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RH: Prey-switching *Panthera leo*

**Prey-switching of *Panthera leo* between wet and dry seasons in Chobe National Park, Botswana**

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One of the most important elements to studying ecosystems is understanding predator-prey dynamics. Preferred prey species and prey-switching abilities of carnivores is among the most critical aspects as it affects populations at lower trophic levels and can change the structure of the food web (Owen-Smith and Mills 2008a). Prey-switching is defined as a significant difference in targeted prey between two or more time periods or spaces as given variables change (Bissett et al. 2012). Such data is useful for predicting changes in species abundances, which then informs management decisions (Clements et al. 2014). Maintaining ecological balance amongst prey animals not only prevents one ungulate from overgrazing a given area, but also may aid in the survival of rarer species (Power 2002). The African lion (*Panthera leo*) is a prime example of a carnivore that has the potential to have this significant effect on its surrounding environment. The mammals that make up the major components of this feline’s diet are wildebeest (*Connochaetes taurinus*), warthog (*Phacochoerus africanus*), kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*), waterbuck (*Kobus ellipsiprymnus*), and zebra (*Equus quagga burchellii*) (Lehmann et al. 2008).

There are several factors that may influence the frequency with which lions target a given species. First, prey-switching may become more likely in small, fenced reserves of several thousand hectares containing a diverse array of animals, and could work to the detriment of small populations unable to migrate outside (Power 2002; Lehmann et al. 2008). Second, factors such as prey size and the proportion of hunting males and females in a pride may have a strong effect (Lehmann et al. 2008; Clements et al. 2014). Lions generally prey upon species equal to or slightly larger than their own weight, corresponding to 60-250 kg; males tend to select for larger animals than females (Lehmann et al. 2008; Owen-Smith and Mills 2008a). Their size and therefore strength also permit them to hunt a wider variety of large species than other African carnivores, resulting in purposeful foraging in regions populated by large prey (Radloff and Du Toit 2004; Hayward et al. 2011). Third, increased prey abundance can contribute to increased predation pressure; a preferred species could migrate into the lions’ territory, increasing the amount of vulnerable juvenile animals (Bissett et al. 2012).

 In addition to the importance of reserve size, prey size and pride composition, and prey abundance in determining which species lions target most, seasonal conditions are critical to consider as well. As a fourth point, they influence lion home range and hence energy expenditure in the search for prey (Tuqa et al. 2014). Good habitat conditions and abundant food are synonymous with smaller ranges, and dispersed prey at lower densities equate to larger predator territories and require increased energy expenditure (Tuqa et al. 2014). Fifth, rainfall and drought influence both prey and predator fitness levels which shifts food web dynamics (Owen-Smith and Mills 2008b). For example, drought may physically weaken some prey, while rainy seasons could increase the susceptibility of others to attack by increasing grass height or causing herd dispersal due to abundant water and forage (Owen-Smith and Mills 2008b). Seasonal mating behavior and gestation also affect prey vulnerability (Owen-Smith 2008). Bulls from species such as wildebeest, kudu, and waterbuck are commonly weakest and easier targets for lions in the dry season when intraspecific competition for females is at its highest, and females are most susceptible in the wet season during and after gestation (Owen-Smith 2008). Predators are affected too as favorable or severe circumstances may change preferences when hunting (Bissett et al. 2012). For example, smaller prides may target smaller, easier species, whereas larger prides could habituate to pursuing larger, weakened species after a period of unfavorable environmental conditions passes (Owen-Smith and Mills 2008b; Bissett et al. 2012). Nonetheless, whether seasonal differences in prey targeted are significant largely remains open to question. Studies may only detect significant contrasts in selection if they occur over long periods of time where large variations in prey abundance develop, or when there are abrupt changes over a shorter interval (Davidson et al. 2013).

Considering the various effects that seasonality can have on prey selection of lions, I will examine whether there is a significant difference in the targeted prey of a pride between the wet and dry seasons in the Chobe National Park of Botswana over a ten year period. Little research has been done on the effect of seasonality on lion prey-switching behavior in this region, and many studies pertaining to the topic have originated in small, enclosed reserves. Moreover, given its distance from the equator, the wet and dry seasons contrast starkly in regard to temperature and rainfall more so than further north where similar studies have been conducted (Balek 1977). Implications of this research could be used to inform management decisions for maintaining populations. Increased predation can cause severe declines even in large national parks, which may have prominent effects on vegetation dynamics by altering primary production (Owen-Smith and Mills 2008b; Fritz et al. 2011). Because the productivity of an ecosystem is mainly influenced by large herbivores that have few natural predators, changes in predation from large carnivores such as lions can have a significant outcome (Fritz et al. 2011). This top-down process then monitors the health of the ecosystem and may also alter bottom-up processes when vegetation quality changes, particularly affecting prey distribution (Fritz et al. 2011). Alternatively, switching to smaller species can have a prominent effect on prey abundance and hence primary production when combined with predation pressure from other carnivorous species (Fritz et al. 2011).

