Research to date has largely focused on how changes to prominent interactions (especially seed dispersal) affect plant species and communities, while concurrent disruptions to less-studied processes may have opposing effects. With a particularly limited understanding of non-trophic interactions – such as physical damage to seedlings by vertebrate trampling, rooting, and digging – it remains difficult to predict the outcomes of defaunation for tropical forest plant communities. We established 1800 artificial seedlings in 18 intact and disturbed sites across the three main tropical forest regions – the Neotropics (Peru), the Afrotropics (Gabon) and the Indo-Malayan tropics (Malaysian Borneo) – to isolate non-trophic vertebrate physical damage from other causes of seedling mortality (herbivory, pathogens, abiotic desiccation, etc.), and to understand its effects in intact and anthropogenically-disturbed forests. We found that vertebrate physical damage is a consistent force in forests across the tropics, and that hunting significantly alters its strength, with a ~70% decrease in damage in hunted vs. intact sites that resulted in a ~3.5-fold (350%) increase in artificial seedling survival. Our results reveal an understudied mechanism that may contribute to changes in seedling survival, stem density, and plant community composition in tropical forests subjected to hunting.

1. Introduction

Plant-animal interactions are prominent in tropical forests (Price et al., 1991), and can be beneficial (e.g. pollination, seed dispersal) or detrimental (e.g. herbivory, seed and seedling predation) to plant reproduction and survival. Disruptions to these interactions – such as defaunation resulting from hunting (Redford, 1992) – can generate broad changes in tree recruitment (Terborgh et al., 2008), forest structure (Dirzo and Miranda, 1990), and carbon storage (Osuri et al., 2016), with demographic filtering at the seed and seedling stages responsible for many of the effects (Kurten, 2013). Research to date has largely

* Corresponding author.
E-mail address: cooper.rosin@duke.edu (C. Rosin).

http://dx.doi.org/10.1016/j.gecco.2017.06.001

focused on a subset of prominent bi-trophic interactions (especially seed dispersal), while concurrent disruptions to other less-studied ecological processes may have unexpected or even opposing effects (Kurten, 2013; Wright, 2003).

Largely ignored in recent research are non-trophic interactions (Ohgushi, 2008), such as trampling, rooting, digging, and other incidental physical damage that occurs as animals use their habitat. The strongest of these ecological effects are obvious: elephants create vast networks of trails through repeated trampling (Blake and Inkamba-Nkulu, 2004), and maintain forest clearings called bais (Klaus et al., 1998); foraging herds of peccaries root and dig, disturbing the soil and vegetation over large areas and acting as "ecosystem engineers" (Beck et al., 2010). While extensive localized damage is conspicuous, multitudinous small effects – such as the trampling of many individual seedlings across large spatial and temporal scales – could have equally consequential effects for plant communities. With very limited understanding of these interactions, it remains difficult to predict the outcomes of defaunation for tropical forests.

Little is known about the role of vertebrate physical damage to seedlings in the tropical forest understory (Clark and Clark, 1989), as well as how this force may be altered by defaunation. The assessment of physical damage can be difficult, given that vertebrate and invertebrate herbivory, pathogen attack, abiotic desiccation, and other factors can produce visually similar forms of seedling mortality. To isolate the effects of physical damage (by both vertebrates and falling plant debris) from other causes of mortality, we used a modified artificial seedling model designed to replicate natural seedlings in general shape, flexibility, and resilience to damage (Clark and Clark, 1989, Fig. 1). The model provides an index of damage that is ideal for comparison across sites (Clark and Clark, 1989) and between forests with different human disturbances such as hunting (Roldán and Simonetti, 2001).

We sought to quantify physical damage to seedlings in biogeographically distinct forests across the tropics, and to compare these effects between intact forests (protected sites without any recent human disturbance) and those subjected to hunting and/or logging. We assessed damage to a total of 1800 artificial seedlings across 18 sites, with three sites in each of two forest conditions (intact vs. hunted and/or logged) in Peru, Gabon, and Malaysian Borneo. We hypothesized that: 1) non-trophic vertebrate damage would be highest in Gabon and Malaysian Borneo, where megafauna remain abundant; and 2) hunting-induced defaunation would significantly reduce non-trophic vertebrate damage, resulting in proportionally greater debris damage but reduced damage overall.

2. Methods

2.1. Study sites

We conducted our study in both intact and disturbed forests of Peru, Gabon, and Malaysian Borneo (Fig. 1). In total, we established 18 experimental sites, with three sites in each of two forest conditions (intact vs. hunted and/or logged) in each of

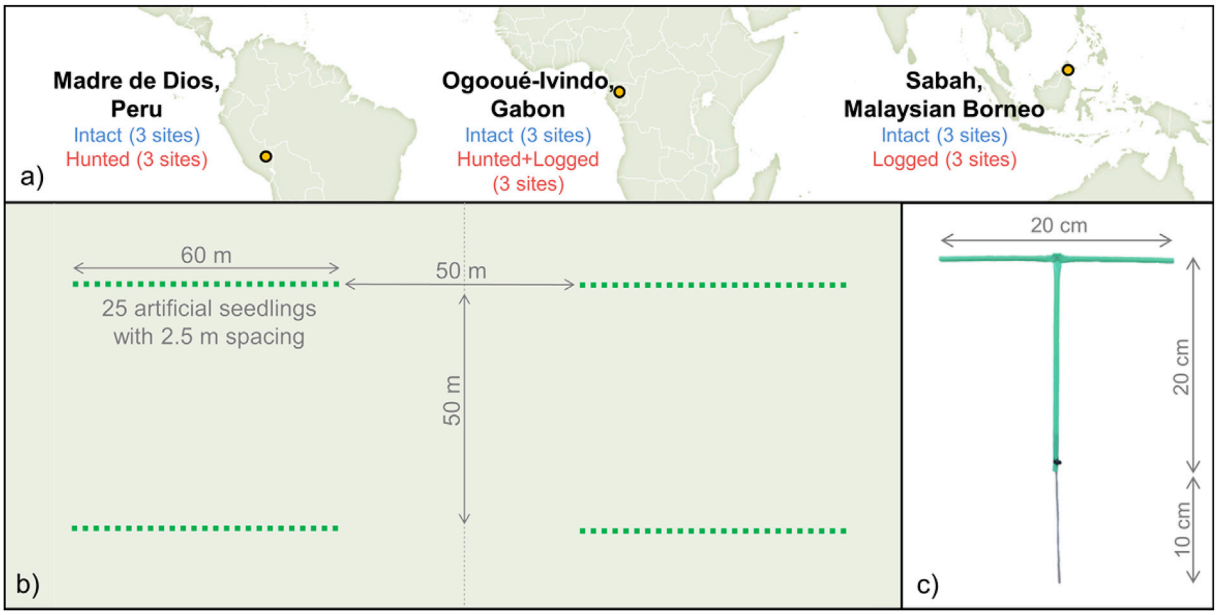

Fig. 1. a) Map of study areas, with three sites in each of two forest conditions (intact vs. hunted and/or logged) in each of the three main tropical forest continents; b) The experimental design for a single site, made of four parallel lines of 25 artificial seedlings (green dotted lines; grey arrows indicate spatial scale and distance between seedling lines; central grey dashed line represents the access route) – in total, we established 18 sites and 1800 artificial seedlings; c) The artificial seedling model, constructed of two green plastic drinking straws attached to a stiff wire "root".