REPUBLIC OF NAMIBIA

Khaudum National Park's Full Moon Waterhole Game Count, October 2019

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Introduction

Namibia is a signatory to the International Union for the Conservation of Nature and Natural Resources (IUCN) amongst others and must adhere to the global conservation goals of conserving genetic, species, ecosystem and landscape diversity and maintain essential ecological processes and life support systems(Leroux *et al.* 2010). Population estimates of wild animals is an important pillar in monitoring the conservation efforts invested (Majumder 2015). Protected areas in Namibia are now considered as cornerstones of conserving and preserving essential biodiversity and as one of the tools to eradicate rural poverty and contribute to the GDP of the country(National Planning Commission 2013). Given the increasing reliance on national parks, it is imperative that these areas are managed effectively and efficiently. Wildlife monitoring (game count) in national parks is essential in ensuring that protected areas are managed effectively and remain development engines in their regions, ensuring the conservation and high economical returns.

Game count can be defined as the process of determining the wildlife population and understanding the dynamics of wildlife populations in a protected area. Khaudum National Park's (KNP) full moon 72 hours waterhole game count is an annual exercise, gathering valuable information(Young 1972) which guides conservation priorities in the park and helps evaluate wildlife responses towards management activities (Msoffe *et al.* 2010). The full moon game count is becoming ever popular in determining wildlife population distributed across a large semi-arid woodland devoid of natural surface water. Aerial counts using the Systematic Reconnaissance Flight (SRT) technique is another method used to determine population abundance within the park (Msoffe *et al.* 2010). However, the high cost involved (Lindeque 1997), limits the use of this technique in KNP and is only used if costs are covered by donor-funded projects. The recent changes in conservation philosophies have ironically put more pressure on the development of a constant and frequent wildlife monitoring programme (Lindeque 1997) which will help in the development and implementation of a Knowledge Base-Management Strategy (KBMS) in KNP. The Knowledge Base-Management Strategy in KNP can only be achieved if there is a sound understanding of wildlife population, dynamics, migratory routes, distribution and trends of wildlife (Msoffe *et al.* 2010). Thus, a reliable monitoring system such as annual game counts in the park represents an essential step in monitoring impacts deriving from management activities (Msoffe *et al.* 2010) and allows for adaptive management (Gaidet *et al.* 2003).

Study Area

Khaudum National Park is located in the north-eastern part of Namibia (Figure 1) and occupies 3841 $km^2$of the Kalahari Sandveld (Wanke and Wanke 2007; Ministry of Environment and Tourism 2019). It is located within the Tree Savannah and Woodland vegetation type defined by Giess (1971). The northern part of the park is renowned for deep sandy dystrophic soils, dominated by *Burkea africana* and *Eragrostis pallens.* To the south, it becomes a hardveld dominated by sandy-loamy soils, giving rise to a mixed *Acacia*-broadleaf vegetation, intercepted by isolated forests of *Baikea plurijuga* on deeper sands (Ministry of Environment and Tourism 2019). This area has a mean annual rainfall of 475 - 525mm, with rains falling from October to April, with February being the wettest month(Ministry of Environment and Tourism 2019). The daily maximum temperatures range between 36 °C to 40 °C and can be expected between September and October. Between June and July temperatures in the park can drop as low as 0°C making this the coldest months in the park (Ministry of Environment and Tourism 2019.