My hypothesis is that season will have a significant effect with resultant predictions that a difference will be detected between zebra, wildebeest, kudu, and warthog due to migration patterns (Owen-Smith 1996). I predict that zebra and wildebeest will make up the largest proportion of prey in the wet season, and that kudu and warthog will be most targeted during the dry season.

**Materials and Methods**

*Ethics statement*.---All research will follow the American Society of Mammalogists’ (ASM) guidelines in addition to the procedures laid out by the Institutional Animal Care and Use Committee (IACUC).

*Study site*.---Chobe National Park is situated in the northern part of Botswana and covers approximately 1.1 million hectares of land (Omphile and Powell 2002). The study will cover 50,000 hectares of the park, comprising approximately 4.5% of the total area to encompass the pride’s home range in addition to buffer room should the range shift (Tuqa et al. 2014). The dry season occurs from June to October with an average temperature of 9 to 26ºC, whereas the wet season spans from November to May with around 690 mm of rain per year and an average temperature of 19 to 35ºC (Omphile and Powell 2002). Of the main prey species hunted by lions, zebra, wildebeest, impala, kudu, and warthog are common in addition to buffalo (*Syncerus caffer*), elephant (*Loxodonta africana*), tsessebe (*Damaliscus lunatus*), and giraffe (*Giraffa camelopardalis*) (Owen-Smith 1996). Terrain is mostly flat and primarily consists of woodland and tree savanna with some grassland floodplains (Omphile and Powell 2002).

*Data collection*.---The study will be conducted over a ten year period from January 2020 to December 2029. Eight females and four males from a pride will be GPS-Simplex collared, representing individuals of six different subgroups with independent behavioral dynamics but a shared territory composing the pride (Power 2002; Davidson et al. 2013). These collars will allow for the recording of positional data every hour from 18:00 to 6:00; if the location remains the same for four or more hours within a 200 meter circumference, a team will investigate if a kill is present (Davidson et al. 2013). Batteries will be replaced as needed. Daily observations will also be made from a vehicle twice a day from 2:00 to 6:00 and 18:00 to 22:00 two times a week using Coleman spotlights with red filters. An additional observation will occur during the day from 14:00 to 16:00 if the lions do not eat in three days; this will be determined based off of the distension of the lions’ bellies (Power 2002; Lehmann et al. 2008). Species of prey will be recorded whenever the felines make a kill (Lehmann et al. 2008). Reports of hunting activity will also be documented by rangers conducting daily monitoring sessions within the pride’s territory (Radloff and Du Toit 2004). Any additional unoccupied kills discovered during these periods will be identified and documented if they show evidence of lion predation such as claw marks, carcass position, lion tracks and fecal matter, and evidence of a hunt as opposed to scavenging behavior (Davidson et al. 2013). Lastly, to determine prey abundance, aerial census counts will be conducted of prey species for three days in August and February each year, corresponding to the middle of both the dry and wet seasons (Bissett et al. 2012).

*Data analysis*.---The total number of discovered and observed kills will be added up from all the subgroups; the exception is when two or more such coalitions participate in the same hunt. Chi-square tests will be performed for each individual prey species comparing proportions of prey hunted between the wet and dry seasons (Davidson et al. 2013). Observed proportions will be obtained by dividing the number of animals killed by the total number of prey caught for the two respective seasons (June to October and November to May). Expected values will be derived from the aerial census counts (Bissett et al. 2012) by dividing the number of the prey species of interest by the total number of prey animals within the lions’ home range and multiplying this value by the total number of prey caught. If significant differences are detected for prey species within a given year as demonstrated by *α* values less than 0.05, raw, observed proportions will be examined to determine in which season kill counts are highest. Moreover, to account for the possibility that prey size rather than species may have a dominant effect on prey-switching behavior, an additional t-test will be conducted on weight. These values will come from a table of mean adult body mass values for different species and will be multiplied by 0.7 for subadults and 0.3 for juveniles, based on the size of the skeleton (Radloff and Du Toit 2004).

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