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Lion predation on livestock and native wildlife in Waza National Park, northern Cameroon

Abstract: The feeding ecology of lions (*Panthera leo*, Linnaeus 1758) was investigated in and around Waza National Park, northern Cameroon. Diet was determined using global positioning system (GPS) data of lion kill sites (clusters of GPS location points) collected using radio collars. Lions consumed 14 different prey species, with five species that were either medium (50–200 kg) or large (>200 kg) in size forming the bulk of kills. The western kob (*Kobus kob kob*) was the most common (23.5%) wild prey of lions, but worryingly livestock (predominantly cattle) constituted as much as 21.6% of the diet. This creates a conservation problem resulting in lions being killed in retaliation. However, this conflict is strongly exacerbated by herders driving their cattle into the park for forage and water. Wild prey was also consumed outside the park (6.7%), suggesting excursions beyond the park boundary. Lions showed a preference for wild prey over livestock when relative abundances were considered. Management efforts to reduce livestock intrusion into the park and to reverse the declining trends of wild prey populations would significantly reduce predation of livestock and prevent persecution of lions in this park, but conflict mitigation measures outside the park are also urgently needed.

Keywords: African lion; diet composition; GPS data clusters; prey preference.

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Introduction

Efforts to conserve large terrestrial carnivores are challenged by increasingly complex requirements broadly associated with human population growth (Woodroffe and Ginsberg 1998). Recently this has become increasingly problematic and threatens the persistence of the African lion (*Panthera leo*, Linnaeus 1758) in many regions (Tumenta et al. 2010) where they regularly succumb to persecution in retribution for livestock depredation (Woodroffe and Frank 2005). Among a list of requirements, lions require a large and stable prey base to meet their energetic needs (Schaller 1972). Lion diet thus varies across a range of predator, prey and environment-related variables (Funston et al. 2001, Radloff and Du Toit 2004). Lions prey on a broad range of species, typically ranging from medium to large-sized mammals. Lions in East and Southern Africa select a higher proportion of large prey (Hayward and Kerley 2005, Owen-Smith and Mills 2008) than lions in West and Central Africa (Breuer 2005, Bauer et al. 2008). Typically the preferred prey weight of lions ranges from 190 to 550 kg, although the median weight of 350 kg is more selected (Hayward and Kerley 2005). Prey species outside the preferred weight range are generally avoided. However, lions are generally thought to be opportunistic in their feeding (Schaller 1972, Hayward and Kerley 2005) and to consume prey according to availability (Mills and Shenk 1992, Breuer 2005, Bauer et al. 2008). Prey preference is influenced by many factors, notably prey size, prey availability (density and scarcity) and prey vulnerability (Schaller 1972, Carbone et al. 1999, Hayward and Kerley 2005).

Predators have been reported to increase their attacks on livestock as a consequence of low natural prey availability (Mishra 1997, De Iongh et al. 2004, Woodroffe and Frank 2005). Hemson (2003) found that lions in the Makgadikgadi National Park, Botswana, increased the frequency of livestock predation during seasonal periods of low wild prey availability. Patterson et al. (2004) also recorded that livestock depredation increased when native prey was less accessible in Tsavo National Park, Kenya. Prey vulnerability is another factor that influences prey selection. Livestock lack the physiological or morphological adaptations to escape from predators and defend themselves. They are easier to catch than wild prey and are thus considered vulnerable.
The wild prey base for lions in Waza National Park, northern Cameroon, has drastically declined in recent decades in response to a severe rinderpest outbreak in 1982/1983, impact of the Maga dam on the natural regime of the Waza Logone floodplain, drought in the 1980s (Scholte 2005, Scholte et al. 2007) and recently intensive human encroachment and poaching (De longh and Bauer 2008, De longh et al. 2009, Foguekem et al. 2010, Tumenta et al. 2010). The lion population in Waza National Park has also suffered persecution from herders for livestock depredation and coupled with other factors declined from about 50 individuals in 2002 to fewer than 20 in 2008 (Tumenta et al. 2010). Aerial counts of mammals in 2007 revealed a minimum of 3466 herbivore mammals in the park against a minimum of 21,000 livestock counted in a 5-km peripheral zone east of the park (Foguekem et al. 2010).

