



Short Communication

Performance of individual species as indicators for large mammal species richness in Northern Tanzania



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ARTICLE INFO

Article history:

Received 2 September 2014

Received in revised form

22 November 2014

Accepted 13 January 2015

Keywords:

Connectivity
Conservation planning
Fragmentation
Indicator species
Mammal community
Umbrella species

ABSTRACT

In order to prioritize areas for biodiversity conservation, conservation practitioners frequently employ a single species whose distribution is statistically related to overall species richness. However, the performance of single mammal species in terms of (1) their strength, (2) spatial and (3) temporal variability for predicting large mammal species richness has rarely been assessed. Drawing upon data from multiple vehicle-based surveys in four study sites with varying conservation management approaches in the Tarangire–Manyara ecosystem, we assessed the performance of thirteen candidate indicator species. Overall, we found that the association strength between the distribution of single large mammal species and overall large mammal species richness varied (1) considerably across four management units within the same ecosystem, (2) between seasons and (3) years. In contrast to a study carried out in central Tanzania, elephants performed poorly as an indicator of large mammal species richness. Applying our findings to conservation planning, we suggest that information on zebra and wildebeest distribution should be used for delineating corridors for large mammals between protected areas in this ecosystem. The distribution of these two species had a high correlation with overall large mammal species richness, and these correlations were relatively constant throughout time and space. More generally, our study suggests that the performance of indicator species (1) should be assessed across multiple seasons because snapshot surveys may provide biased estimates of indicator performance, (2), cannot necessarily be extrapolated to other ecosystems and (3) should be supplemented by ecological or functional considerations.

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1. Introduction

In a rapidly changing world, conservation interventions need to be located in areas of high biodiversity value (Howard et al., 1998; Myers et al., 2000). Biodiversity value is often associated with high species richness and hence, conservation planners often seek to implement conservation actions in areas with high species richness (Vanewright et al., 1991; Wilson et al., 2006). While this

strategy itself does not account for complementarity of species occurrence between sites (Howard et al., 1998), this approach has obvious advantages if the primary conservation goal is to sustain diverse mammal communities across landscapes (Epps et al., 2011; Fleishman et al., 2006). Yet, conducting species inventories over large spatial scales and subsequent conservation planning for multiple species is time and resource consuming, and thus costly (Cushman et al., 2013; Epps et al., 2011; Gardner et al., 2008; Kessler et al., 2011). To make conservation planning cost-effective, multiple attempts have been made to identify individual species that indicate high species richness over a large geographic range (Caro, 2010; Caro and O'Doherty, 1999; Epps et al., 2011; Fleishman et al., 2005). If it was possible to identify a single species whose distribution would coincide with high overall species richness, conservation planning based on the distribution of this species would provide effective protection for many other species as well.

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However, several issues need to be considered when adopting such an approach. First, indicator species should be well known biologically, readily observable in the field, occupy a wide geographic range, and have high habitat fidelity (Caro and O'Doherty, 1999). Secondly, within a given ecosystem, the composition of mammal communities may differ considerably across areas with differing conservation status (Kiffner et al., in press), or across seasons (Morrison and Bolger, 2012). Such limited spatial and temporal congruency of species distributions might severely affect the surrogate performance of a single species but, surprisingly, the spatial and temporal performances of indicator species have rarely been assessed (Andelman and Fagan, 2000; Trindade-Filho and Loyola, 2011). Thirdly, favourable indicator species would perform similarly in different ecosystems. Yet, the utility and transferability of a single surrogate species for conservation planning might be problematic because (1) cross-taxon relationships are often non-functional (i.e. spurious correlations that do not imply a cause and effect relationship), and (2) mammal community composition often differs substantially across ecosystems (Caro, 2010; Sætersdal and Gjerde, 2011). In short, a given species might be a useful indicator of species richness in one ecosystem, but might be loosely correlated to species richness in another ecosystem. Hence, naïvely transferring the use of an indicator species that has proven useful in one ecosystem to a different ecosystem might result in compromised conservation actions (Hermoso et al., 2013).

