INTRODUCTION

Arguably seen as one of the most successful large carnivore in Africa, spotted hyenas (*Crocuta crocuta*) (hyenas hereafter) are often overlooked compared to other, more charismatic carnivores. Their wide dietary range, high tolerance levels towards disease, lions and human presence have made them a truly successful predator in a human dominated landscape. Perhaps because hyenas are so successful and widespread they are seen as less important within the assemblage of large carnivores. However, where limited resources for research are normally put to good use for large carnivores classified as endangered or vulnerable, such as wild dogs and lions respectively, more often than not hyenas are found to hold the vital missing piece of the puzzle when it comes to understanding the dynamics and influencing factors that regulate these populations within a protected area - be it predator or prey populations.

It is postulated that larger and more dominant species will have a negative impact on the distribution and numbers of smaller rival species. This is evident when considering the abundance and distribution of spotted hyenas to brown hyenas (*Hyena brunnea*), not only in Kruger National Park (KNP) and most east African countries, but also in Notugre. Sightings of brown hyenas, which were once frequent and considered widespread across the reserve, now only occur in isolated cases along the Limpopo River with the majority of sightings along the Motloutse River. There is a remarkable difference between the abundance of these two species in Notugre, compared to reserves immediately to the south of the Limpopo River, such as Mapungubwe National Park.
(MNP), Venetia and Vhembe. While Notugre is considered to have a high density of spotted hyenas and a very low density of brown hyenas, an inverse relationship is observed in these neighboring reserves. This could be ascribed to possible persecution of spotted hyenas by farmers on the South African side of the Limpopo. Spotted hyenas take longer to recolonize an area where they were previously persecuted (Kruuk, 1972; Henschel, 1986; Smuts, 1982). This was evident in KNP where culling operations was put in place to reduce lion (*Panthera leo*) and spotted hyena numbers in order to curb the decline of wildebeest (*Connochaetes taurinus*) and zebra (*Equus quagga burchellii*) populations. This was a misguided attempt and although lions recovered to their former numbers, spotted hyenas took more than a decade to achieve theirs.

Historically, Notugre had a low density of large carnivores, especially hyenas as described by McKenzie (1990). The reason for McKenzie’s study on Black-backed jackal (*Canis mesomelas*) (jackal hereafter) came about due to a serious lack of large, cursorial predators in Notugre, which in turn lead to unusual jackal behavior (McKenzie, 1990). In subsequent years hyena numbers slowly recovered bringing with it a stable platform in the carnivore guild. In more recent times hyenas are considered the most dominant and abundant large predator in Notugre and their high density might have a negative effect on other large predators such as lions and brown hyena.

As part of an ongoing lion project, in 2008 a spotted hyena survey was conducted throughout the Notugre in order to determine the distribution and abundance of hyenas in the reserve. Surveys were conducted in 2008 and in 2009 to determine not only if the hyena population changed but to also test one of our hypothesis of whether spotted hyena populations were affected by the growing population of lions in the reserve since 2009. This year’s survey was the third conducted in Notugre.
METHODS

Calling stations

Between the months of May and June, 19 calling stations were conducted throughout the reserve, each having an effective calling radius of 3 km. Each calling station effective sampling area was 28 km², covering ~ 70% of Notugre. Each calling station was randomly selected and arranged in ArcGIS 10.2 order to avoid overlap between calling stations and to make sure the stations didn’t interfere with camps or nearby villages.

A set of horned-shaped speakers were placed on a table in the back of our vehicle. The speakers were connected to an amplifier and an MP3 player was used to broadcast a buffalo calf in distress call for 60 minutes. Every 15 minutes the speakers were turned 90 degrees in order to create a circular calling radius. Calling stations began shortly after sunset with spotlights used only to scan the area for animals attracted to the station. If the animals attracted were skittish we used headlamps instead of the spotlight.

Carnivores attracted to the calling station were accounted for as well as: GPS location, site description, environmental conditions, age, sex (if possible), time each animal arrived and vocalization if not seen at the site. Careful observations were made as to avoid double counting.

Statistical model

We used the following equations to calculate the abundance estimates and their corresponding confidence intervals:

Density

\[ D = \frac{\bar{y}}{a} \]

where \( \bar{y} \) is the mean of the counts and \( a \) is the size of each sample

Abundance Estimate

\[ N = D \cdot A \]

where \( A \) is the volume of the sample frame (28km².)
Sample Variance of the Counts

\[ s_y^2 = \frac{\sum_{i=1}^{u} (y_i - Da_i)^2}{u - 1} \]

where \( u \) is the number of samples taken (19)

Variance of the Density

\[ s_D^2 = \frac{1}{a^2} \cdot \frac{s_y^2}{u} \cdot (1 - \frac{u}{U}) \]

where \( U \) is the total number of sample units (28)

Variance of the Abundance

\[ s_N^2 = s_D^2 \cdot A^2 \]

95% Confidence Interval

\[ s_N^2 = s_D^2 \cdot A^2 \]

where \( s_N \) is the standard error of the abundance and the \( t \) value is chosen using 18 degrees of freedom

RESULTS

From our survey of 19 calling stations, we counted 101 spotted hyenas covering ~70% of the reserve. We also counted 7 lions, 2 leopards and 42 jackal. Lions were only attracted to two calling stations. The average response time (minutes) for hyenas and jackal were (mean ± SE) 16.31 ± 3.2 and 9.9 ± 2.3 respectively. Average clan size at our calling stations was 5.3 ± 0.9. The largest number of hyenas attracted to a calling station were 13. In fact, two clans of that size in two different occasions were attracted. As with previous years’ surveys, all hyenas were estimated to be over one year of age, since smaller cubs are restricted to the protective nature of their dens.

