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Short communication

The effects of precipitation history on the kilometric index of Dorcas gazelles

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A B S T R A C T

Temporally and spatially unpredictable precipitation is one of the main challenges facing wildlife in arid environments. It is therefore expected that precipitation patterns are an important factor determining the distribution of herbivore populations in arid environments. The objective of this study was to examine the relationship between precipitation history and Dorcas gazelle kilometric index (KI) in a hyper-arid landscape. There was a significant relationship between Dorcas gazelle KI and precipitation history. Dorcas gazelle KI was significantly higher in areas with more recent rainfall. The lower KI in areas experiencing droughts could be the result of several possibilities such as a reduced carrying capacity, density reduction from animals dispersing to higher quality habitat, and lower survivorship. Our results illustrate the need for conservation efforts in desert areas to take into account the unpredictable nature of precipitation, as some Dorcas gazelle populations may not be able to withstand long durations of drought.

1. Introduction

Temporally and spatially unpredictable low quantity precipitation is one of the main challenges facing wildlife in a hyper-arid environment (Noy-Meir, 1973). Precipitation patterns are important as they can determine plant productivity, nutritional quality, and distribution (Nagy, 1988; Mduma et al., 1999; Milton and Dean, 2000; Ward et al., 1993, 2000). It is therefore expected that precipitation patterns are an especially important factor determining the distribution and indirectly regulating herbivore populations in arid environments. Ungulates that have limited or no access to standing surface water often utilize areas with recent rainfall and species distribution is sometimes related to precipitation history (Corp et al., 1998; Stanley Price, 1989; Tear et al., 1997). Droughts can reduce carrying capacity of the environment through a reduction of primary production, which can result in significant animal mortality (Nagy, 1988; Owen-Smith et al., 2005; Sinclair et al., 2007; Spalton, 1993; Stanley Price, 1989; Young, 1994).

Gazelle populations in arid environments are experiencing declines worldwide as a result of overhunting, habitat destruction, and habitat degradation (Newby, 1990; Ryder, 1987; Saleh, 1987). Despite Dorcas gazelles, *Gazella dorcas*, being the most widespread and common gazelle species of North Africa, their populations are rapidly declining (Chammem et al., 2008; El Alqamy and Baha El Din, 2006; Mallon and Kingswood, 2001; Saleh, 1987). The distribution of Dorcas gazelles in the Saharan desert includes areas with differing amounts of precipitation and a variety of habitats ranging from gravel and sandy plains, sand dunes, wadis, sebkhas, rolling limestone hills, and plateaus (Mallon and Kingswood, 2001). Studies that identify important factors affecting large antelope populations are important because of large mammal potential as a revenue source for wildlife viewing tourism, conservation value, and ecological roles in the environment (Gordon et al., 2004; Young, 1994). The objective of this study was to examine the effects of precipitation history on the kilometric index of Dorcas gazelles in a hyper-arid landscape.

This study occurred in Egypt's Eastern Desert, Red Sea mountains located within Wadi Gemal National Park (N 24° 27′, E 34° 56′; 7000 km^2), Ras Banas peninsula (N 23° 96′, E 35° 68′), and Elba National Park (N 23° 00′, E 35° 05′; 36,000 km^2). The study region is characterized by an arid climate, with hot, rainless summers and mild winters. Precipitation is unpredictable, falling mainly in the autumn and winter months, but is not an annual event (Mahmoud, 2010). For example, rainfall is often a localized event, which can occur in one valley, but not a neighboring valley only a few

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kilometers away (pers. observation). The average annual precipitation in Ras Banas is approximately 17 mm (as cited in Mahmoud, 2010). The monthly mean temperature varies between 24 and 38 °C during the summer and 12 and 26 °C during the winter. Vegetation is sparse, dominated by mostly *Balanites aegyptiaca*, *Acacia tortilis raddiana* and *A. tortilis tortilis* trees and *Zilla spinosa* shrubs (Attum and Mahmoud, 2012; Mahmoud, 2010).

Gazelle surveys took place during June 2008 along known routes as part of a continuing gazelle monitoring program. We calculated the kilometric index (KI: number of animals observed/distance surveyed) of Dorcas gazelles for each survey route. The low Dorcas gazelle densities and infrequent distribution prevalent throughout the Eastern Desert make it logistically difficult to use line transect methods. KI are useful indicators commonly used for detecting relative abundance and broad ecological features affecting populations of large herbivores (Acevedo et al., 2008; Barrio et al., 2010; Maillard et al., 2001; Morellet et al., 2007; Vincent et al., 1991). Surveys occurred along the length of valleys and across open plains. The low vegetation cover, high visibility, and the use of expert local trackers, former hunters now employed by the protected areas, reduced the potential errors associated with missing observations of small groups or individuals and animals further away from the survey routes.

Surveys started just after sunrise or approximately two to three hours prior to sunset. The vehicles were driven slowly at around 30 km/h with a team of at least two observers along predetermined routes. For every gazelle observation, the following data were collected: date and time, the number of animals observed (it was often not possible to identify sex or age class due to the flighty nature of the animals) and the longitude and latitude coordinates of the observation.