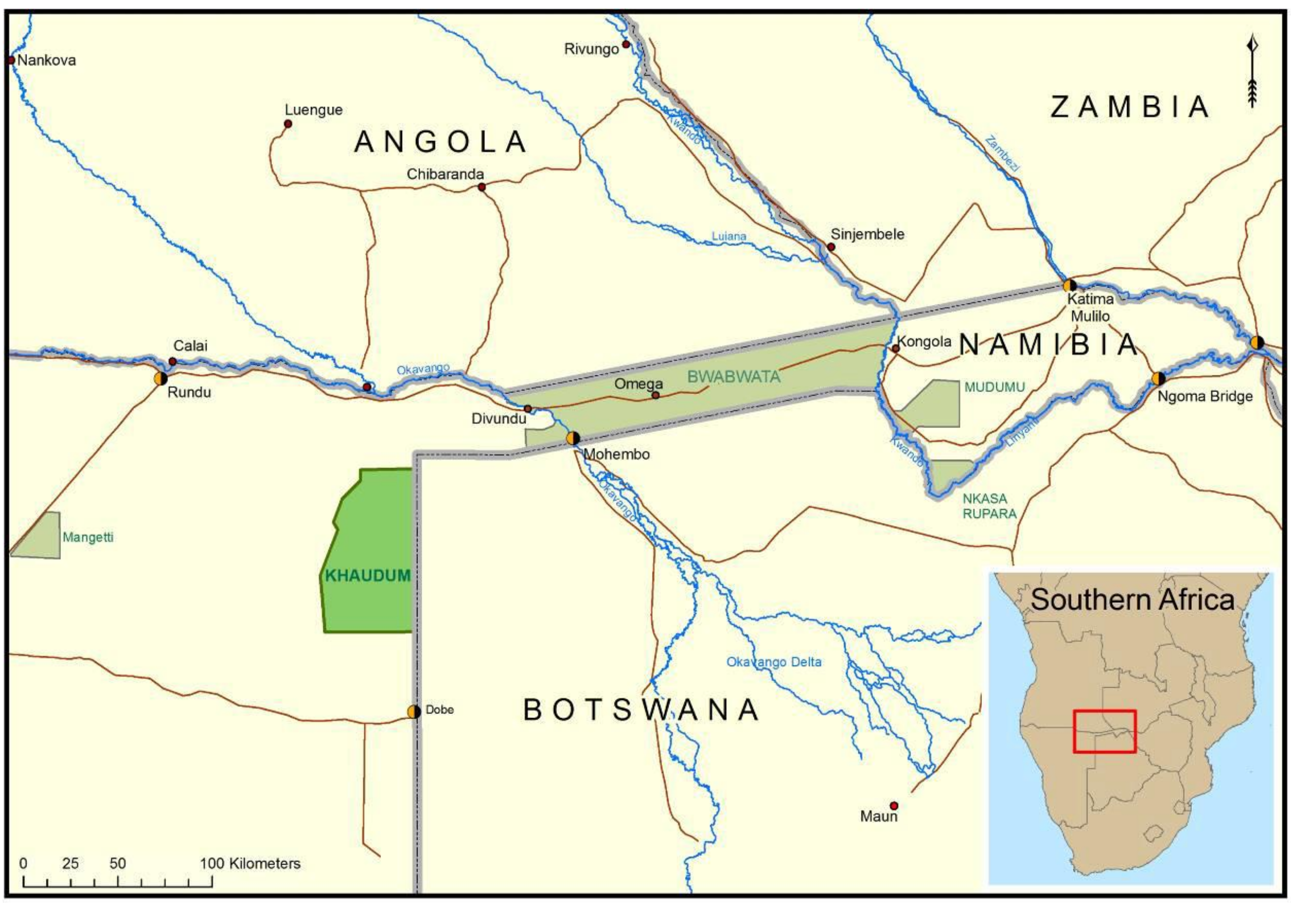

Figure 1: Shows the location of Khaudum National Park in the North-eastern part of the country.

The park has no physical boundaries, allowing for wildlife to move freely and re-populates neighbouring conservancies (George Mukoya, Muduva Nyangana, Nyae Nyae, N≠a-jaqna and Onjou), emphasizing the important role it plays in conservation and rural poverty eradication. Furthermore, the presence of the poisonous *Dichapetalum cymosum* deters livestock from Small-scale Communal Farms (SSCF) west of the park, from utilizing the park. The park is renowned for its large elephant herds and provides refuge for free-roaming rare and endangered species such as *Hippotragus equinus*, *Damaliscus lunatus* and *Lycaon pictus* (Wanke and Wanke 2007). Khaudum is a transitional area, allowing for arid specialist species such as the *Oryx gazella* and species requiring moist habitats like the *Hippotragus equinus* to co-exist and form part of a bigger conservation area known as Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA).