Population estimates from our survey indicate that there are approximately 150 hyenas (95% CI’s of 117 to 182) in Notugre, resulting in a density of 20.8 / 100km² (Table 1 & Figure 1). Compared to previous years’ surveys, even though the number of hyenas counted increased, an analysis of variance showed that there was no statistical increase in population size in Notugre, \([F (2, 47) = 0.843, p = 0.436]\) suggesting a stable population (Figure 1). One reason for observing
more hyenas is attributed to the fact that our survey intensity increased over the years from 14 calling stations in 2008 to 19 in 2015. With more calling stations being done a larger percentage of the reserve can be covered resulting in a more precise measure of population size.

Table 1. Summary of spotted hyena surveys done in the Northern Tuli Game Reserve, Botswana.

<table>
<thead>
<tr>
<th>Year</th>
<th># of Calling Stations</th>
<th>Counted</th>
<th>Estimated population size (N)</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>Density / 100km</th>
<th>Black Back Jackal</th>
<th>Leopard</th>
<th>Lion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>14</td>
<td>48</td>
<td>96</td>
<td>52</td>
<td>141</td>
<td>17.5</td>
<td>35</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>17</td>
<td>82</td>
<td>136</td>
<td>95</td>
<td>177</td>
<td>20.3</td>
<td>37</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>19</td>
<td>101</td>
<td>150</td>
<td>117</td>
<td>182</td>
<td>20.8</td>
<td>42</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 1. Population estimates of spotted hyenas based on surveys in the Northern Tuli Game Reserve, Botswana.
Figure 2: Ordinary Kriging Prediction map illustrating spotted hyena density across the Northern Tuli Game Reserve, Botswana, with corresponding 19 calling stations conducted in 2015. Each is labeled with the amount of spotted hyenas present at each calling station. Color coding from low density (green) to high density (orange).
Figure 3: Map showing the distribution of calling stations with color-scheme indicating the skittishness of spotted hyenas attracted during the 2015 survey in the Northern Tuli Game Reserve, Botswana.

Discussion

While conducting calling stations, each location entailed different experiences. Notable behavioral differences were observed and recorded at calling stations relative to reserve borders. The deeper the stations were within the reserve, the less skittish hyenas appear to have been to our presence (Figure 3). Hyenas would approach our vehicle with confidence, investigate the scene
and either lose interest and walk off, or find a resting spot and lay around until we depart. Hyenas located along the Tuli Circle and Shashe River, as well as around Loensa displayed the most skittish behavior – reluctant to approach our vehicle, lurking in the distance and running away at the first sight of a spotlight. Due to their skittishness, headlamps or night vision binoculars were used in order to keep track of incoming hyenas without scaring them away. From 101 hyena attracted, five hyenas had severe snare wounds around their necks. Some still had the wire snare embedded in their necks, dragging the wire along as they move. Locations of these snared animals were mostly along the northern/western border of Notugre and one closer to the Limpopo river.

Figure 4. Spotted hyena with fresh snare wound around its neck.

Density distribution of hyenas varied across Notugre, as can be seen from the prediction map (Figure 2). Regions with highest hyena density are predominantly found from the central parts of Mashatu and Uitspan, ranging north across Naledi, Jwala and Nitani. Regions in Notugre with the lowest predicted hyena density occur along the Shashe-Limpopo river confluence, Loensa and Fairfield’s western border. Even though the extent of our work only covered Notugre, a big clan of 10 was found in the southernmost tip of Red Shields. Ironically this clan was using the same rocky outcrop along the main road as a den, which the former resident pack of wild dogs also used. It is worth noting that during my relative short time conducting research in Notugre, there has been a noticeable increase in the activity and presence of spotted hyenas in south west / Red Shields.
region and further upstream of the Limpopo river. Something that is echoed by Stuart Quinn as he lives in that region and is in the best position to observe this.

Even though the population estimates suggests a stable population, the spatial distribution and range expansion of arguably the most dominant large predator in Notugre is definitely worth researching. A range expansion, and increase in spotted hyena numbers will not only result in higher levels of inter-specific competition with other large predators in the region, such as brown hyenas and lions, but also effect prey populations and perhaps more importantly lead to increasing human-wildlife conflict. A better understanding of the spatial-temporal movement of spotted hyenas and the associated clan sizes is an essential component of monitoring the impact and distribution of these amazing predators in our beloved reserve.

Our baseline data on population estimates and distribution allows us to expand our knowledge and understanding of how hyenas function within our reserve, but more importantly how this species function within the Greater Mapungubwe Transfrontier Conservation Area (GM-TFCA). As evident from a lion population perspective, Notugre is considered a ‘stronghold’ or ‘source population’ for the GM-TFCA, which might also hold true for spotted hyenas.

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LITERATURE CITED