We surveyed fifteen sites, four plains and eleven valleys, with a mean survey length of 23.4 km ± SE 3.6 and 31.5 km ± SE 15.2, respectively. Valleys were characterized as dry river beds that run from within the mountains and drain into open plains. The open plains, which are located between the mountains and the Red Sea, consist of sandy or gravel plains intersected with alluvial fans and channels. The chosen localities were believed to contain the highest density and abundance of gazelles according to local people and preliminary surveys.

Given the lack of detailed precipitation records for the area, we interviewed local people who reside in areas with gazelles to record the last precipitation event in each survey area Although we do not know the exact rainfall quantity and date, records from local provide a relative measure of “effective precipitation” that involves soil penetration of approximately five centimeters or deeper and results in widespread primary production (Beatley, 1974; Fernández, 2007; Sala and Lauenroth, 1982). The interviewees are pastoralists whose lifestyle is dependent upon effective precipitation and therefore often do not recall rainfall events that do not stimulate widespread primary productivity (Krzywinski and Pierce, 2001). In our analysis, we recorded the last effective precipitation event, allocated to the nearest year in absence of precise dates. We examined the effect of precipitation history on Dorcas gazelle KI through the use of a linear regression.

Our results indicate that precipitation history is an important factor affecting Dorcas gazelle KI, which was significantly higher at sites with more recent precipitation and lower in areas experiencing a drought ($F_{1,14} = 16.58$, $t = -4.07$, $r^2 = 0.53$; $P = 0.001$; Fig. 1).

Precipitation history and corresponding vegetation biomass has been suggested as the single most important factor in determining arid land mammal distribution (Corp et al., 1998; Groom and Harris, 2009; Stanley Price, 1989; Tear et al., 1997). The lower KI in areas experiencing droughts could be the result of several possibilities

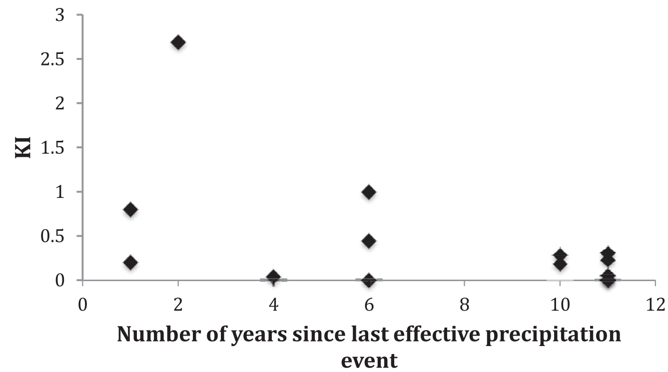

Fig. 1. The relationship between precipitation history and Dorcas gazelle kilometric index (KI).

such as a density reduction from animals dispersing to areas receiving recent rainfall, reduced carrying capacity, and lower survivorship (Islam et al., 2010; Ogutu and Owen-Smith, 2003; Sinclair et al., 2007; Treydte et al., 2001). Mammals in arid regions often have much larger activity ranges as a result of having to travel long distances to utilize patchy, spatially, and temporally distributed resources (McNabb, 1963; Rautenstrauch and Krausman, 1989). Mammals are known to migrate or disperse from areas undergoing drought with lower carrying capacity to areas with more recent precipitation and presumably higher carrying capacity (Bekenov et al., 1998; Corp et al., 1998; Norbury et al., 1994). The carrying capacity of the environment is often based upon the precipitation quantity, frequency, and distribution. Increased aridity can reduce the carrying capacity of the environment by reducing the forage quality of surviving vegetation (Mduma et al., 1999; Milton and Dean, 2000; Spalton, 1993; Treydte et al., 2001). Wildlife survival, recruitment, and population declines are particularly sensitive to prolonged periods without precipitation (Islam et al., 2010; Ismail et al., 2011; Owen-Smith et al., 2005; Sinclair et al., 2007; Spalton, 1993; Stanley Price, 1989; Treydte et al., 2001; Young, 1994). The reproduction of desert wildlife often decreases in response to decreased precipitation and corresponding primary production (Ismail et al., 2011; Spalton, 1993; Stanley Price, 1989). The ability of animals to reach areas with rainfall may determine reproductive success and survival (Corp et al., 1998; Treydte et al., 2001; Young, 1994).

Precipitation history, although an important factor, only explained 53% of the variation in Dorcas gazelle KI. This suggests that other variables such as perennial vegetation availability, landscape features, and anthropogenic disturbances may contribute to variation in Dorcas gazelle KI (Attum, 2007; Attum and Mahmoud, 2012; Chammem et al., 2008; Grettenberger, 1987; Lawes and Nanni, 1993). It is believed that some Dorcas gazelle populations, just like other arid antelope species, are able to persist without access to drinking water as long as they find vegetation with adequate moisture content (Ostrowski and Williams, 2006; Tear et al., 1997). For some plant species, as the time from the last rainfall event increases, plant water content, protein content, and digestibility all decrease (Spalton, 1999; Tear et al., 1997). Short-lived perennials, such as grasses, show a short-term increase in nutritional quality after a rainfall, with the nutritional benefits gone roughly one year and a half after the precipitation event (Corp et al., 1998). While Dorcas gazelles may opportunistically consume available annuals and short lived perennials, it is believed that drought resistant perennials such as *A. tortilis* tree, *B. aegyptiaca* tree and *Z. spinosa* shrub are important components to the diet of Dorcas gazelles in