GfÖ Ecological Society of Germany, Austria and Switzerland

Basic and Applied Ecology 15 (2014) 179–186

Basic and Applied Ecology

www.elsevier.com/locate/baae

Invasive rat space use on tropical islands: Implications for bait broadcast

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Received 14 June 2013; accepted 27 January 2014
Available online 2 February 2014

Abstract

Invasive rats on oceanic islands impact a large number of native species. Control programmes, and in many cases complete eradication, are used to alleviate these impacts. Basic data on rodent biology facilitate the design of control or eradication programmes, and is particularly required for programmes on tropical islands where such data are missing. Here we test for interactive effects of habitat and season that may alter black rat (*Rattus rattus*) space use dynamics and inform rodent management on two tropical islands. Five years of summer and winter trapping data were analysed using spatially explicit capture–recapture to calculate rat space-use and overlap, coupled with spool and line experiments ground-truthing microhabitat use. Variation in individual rat space use is primarily driven by sex and bottom-up trophic effects of seasonal rainfall on food resources, but is altered by island-specific contexts. In the absence of other introduced mammals, rats tend to have stable range overlap throughout the year but home range sizes fluctuate seasonally with rat density. The presence of other introduced mammals causes predictable greater seasonal fluctuations in rat space-use, putatively a behavioural adjustment to feral cats (*Felis catus*) diet-switching to rats from seasonal influxes of their alternative seabird prey. We identify winter as the recommended treatment period on both islands and discuss bait broadcast strategies.

Zusammenfassung

Invasive Ratten beeinträchtigen auf ozeanischen Inseln eine große Anzahl von einheimischen Arten. Kontrollprogramme und in vielen Fällen die vollständige Ausrottung werden genutzt, um diese Beeinträchtigungen zu mildern. Grundlegende Daten zur Kleinsäugerbiologie erleichtern die Planung von Kontroll- und Ausrottungsprogrammen. Sie werden besonders für Programme auf tropischen Inseln benötigt, wo solche Daten fehlen. Hier untersuchen wir die Interaktionen zwischen Habitat und Jahreszeit, die die Raumnutzung von Hausratten (*Rattus rattus*) verändern und dem Kleinsäugermanagement zugrunde gelegt werden können. Sommer- und Winterfallenfänge aus fünf Jahren mit räumlich explizitem Fang/Wiederfang wurden analysiert, um Raumnutzung und Überlappung der Ratten zu berechnen. Mit der Fadenspulen-Methode wurden Vergleichsmessungen zur Mikrohabitatnutzung durchgeführt. Die Variation der Raumnutzung durch Rattenindividuen wird in erster Linie vom Geschlecht und den durch saisonale Regenfälle bedingten Nahrungsressourcen bestimmt; sie wird aber durch inselspezifische Zusammenhänge modifiziert.

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http://dx.doi.org/10.1016/j.baae.2014.01.005

Wenn keine anderen eingeführten Säuger vorhanden sind, ist die Überlappung der Territorien über das Jahr hinweg tendenziell stabil, aber die Größe der Aktionsräume schwankt saisonal mit der Rattendichte. Die Anwesenheit anderer eingeführter Säuger ist mit vorhersagbaren, größeren saisonalen Schwankungen der Raumnutzung durch die Ratten verbunden–vermutlich eine verhaltensbedingte Anpassung an den saisonal bedingten Nahrungswechsel verwilderter Hauskatzen (*Felis catus*) von Seevögeln, ihrer alternativen Beute, hin zu Ratten. Wir fanden heraus, dass auf beiden Inseln der Winter die zu empfehlende Behandlungszeit ist, und diskutieren verschiedene Köderausbringungsstrategien.

Keywords: *Rattus rattus*; Spatially explicit capture–recapture; Spool and line; Home range; Overlap; Microhabitat use; Eradication

Introduction

Invasive rats (*Rattus exulans*, *R. norvegicus* & *R. rattus*) have been introduced to most archipelagos in the world from polar to tropical islands (Atkinson 1985). Their adverse impacts on biodiversity through direct consumption (Jones, Tershy, Zavaleta, Croll, & Keitt 2008) or synergic indirect effects (Russell 2011) have been well documented and have been proven to be very persistent (Bourgeois, Ouni, Pascal, Dromzée, & Fourcy 2013). Their capacity to cause detrimental effects on native fauna and flora is a consequence of their ability to adapt their biology to novel environments. Particularly, rats introduced on oceanic islands can adapt their body size, their breeding strategy or their diet to the island characteristics (e.g. climate, weather patterns, habitats, community structure) (Russell, Ringler, Trombini, & Le Corre 2011). This plasticity might also be reflected by adaptive space use strategies.

Several studies have investigated the space use dynamics of invasive rodents, usually in mainland temperate environments, which have provided biological information on rat movements either in a single specific location or at limited spatio-temporal scales (Dowding & Murphy 1994; Cox, Dickman, & Cox 2001). Methods have generally used expensive and time-consuming radio telemetry experiments that prevented tests for complex environmental effects (e.g. individual covariates, season, habitat, site) on ranging dynamics. Particularly little is known about interactions between weather patterns and island community structure on rat spatial ecology. From a conservation perspective, biological data on rat space use – their home ranges, the distances they move, their aggregation and their preferred microhabitat features – are essential to provide guidelines for the design of control and eradication strategies (Hooker & Innes 1995).

Eradication techniques to restore invaded islands have considerably improved from bait stations and hand broadcast of toxic bait to aerial broadcast of bait-delivered anticoagulants (Howald et al. 2007). Spatial patterns in bait delivery occur during broadcast, but whereas optimal spacing in bait broadcast or between stations leads to efficient use of bait, gaps may lead to reduced control efficacy or even eradication failure, such as when space between bait lines or stations exceeds minimal rat home range (Morgan 2004).

In this study we investigate rat movements and home ranges on two tropical Indian Ocean islands and use the findings to supply information to tropical eradication managers. The study first aimed to test contributions of intrinsic and environmental parameters on rat space use dynamics, and the consistency of any such effects between islands. We used live trapping experiments to produce a large and robust spatio-temporal dataset of tropical rat home range and measures of home range overlap. Within individual home ranges, we also aimed to determine whether rats range uniformly within the total space they use or if they differentially use parts of their home range. For this purpose we compared results from daily movement and simulated home range sizes. Finally, for each island we looked at what could be the recommended treatment period and conservative bait gap threshold, i.e. the maximum tolerable distance between bait broadcast or stations of baits to ensure all rats rapidly encounter baits. For each combination of island and habitat we used the smallest home range scenario depending on age and sex of the rats but also according to season.

Materials and methods

Study sites

The study was conducted on Europa and Juan de Nova, two coralline atolls lying in the south-western Indian Ocean between East Africa and Madagascar. Both islands are French overseas territories located in the Mozambique Channel (Fig. 1), part of the Iles Eparses and under the authority of the Terres Australes et Antarctiques Françaises (TAAF). Europa (2223 ha, 22°21′ S, 40°21′ E) is a relatively undisturbed island and a major breeding site for eight seabird species (ca. 1 million pairs) as well as green turtles. Black rats and goats (*Capra hircus*) are the only two introduced mammals present on the island. Juan de Nova (561 ha, 17°03′ S, 42°45′ E) was mined for guano and holds the largest sooty tern (*Onychoprion fuscatus*) colony of the south-western Indian Ocean with approximately two million pairs. Black rats coexist with introduced cats (*Felis catus*) (estimated at around 60 individuals) and mice (*Mus musculus*). On both islands, climate is semi-arid with a warm and wet season during the austral summer (November–April) and a dry season during the cooler austral winter (May–October).