Methods and Materials

The waterhole fool-moon game count survey was conducted during the hottest period of the year (October) for a duration of 72 hours (3 days and 3 nights), which ensured that wildlife in the park is solely dependent on artificial water points. The survey was conducted at all the 13 water points (11 artificial and 2 fountains), with each water point having a team of eight people, working in shifts. The counting commenced on 12 October 2019, a day before the full moon and finished on 15 October 2019, a day after the full moon. The long-term success of wildlife monitoring (game count) in KNP is depended on the participation of the local and international community in such management events. A total of 73 local and international tourists participated in the annual game count of the park, to remedy the challenge of limited staff availability. The count was conducted from existing wildlife view platforms and waterholes that were deemed unsafe (Khaudum fontein and Shiyambi) were counted by staff members. Participants were briefed regarding the procedures of the game count before they left for their respective waterholes. This was done with the aim of educating participants of the full moon game count, guaranteeing their safety and ensuring that their presences at the waterholes do not influence the drinking behaviour of wildlife.

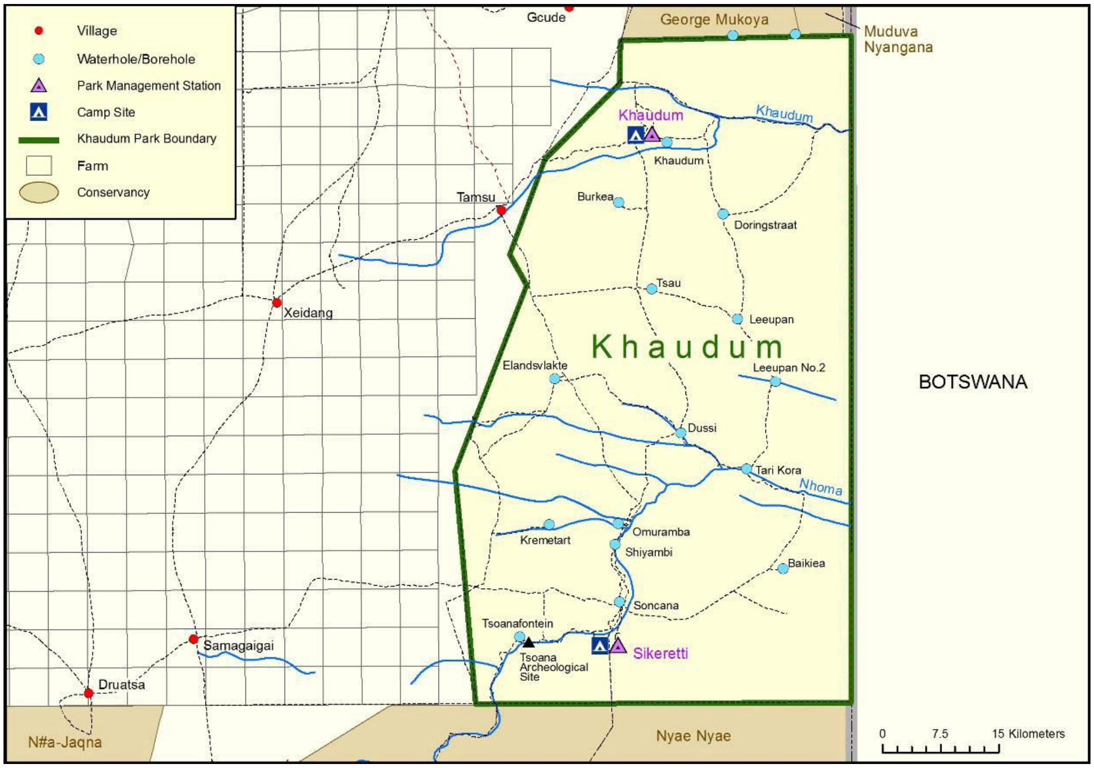

Figure 2: Shows the location of all water points in Khaudum National Park

The briefing focused on the following rules and regulations:

I. Work in shifts to ensure that there is always a team counting during the duration of 72 hours and team members that are not counting should be resting to avoid sleeping on duty when their shift starts.

II. All animals utilising the waterhole should be counted.

III. Excessive noise (music, talking loudly and running of the engine) is not allowed during the duration of the count.

IV. Avoid excessive movement around the water point.

V. Large fires are not allowed, participants should make use of smaller fires which should not burn longer than 30 minutes or make use of gas bottles for cooking.