Thus, given the low wild prey densities, we expected that lions in Waza National Park might switch their diet to the more abundant livestock, considering its profitability as a large, vulnerable prey. Furthermore, because of the low wild prey densities, we additionally expected that lions would be less selective and would consume a wider range of prey species. To test this, we assumed that the proportions of prey species carcasses identified at global positioning system (GPS) clusters would reflect the actual proportions of wild and livestock prey in the park.

**Materials and methods**

Waza National Park lies between latitudes 10°50’ and 11°40’ and longitudes 14°20’ and 15°00’. The climate is Sudano-Sahelian and semi-arid tropical. Rainfall is low and irregular between years, with a mean annual rainfall of 600 mm (Beauvilain 1995). Temperatures range from 15°C (January mean minimum) to 48°C (April mean maximum). Waza National Park is characterized by three seasons: a wet season, from June to October; a cold dry season, from November to February; and a hot dry season, from March to May. The park has three main vegetation zones: (1) The floodplain zone in the eastern half is dominated by heavy cracking clay soils (vertisols) and grasses like *Sorghum arundinaceum*, *Pennisetum ramosum*, *Echinochloa pyramidalis*, *Oryza longistaminata*, *Hyparrhenia rufa* and *Vetiveria nigritana*. (2) The *Acacia* zone lying between the floodplain and the woodland is also a zone with clay soils, dominated by *Acacia seyal* trees interspersed with *Balanites aegyptiaca*, *Piliostigma reticulatum* and *S. arundinaceum* (3). The woodland zone found west of the park is on sandy soils and is dominated by *Sclerocarya birrea*, *Anogeissus leio-carpus* and *Lannea humilis* (Wit 1975).

Observing lions on kills in low prey density areas with intense human pressure is difficult. Lion diet was thus investigated using the method of GPS cluster searches for carcasses of prey consumed by lions (Anderson and Lindzey 2003, Sand et al. 2005, Tambling et al. 2010). Five lions from four different “prides” were radio-collared from 2007 to 2009 using Vectronic GPS PLUS collars equipped with a very high frequency transmitter (Vectronic Aerospace GmbH, Berlin, Germany) and African Wildlife Tracking GPS GSM collars (African Wildlife Tracking, Pretoria, South Africa). GPS positions were regularly downloaded from the collars. The locations of clusters of lion positions were entered into a handheld GPS unit, and the sites were visited to investigate the presence of kill remains.

Lions are most active during the night and feed on average 4–5 h when a kill of reasonable proportion is acquired (Schaller 1972). Therefore, we selected nocturnal GPS position clusters of 3 h and longer that were within a radius of 50 m. The GPS point in the middle of the cluster was put in a GPS unit and the location was visited by car or on foot. At the location of the selected fix, carcasses were searched for within a 100-m radius. The location, species and size (small, <50 kg; medium, 50–200 kg; large, >200 kg; Bauer et al. 2008) were noted. Mean adult female body weight (Kingdon 1997) was used for biomass calculations of prey. The age of carcasses was roughly estimated in the field and was later compared with the exact locations of GPS-collared lions.

Prey selection was calculated using frequency of occurrence expressed as percentages. To determine prey consumption based on body size, prey type, location and season, $\chi^2$ goodness of fit test was performed. Prey preference was calculated using the Jacobs’ index with log $Q$ giving positive values for preference and negative values for avoidance (Jacobs 1974), with the formula $D=(r-p)/(r+p-2p)$, where $r$ is the proportion of GPS-pointed kills for a particular species (the fraction of a species in the diet) and $p$ is the proportional availability of that species (the fraction of the species in the habitat). Prey preference was calculated only for species for which abundance estimates were available. Data of prey abundance were derived from large mammal counts conducted in Waza National Park in 2007 and 2010 (Foguekem et al. 2010, Saleh 2010).

