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ORIGINAL ARTICLE

Are owl pellets good estimators of prey abundance?

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Abstract Some ecologists have been skeptics about the use of owl pellets to estimate small mammal's fauna. This is due to the assumptions required by this method: (a) that owls hunt at random, and (b) that pellets represent a random sample from the environment. We performed statistical analysis to test these assumptions and to assess the effectiveness of Barn owl pellets as a useful estimator of field abundances of its preys. We used samples collected in the arid Extra-Andean Patagonia along an altitudinal environmental gradient from lower Monte ecoregion to upper Patagonian steppe ecoregion, with a mid-elevation ecotone. To test if owls hunt at random, we estimated expected pellet frequency by creating a distribution of random pellets, which we compared with data using a simulated chi-square. To test if pellets represent a random sample from the environment, differences between ecoregions were evaluated by PERMANOVAs with Bray–Curtis dissimilarities. We did not find evidence that owls foraged non-randomly. Therefore, we can assume that the proportions of the small mammal's species in the diet are representative of the proportions of the species in their communities. Only Monte is different from other ecoregions. The ecotone samples are grouped with those of Patagonian steppes. There are no real differences between localities in the small mammal's abundances in each of these ecoregions and/or Barn owl pellets cannot detect patterns at a smaller spatial scale. Therefore, we have no evidence to invalidate the use of owl pellets at an ecoregional scale.

1. Introduction

Oliver Pearson, a pioneer in Patagonian mammalogy, always said that owls were his best field assistants during Patagonian surveys. They hunted more species and more individuals than his trap lines, so they were useful estimators of field abundance. However, estimation of small mammal's abundance is difficult and controversial. Different methods can be used but each of these has some limitations and produces special biases on the abundance assessments. Trap success is

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a technique frequently used, where the trap-attracted species are over-estimated and trap-shy are under-estimated. Besides, the efficiency of trapping is related with the ecological habits of the small mammal species surveyed (ground-dwelling, scansorial, fossorial, etc.), requiring a different type of trap sampling. The environmental heterogeneity and specificity of small mammal habitat selection demands large sampling effort to properly assess an area. This can be possible in studies on species population dynamics or community composition analysis; but difficult or even impossible at landscape scale surveys (for advantages and biases of different sample techniques, see Millán de la Peña et al., 2003; Torre et al., 2004).

A complementary method is the analysis of raptor pellets. Owls swallow their prey as a whole and expel undigested remains, such as bones, compacted in hair and feathers. Ecologists and mammalogists have been skeptical about the validity of owl pellets as samples representing relative abundance of prey species in an area. The use of pellet contents as an estimate of relative abundance of small mammal in the field depends on two assumptions: (a) owls hunt at random, and (b) pellets represent a random sample of species ingested (Yom-Tov and Wool, 1997). Despite its frequent use for different ecological purposes, controversy still persists about the fact that whether abundances of each prey in the owl's diet represent the proportion of species in the field. Some studies reported a positive association between trapping data and pellet sampling (Bernard et al., 2010; Glue, 1971; Hanney, 1962; Mikkola, 1983; Terry, 2010) while others did not find such association (Perrin, 1982; Torre et al., 2004). Avenant (2005) demonstrated that Barn owls are efficient samplers of the small mammals because they can detect more species and can more accurately sample the species abundance compared to trapping exercised over the same period. Terry (2010) found a high fidelity of the death assemblages to the living community in terms of richness, evenness, taxonomic composition, and rank and proportional abundances of the prey species.

Although some studies compared the small mammal abundances data collected by two complementary methods (owl pellet and trapping), yet even if abundance estimations are different, it does not exclude pellets as appropriate methodology in species relative abundance studies. Both methods have their own biases; therefore we believe that it is wrong to use one of these (traps) to validate the other (pellets sample). This is especially relevant with Barn owl (*Tyto alba*) pellets, as these were employed to measure biodiversity in several ecological studies (Avery et al., 2002, 2005; Bernard et al., 2010; González-Fischer et al., 2012; Heywood and Pavey, 2002; Lyman, 2012; McDowell and Medlin, 2009a; Millán de la Peña et al., 2003; Torre et al., 2004). Fidelity of Barn owls for the same roosting place produces large amounts of small mammal bones that accumulate over time and become a part of sediments. This particular habit enables paleontologists to employ these assemblages in taphonomical, paleoecological and paleoenvironmental reconstructions, based on the variations in the proportions of small mammal's species over time (Andrews, 1990; Avery, 2001; Fernández-Jalvo, 1995; Pearson, 1987; Pearson and Pearson, 1993; Teta et al., 2005; etc.).

In Argentinean Patagonia, food habits of Barn owls were assessed along latitudinal (Trejo and Lambertucci, 2007) and also elevational gradients (Travaini et al., 1997). Both studies concluded that Barn owl pellets are a good complement to trapping in attempts to efficiently sample a small mammal community. Moreover, Travaini et al. (loc. cit.) concluded that Barn owl diets reflected the real composition of cricetid rodents along the altitudinal gradient and that consumption of prey species was dependent on their availability. Recently, a study was undertaken at a landscape scale to document the effects of altitudinal gradients on the community composition, abundance, and species richness of small mammals in Patagonian arid lands using Barn owl pellets (Andrade and Monjeau, 2014). The study reflected spatial variation of community composition of small mammals along the altitude gradient. Pellet samples were also employed to define geographic distribution ranges of some small mammal species (Andrade, 2008; Martin, 2003; Nabte et al., 2009; Udrizar Sauthier et al., 2007, 2008, 2011).

Barn owl (*T. alba*) is a medium sized, active hunter owl, and territorial in its feeding habitat. It is mainly nocturnal but may also be active during the early evening and morning hours. Its hunting area may vary from 400–500 m to 2–3 km, depending on food availability, and it searches for prey by silently flying over open areas. It feeds on vertebrates, mainly rodents (Andrews, 1990). McDowell and Medlin (2009b) and Heywood and Pavey (2002) showed that Barn owls can switch to alternative prey only when rodents are scarce and may return to preferred preys as soon as they become available.

Yom-Tov and Wool (1997) provides the only study which indirectly tests that pellets constitute a random sample of prey small mammal species. The study worked with the hypothesis that pellets are a random sample of their catch. The study concluded that Barn owls are though not selective hunters yet the contents of the pellets could be biased toward larger preys. Andrews (1990) evaluated the response of Barn owl to prey size and found that the more abundant small mammal species in the field was more abundantly consumed by the owl, though it adapts to different sized prey depending on their availability. Bernard et al. (2010) found that Barn owl is an opportunistic predator, though density/availability of other prey species can affect their relative consumption.

The objectives of this paper were to test the two assumptions in the use of pellet contents as an estimate of relative abundance of small mammal in the field and to address two derived questions: (1) do Barn owls hunt at random? and (2) are pellet contents of this owl a useful tool to characterize the small mammal's assemblages sampled in different habitats at the arid Patagonia? We also discuss the advantages and biases in the estimation of rodent abundances through the pellet content analysis.

2. Material and methods

2.1. Study area

Continental Patagonia, located in the southernmost end of South America (between 39°S and 55°S) presents a sharp environmental gradient, due to the synergy between precipitation and temperature (Paruelo et al., 1998). Gradually decreasing precipitation sets boundaries of the main vegetation types from west to east: forest, bunchgrass steppe, brush-grass steppe and bush steppe (León et al., 1998). Extra-Andean arid Patagonia is located east of the Andean mountains, lying between sea level and 1800 m above sea line (a.s.l). This sharp elevational