VI. Commercial photography and filming shall not be tolerated.

VII. Information collected during the count should purely be used for management purposes and not to start debates on social media.

VIII. The count commences 12 o'clock on the start day and concludes 12 o'clock on the end day, furthermore, data sheets should be changed every 24 hours.

IX. Avoid double counting by looking at significant distinguishing features of animals e.g. broken tasks and horns, collars etc.

X. Count only the animals that are drinking and avoid counting all animals that are more than 1 meter away from the water point, this does however not apply to predators.

The credibility and accuracy of the past game count in the park has been questioned due to the use of only two staff members per waterhole, requiring them to count for a continuous 72 hours. This underlines the important role that friends of the park play in the monitoring process in state protected areas.

Data Analyses

Percentage abundance was calculated, to give an indication of the abundance of each species, at each waterhole, relative to the total count of that species. The following formula was used to calculate percentage abundance: $\frac{Ni}{Nt}$x 100 where Ni represents the number of individuals of each species at a waterhole and Nt represents the total number of individuals counted during the count. In order to determine the wildlife population in the park, extrapolations were done using the following formula $\frac{(\mathrm{Nt} * \mathrm{Fr})}{\mathrm{Nd}}$, where Nt represents the number of a particular animal species counted during the count, while Fr represents how frequent that particular species needs water and Nd represents the number of days the count took place. Diversity was calculated amongst the different waterholes using the Shannon diversity index. Calculations were done in Microsoft Excel (2007) using the following formula: H' = -$\sum p_i \ln p_i$; whereby 'H' represents the information content of the sample, 'pi' refers to the proportion of species and 'ln' is the natural logarithm (Garshong 2013). Species richness was determined by counting the total number of species present per waterhole. The Shapiro Wilk test was used to test for normality, proving that collected data was normally distributed. Hence, the parametric test, one way ANOVA, was used to test for significant differences, using a statistical significance level of 95 % ($p < 0.05$). The Tukey test was used to show where the differences occur amongst the waterhole. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) (IBM SPSS 2013).

Results & Discussion

The full moon game count technique is one of the most reliable methods, in determining wildlife abundance across Khaudum National Park, a large semi-arid woodland savannah, devoid of natural surface water. However, for species (giraffe, oryx, duiker, and steenbok) that do not require regular water intake for indefinite periods this method could be unreliable(Young 1972; Knight*et al* 1988). Wildlife preference of waterhole in KNP is influenced by a variety of factors ranging from habitat, water quality, water availability, prevailing weather conditions, availability of food in the close vicinity of the water point, predators, and disturbances at the waterholes (Young 1972). A total of 14,486wild animals were counted at the 13 waterholes across the park (Table 1). The highest wildlife population was observed at Tsoanafontein yielding 12.87% (1,865) of the entire counted population, while Shiyambi yielded the lowest population of 1.89 % (274). Other waterholes yielded the following abundances: Tsau 11.61.89% (1,682), Doringstraat 10.06% (1,457), Burkea 9.00% (1,304), Leeupan 8.89% (1,288), Khaudum Fontein 7.93% (1,149), Dussi 7.56% (1,095), Sypan 7.06% (1,023), Soncana 6.39% (925), Tari-Kora 6.12 (886), Omuramba 5.91% (856) and Elandsvlakte 4.71% (682). There was a significant difference (0.017, $p< 0.05$) in the mean daily wildlife abundance across the different waterholes (Figure 3). Shiyambi waterhole yielded a significantly low mean daily abundance then that observed at Burkea ($Z= 0.021$, $p< 0.05$), Doringstraat ($Z= 0.006$, $p< 0.05$) and Leeupan ($Z= 0.047$, $p< 0.05$).Tsoanafontein yielded a significantly higher mean daily wildlife abundance then that observed at Elandsvlakte ($Z = 0.004$, $p< 0.05$), Omuramba ($Z= 0.023$, $p< 0.05$), Shiyambi ($Z= 0.000$, $p< 0.05$), Soncana ($Z= 0.048$, $p< 0.05$) and Tari-Kora ($Z= 0.029$, $p< 0.05$). Further significant differences were observed at Tsau waterhole yielding a higher mean daily wildlife abundance then that observed at Elandsvlakte ($Z= 0.023$, $p< 0.05$) and Shiyambi ($Z= 0.001$, $p< 0.05$).