**Results**

The GPS cluster data revealed a total of 14 prey species from 162 carcasses of prey species identified. Prey species included the western kob (*Kobus kob kob*), topi (*Damaliscus****
korrigum), roan antelope (Hippotragus equinus), red-fronted gazelle (Gazella rufifrons), warthog (Phacochoerus africanus), giraffe (Giraffa camelopardalis), elephant (Loxodonta africana), marabou stork (Leptoptilos crumeniferus), shoats (sheep and goats), cattle (Bos primigenius indicus), horse (Equus ferus caballus), jackal (Canis aureus), reedbuck (Redunca redunca) and ostrich (Struthio camelus). Percentage contribution of each prey species to the total diet of lions was determined. Five species made up the bulk (84%) of the lion’s diet, with the western kob (23.5%) being the species most often selected, followed by cattle (17.3%), topi (16.7%), roan antelope (13%) and giraffe (13%). In terms of numbers of carcasses located, the bulk (84%) of the lion’s diet, with the western kob (23.5%) being the species most often selected, followed by cattle (17.3%), topi (16.7%), roan antelope (13%) and giraffe (13%). The highest number of prey species were consumed in the Acacia vegetation zone (38.3%) followed by the woodland vegetation zone (34.6%) and the floodplain vegetation zone (27.2%). However, the proportion of prey consumed within various vegetation zones of the park was not different significantly ($\chi^2=3.11$, df=2, $p=0.21$).

In all three seasons (cold dry, hot dry and wet), significantly more wild prey was consumed than livestock ($\chi^2=52.25$, df=1, $p<0.001$). Irrespective of prey type (wild prey and livestock), the highest predation was recorded during the wet season followed by the cold dry season, whereas the lowest predation was recorded during the hot dry season. Predation was not different between the cold dry and wet seasons, but predation during these two seasons was significantly higher compared to predation during the hot dry season ($\chi^2=13.78$, df=2, $p=0.05$). Livestock predation was significantly higher during the cold dry season than during the wet and the hot dry seasons ($\chi^2=17.2$, df=2, $p<0.005$). The gazelle, warthog and all species of livestock were mostly consumed during the cold dry season, whereas the topi, roan and giraffe were mostly consumed during the wet season. During the hot dry season, mostly the western kob was consumed.

A majority of the prey species (67.3%) were consumed at night ($\chi^2=19.36$, df=1, $p<0.001$). Prey species consumed inside the park (81.5%) was significantly higher than prey species consumed outside the park (18.5%) ($\chi^2=64.22$, df=1, $p<0.001$). Cattle constituted 18% of prey consumed inside the park. Significantly more wild prey was consumed inside than outside the park ($\chi^2=111.8$, df=1, $p<0.001$). However, about 6.7% of wild prey predation took place outside the park. Inside the park, male and female lions consumed both wild prey and livestock, whereas outside the park only the males consumed both types of prey, and females consumed strictly livestock.

### Discussion and conclusion

The GPS cluster technique of identifying carcasses proved to be useful in determining lion diet in Waza National Park. This method is commendable for research in other areas with lions in order to provide data for effective conservation of lions. However, it is important to determine whether the age of the carcass corresponds with the age of the GPS cluster. For this reason, it is recommended that only recent GPS cluster data should be used as this will provide the most accurate and reliable results. Furthermore, the decomposition rates of carcasses may differ under different environmental conditions. Thus, it is preferable to study and determine the decomposition rate of

<table>
<thead>
<tr>
<th>Prey species</th>
<th>Number of carcasses</th>
<th>Abundance in Waza</th>
<th>Body mass</th>
<th>% Body mass</th>
<th>% of prey species</th>
<th>% Prey available</th>
<th>Jacobs’ index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kob</td>
<td>38</td>
<td>1,562</td>
<td>69</td>
<td>52</td>
<td>25.68</td>
<td>6.45</td>
<td>-0.06428</td>
</tr>
<tr>
<td>Topi</td>
<td>27</td>
<td>848</td>
<td>113</td>
<td>85</td>
<td>18.24</td>
<td>3.5</td>
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<tr>
<td>Roan</td>
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<td>148</td>
<td>252</td>
<td>189</td>
<td>14.19</td>
<td>0.61</td>
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<tr>
<td>Gazelle</td>
<td>6</td>
<td>28</td>
<td>20</td>
<td>15</td>
<td>4.05</td>
<td>0.12</td>
<td>1.228893</td>
</tr>
<tr>
<td>Warthog</td>
<td>4</td>
<td>21</td>
<td>60</td>
<td>45</td>
<td>2.7</td>
<td>0.09</td>
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</tr>
<tr>
<td>Giraffe</td>
<td>21</td>
<td>604</td>
<td>815</td>
<td>611</td>
<td>14.19</td>
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<tr>
<td>Cattle</td>
<td>28</td>
<td>17,459</td>
<td>330</td>
<td>248</td>
<td>18.92</td>
<td>72.12</td>
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<tr>
<td>Shoats</td>
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<td>35</td>
<td>26</td>
<td>2.03</td>
<td>14.63</td>
<td>0.294821</td>
</tr>
</tbody>
</table>
carcasses prior to the use of this method. Kill sites located using GPS clusters are biased toward large prey; therefore, in areas that lack large prey this method should be combined with scat analysis.