Clearly, these considerations are important when indicator species are being employed for conservation planning. One of the major priorities for large mammal conservation in East Africa is ensuring or re-establishing connectivity within landscapes (Caro et al., 2009) in order to address the shortcomings or lack of past conservation planning attempts (Bartlam-Brooks et al., 2011; Caro et al., 2009; Cushman et al., 2013; Di Minin et al., 2013). Indeed, it has been suggested to use the distribution of indicator species to delineate wildlife corridors (Epps et al., 2011). In many ecosystems, direct and indirect effects of rapid human population growth in former wildlife habitats have reduced functional connectivity of landscapes which in turn has caused wildlife population declines and local extinctions (Balmford et al., 2001; Craigie et al., 2010; Fynn and Bonyongo, 2011; Kiffner et al., in press; Newmark, 1996, 2008; Western et al., 2009). In several ecosystems, wildlife species migrate seasonally between dry and wet season ranges in response to variable resource availability (Bolger et al., 2008; Morrison and Bolger, 2012). Large portions of these annual ranges have little or no protection from human activities, encroachment, or development (Morrison and Bolger, 2014). Under some circumstances, human activities and infrastructures may constitute physical or perceived impermeable barriers to wildlife movement (Bartlam-Brooks et al., 2011; Cozzi et al., 2013). In other cases, animals leave fully protected areas but then fall into ecological traps in the human-dominated matrix (Robertson and Hutto, 2006): they are subject to elevated human-caused mortality resulting from (1) human-wildlife conflicts (Kissui, 2008), and (2) legal (Kiffner et al., 2009; Waltert et al., 2009) and (3) illegal hunting (Kiffner et al., 2013b; Martin et al., 2013).

The Tarangire–Manyara ecosystem of northern Tanzania is a prime example of inadequate conservation planning; protected areas are distributed patchily across the landscape and are largely unconnected leaving wildlife species vulnerable when leaving these protected areas during the wet season (Kiffner et al., 2014a,b; Morrison and Bolger, 2014). In order to identify suitable indicator species for large mammal species richness in this ecosystem, we assessed the occurrence of potential indicator species and overall large mammal species richness along transects in four areas with variable conservation status over a two-year period, capturing the major seasons. Using this dataset, we aimed at identifying the most suitable indicator species based on (1) their strength

in predicting overall large mammal species richness, (2) their consistency in doing so across both seasons and (3) protected areas within one ecosystem. Finally, we used this extensive case study to discuss the utility of indicator species for conserving and possibly re-establishing functional connectivity in East African ecosystems.

2. Materials and methods

2.1. Study area

We conducted fieldwork in the central part of the Tarangire–Manyara Ecosystem (hereafter TME), located in the eastern branch of the Great Rift Valley in northern Tanzania (Morrison and Bolger, 2012). Rainfall is bimodal, with the short rains occurring from November to January, and the long rains from February to May (Mwalyosi, 1981). The study areas were chosen to span major wet and dry season ranges of wildlife species across the TME and to include areas with varying levels of wildlife protection and mammal species composition (Kiffner et al., in press). The study sites included the northern sector of Tarangire National Park (TNP), Lake Manyara National Park (LMNP, except the recently annexed Marang forest), Manyara Ranch (MR), and parts of the Mto wa Mbu game controlled area (CA) (Fig. 1). While wildebeest (*Connochaetus taurinus*), and indeed most other wildlife species are considered to be resident in LMNP year-round, the TNP wildebeest and zebra (*Equus quagga*) populations show distinct migration patterns (Morrison and Bolger, 2012). During the dry season, zebra and wildebeest populations aggregate around the Tarangire River inside TNP. At the onset of the rainy season, they leave TNP and migrate to more nutrient rich areas. Compared to the first scientific assessments of wildlife migrations about 50 years ago, several migration routes have been lost in this ecosystem due to expansion of human settlements and agriculture (Lamprey, 1964; Borner, 1985; Morrison and Bolger, 2014). Nowadays, wildebeest and zebra mainly migrate towards the nutrient rich Simanjiro plains to the east of TNP or to the Northern Plains around Engaruka and Lake Natron. On the northern route they usually pass through MR and some of them spend substantial time on the ranch (Morrison and Bolger, 2014). At the onset of the dry season (June–July) zebras and wildebeest migrate back to TNP. Most of the wet season ranges are outside fully protected national parks. Here, wildlife shares the land with livestock (CA and MR), and substantial expansion of agricultural areas, settlements and other infrastructure take place in the CA (Msoffe et al., 2011). Due to the high human impact, including habitat modification, intensification of agriculture and extensive illegal hunting, the large mammal community composition has been substantially reduced in the CA compared to the more protected MR and the fully protected national parks (Kiffner et al., 2015). Adjacent to MR (which has been set aside to protect the large mammal migration in TME), certain areas in the CA are crucial for allowing movement of animal populations between LMNP and TNP and between TNP and the Northern Plains towards Lake Natron.

2.2. Assessing large mammal species

Data on large mammal distribution were collected during the major seasons (long rains; February–April; dry season: June–October; short rains: November–December) starting from 2011 (short rains only), 2012 (all seasons) to 2013 (long rains and dry season) in CA, LMNP and MR. In each of these areas, we carried out six season-specific surveys. In TNP, field surveys were conducted during the long rains (March) and early (July) and late (October) dry season (starting in 2011) but, not during

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