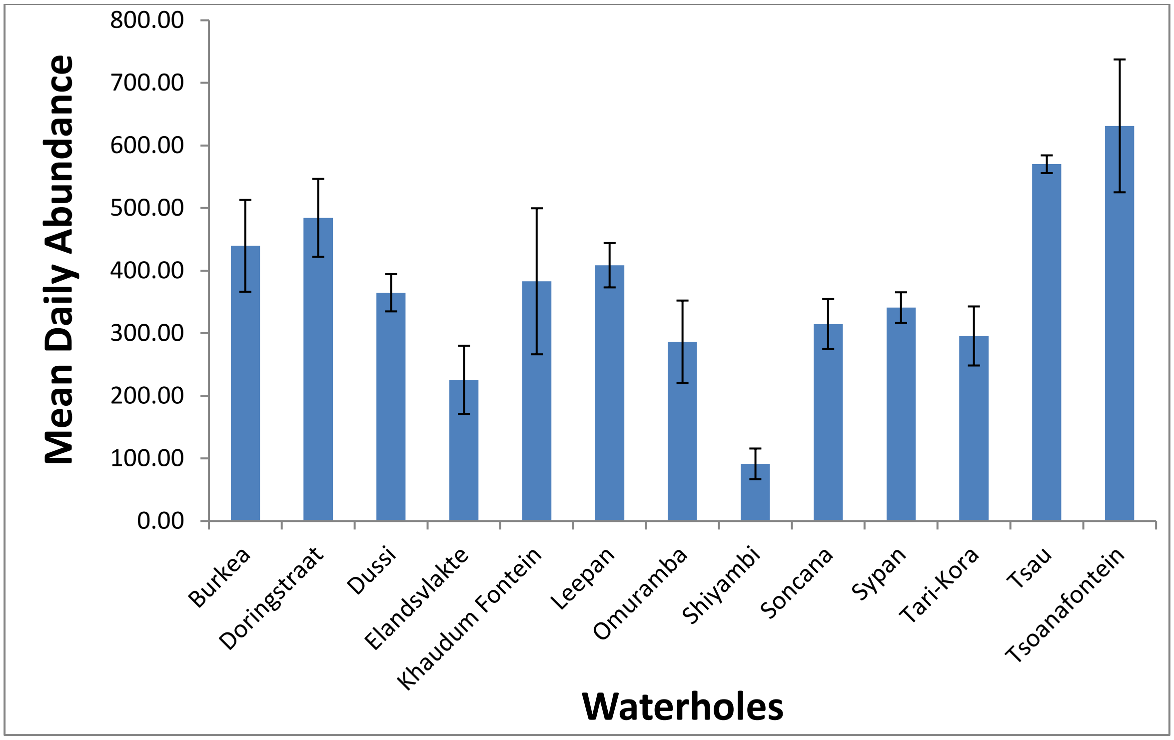

Figure 3: Shows the mean (indicated with a 95% confidence interval) daily wildlife abundance at the different waterholes.

When data was observed from management areas, the northern part of the park yielded the highest wildlife population of 54.56%(7,903), while the southern part of the park yielded 45.44% (6,583). There was a significant difference (Z= 0.018, $p < 0.05$) in the mean daily abundance across the two management areas, with the northern part of the park yielding a significantly higher abundance. Elephants were the most observed species yielding 46.56% (6,746), of which 18.47% (1,246) was observed at Tsoanafontein waterhole. Of the 6,583 elephants observed 55.10% (3,717) was recorded in the southern part of the park, while 44.90% (3029) was recorded in the northern part of the park. There was a significant difference (Z= 0.000, $p < 0.05$) in the mean daily abundance of elephants across the different waterholes (Figure 4). Differences were observed between Tsoanafontein, yielding a significantly higher mean daily abundance of elephants than all the waterholes in the park with the exception of Tsau waterhole (Z= 0.065, $p > 0.05$). Tsau waterhole yielded a significantly higher mean daily elephant abundance than that observed at Dussi (0.028, $p < 0.05$), Elandsvlakte (0.049, $p < 0.05$), Khaudum Fontein (Z= 0.022, $p < 0.05$), Leeupan (0.004, $p < 0.05$), Omuramba (0.016, $p < 0.05$), Shiyambi (Z= 0.000, $p < 0.05$), Sypan (Z= 0.001, $p < 0.05$) and Tari-Kora (Z= 0.027, $p < 0.05$). Elephant abundance at Doringstraat was significantly higher than that observed at Leeupan (Z= 0.032, $p < 0.05$), Shiyambi (Z=