Prey proportions in the lion’s diet reflected more or less the proportion of occurrence of wild prey species in Waza National Park, with a preference for medium to large-size ungulates. Prey preference indices, however, were not dictated by the relative abundance, with the most preferred species, namely, red-fronted gazelle and warthog, being relatively less abundant than more common medium and large-sized species. The preference for warthog could be the result of the slow evasion rate shown by this species and the fact that the lion hunts them inside their burrows (Druce et al. 2004). It is unclear why the red-fronted gazelle was preferred most.

Of concern, however, was that livestock comprised as much as 21.6% of the lion’s diet within and outside the park, confirming earlier studies on livestock depredation in the Waza National Park area based on interview surveys (Bauer and Kari 2001, Van Bommel et al. 2007, Bauer et al. 2008, 2010, Tumenta et al. 2013). This contribution by livestock to the lion’s diet represents 4% of livestock herds around Waza National Park; higher than 2.4% reported by Patterson et al. (2004) in ranches neighboring Tsavo National Park in Kenya. These findings are, however, comparable to 5% losses reported in Zimbabwe’s Gokwe communal lands (Butler 2000). Cattle comprised 80% of the livestock consumed by lions around Waza National Park, highlighting the lion’s preference for large prey when hunting livestock (Kruuk 1980, Mills 1992, Karani 1994). However, with respect to the preference index, lions showed the lowest preference for cattle, indicating that although they are abundant, lions prefer to hunt wild prey species. This can most probably be attributed to the persecution that generally follows the consumption of livestock (De longh et al. 2009, Tumenta et al. 2010).

The Acacia vegetation zone of the park was the richest in prey species occurrence, and lions thus killed the highest amount of prey in this zone. During the dry season, all except one watering point in this zone dried up during the research period, leading to an outflux of wild prey from this area to the floodplain zone that is more accessible to poachers. These results highlight the urgent need for management to rehabilitate the watering points in this zone to prevent animals from moving out. Livestock predation was highest during the cold dry season, coinciding with the period when migratory livestock are moved en masse into the surrounding area for dry season grazing. Management should intensify surveillance of the park and its boundaries especially during this period, as this can reduce livestock intrusion into the park and curb livestock depredation (Bauer et al. 2010, Tumenta et al. 2013). The fact that 18% of the prey killed within the park was cattle is evidence of how problematic intrusion into the park could be. The highest predation took place at night, concurring with earlier studies on livestock depredation in Waza National Park (Bauer and Kari 2001, Van Bommel et al. 2007, Tumenta et al. 2013) and elsewhere (Hemson 2003, Ogada et al. 2003, Patterson et al. 2004, Frank et al. 2005). Male and female lions both moved out of the park and both killed livestock while outside the park. Livestock, especially cattle, has become an important prey for lions in Waza National Park. Fortunately though, it is not preferred relative to abundance. This is probably because of long-term persecution by humans and reflects an adaptive response by lions. The future of lions in this park depends on the efforts by management to reduce livestock intrusion into the park and to increase populations of wild prey within the park. Thus, are the key ecological considerations to reduce lion predation on livestock. There are also many key livestock husbandry approaches and human attitude shifts that should be further encouraged to reduce conflict. Although only a small amount (6.7%) of wild prey predation was recorded out of the park, it would be necessary for future research to determine why wild prey move out of the park.

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