0.003, $p < 0.05$) and Sypan (Z= 0.009, $p < 0.05$).Furthermore, Shiyambi waterhole yielded a significantly lower mean daily elephant abundance than that observed at Soncana (Z= 0.012, $p < 0.05$), Burkea (0.037, $p < 0.05$) and Elandsvlakte (Z= 0.044, $p < 0.05$).

The roan antelope were the second most observed species yielding 14.18% (2,055) of the total wildlife observed. There were significant differences (Z= 0.000, $p < 0.05$) in the mean daily abundances of roans at most of the waterholes (Figure 4). The mean daily roan abundance at Burkea waterhole was similar to that observed at Doringstraat (Z= 0.354, $p > 0.05$), Khaudum Fontein (Z= 0.354, $p > 0.05$) and Sypan (Z= 0.902, $p > 0.05$), however, there was a significant difference when compared to the other waterholes in the park. Leeupan waterhole was similar (0.516, $p > 0.05$) to Tsau water point, however, the mean daily roan abundance at Leeupan was significantly different from all the other waterholes in the park. Doringstraat waterhole yielded a significantly higher mean daily roan abundance than that observed at Dussi (Z= 0.001, $p < 0.05$), Elandsvlakte (Z= 0.000, $p < 0.05$), Omuramba (Z= 0.001, $p < 0.05$), Shiyambi (Z= 0.000, $p < 0.05$), Soncana (Z= 0.004, $p < 0.05$), Tari-Kora (Z= 0.000, $p < 0.05$) and Tsoanafontein (Z= 0.002, $p < 0.05$). Further significant differences were observed between Khaudum Fontein yielding a high mean daily abundance than that observed at Dussi (Z= 0.001, $p < 0.05$), Elandsvlakte (Z= 0.001, $p < 0.05$), Omuramba (Z= 0.001, $p < 0.05$), Shiyambi (Z= 0.000, $p < 0.05$), Soncana (Z= 0.004, $p < 0.05$), Tari-Kora (Z= 0.000, $p < 0.05$) and Tsoanafontein (Z= 0.002, $p < 0.05$). Furthermore, Sypan waterhole yielded a significantly higher mean daily roan abundance than that observed at Dussi (Z= 0.015, $p < 0.05$), Elandsvlakte (Z= 0.001, $p < 0.05$), Omuramba (Z= 0.008, $p < 0.05$), Shiyambi (Z= 0.002, $p < 0.05$), Tari-Kora (Z= 0.007, $p < 0.05$) and Tsoanafontein (Z= 0.023, $p < 0.05$). It appears if there is a trend between elephant and roan numbers, with the roan decreasing with an increase in elephant numbers at the waterholes. This phenomenon was prominent at waterholes occurring in the southern part of the park. The roans in the south comprise of the following abundances: 96 (Soncana), 65 (Dussi), 65 (Tsoanafontein), 49 (Omuramba), 45 (Tari-Kora), 18 (Shiyambi) and 8 (Elandsvlakte) (Figure 4). Similar low abundances were observed in the blue wildebeest numbers (Table1). This phenomenon could be a result of limited water availability at the water points, altering the movement of elephants and causing them to dominate waterholes favoured by roans, thus affecting the abundance of roans negatively. Valeix *et al.* (2009) found that elephant presence or dominance of a waterhole is unlikely to affect the abundance of other species. However, this may only apply when water is in access supply allowing for co-utilisation of waterholes and thus contradicting Valeix *et al.* (2009) argument. Bothma and du Toit (2010) and Roodt

(2015) found roans to be extremely water-dependent and this is partially due to their exceptional diet, feeding on robust, poor nutrient grasses difficult to digest.

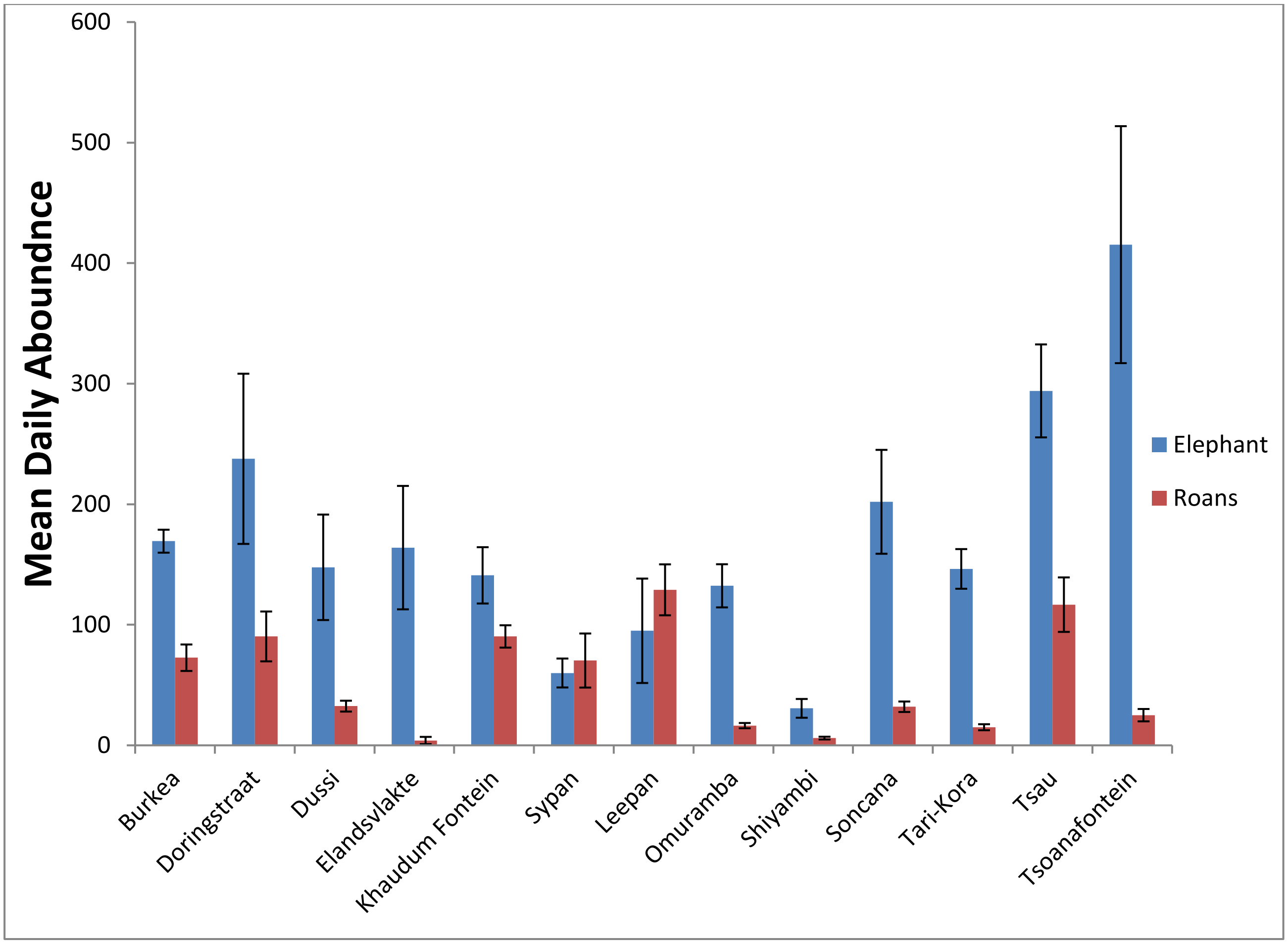

Figure 4: Shows the mean (indicated with a 95% confidence interval) daily elephant and roan abundance at the different waterholes.

However, in the northern part of the park, this trend was denounced. Leeupan and Sypan waterholes yielded a higher mean roan abundance than the mean elephant abundance with other waterholes yielding a fairly higher roan abundance also (Figure 4). Valeix *et al.* (2009) found that roans are more likely to utilise the waterhole when elephants are present because the presence of elephants increases levels of vigilance and deter predators. Furthermore, the size and accessibility of the mud pool might have played a role in ensuring co-utilisation of the water points.

Kudus were observed to be highly abandoned in the southern part of the park and this could be attributed to the availability and abundance of their preferred food (*Acacia* spp). Furthermore, the high kudu numbers observed at Leeupan and Tsau waterhole (Northern management area) where *Acacia* spp. is not dominant could be explained by the presence of clay soils in those areas. Knight*et al* (1988) found that clay particles play a pivotal role in neutralizing the effect of tannin, absorb anti-quality agents and are instrumental in combating acidosis (a gastric condition caused by fermentable soluble sugars found in sprouting vegetation)on browsing species that feed on broad-leaved woody species with high tannin content such as *Terminalia sericea*.

In total, 29 species were observed during the full moon 72 hours game count (Table 1). Species richness was highest at Tsau waterhole yielding 20 species, followed by Burkea and Leeupan both yielding 19 species respectively. Khaudum fontein yielded the lowest richness of 10 species respectively. This is because water availability at the fontein is depended on elephants digging and making water available for other species. Furthermore, Wanke and Wanke (2007) found that water from Khaudum fontein contain high amounts of sulphate ion (SO_4) and is not fit for wildlife consumption. This might deter wildlife from utilizing this water point, causing the lower species richness observed. Significant differences (Z= 0.000, $p < 0.05$) were observed in the mean daily species richness (Figure 5). The differences were observed between Burkea yielding a significantly higher mean daily species richness than Elandsvlakte (Z= 0.017, $p< 0.05$), Khaudum fontein and Shiyambi (Z= 0.000, $p < 0.05$), Sypan (Z= 0.027, $p< 0.05$), Tari-Kora (Z= 0.001, $p< 0.05$) and Tsoanafontein (Z= 0.043, $p< 0.05$). Doringstraat yielded a significantly higher mean daily species richness than Khaudum Fontein (Z= 0.017, $p< 0.05$) and Shiyambi (0.010, $p< 0.05$) while Dussi was significantly different from Elandsvlakte (Z= 0.043, $p< 0.05$), Khaudum Fontein (Z= 0.001, $p< 0.05$), Shiyambi (Z= 0.000, $p< 0.05$) and Tari-Kora (Z= 0.004, $p< 0.05$). Leeupan was significantly different from all the water point in the park, with the exception of Burkea (Z= 0.528, $p> 0.05$), Dussi (Z= 0.296, $p> 0.05$) and Tsau (Z= 0.673, $p> 0.05$). Omuramba, Soncana and Tsoanafontein were significantly different from Khaudum Fontein (Z= 0.027, $p< 0.05$; Z= 0.017, $p< 0.05$; Z= 0.043, $p< 0.05$) and Shiyambi (Z= 0.017, $p< 0.05$; Z= 0.010, $p< 0.05$; Z= 0.027, $p< 0.05$) respectively. Tsau waterhole yielded a significantly higher mean daily species richness than Elandsvlakte (Z= 0.010, $p< 0.05$), Khaudum Fontein (Z= 0.000, $p< 0.05$), Omuramba (Z= 0.043, $p< 0.05$), Shiyambi (Z= 0.000, $p< 0.05$), Sypan (Z= 0.017, $p< 0.05$), Tari-Kora (Z= 0.001, $p< 0.05$) and Tsoanafontein (Z= 0.027, $p< 0.05$).

Shannon diversity (SD) was highest at Leeupan waterhole yielding a diversity score of 1.962 while Elandsvlakte waterhole yielded the lowest diversity score of 1.157. When data was observed from management areas the northern part of the park yielded a significantly higher diversity score of 1.719 (Z = 0.000, $p < 0.05$), which was significantly different from that observed in the southern part (SD: 1.425) of the park. Furthermore, there was a huge fluctuation in the diversity score in the southern part of the park with the highest waterhole (Dussi) yielding a diversity score of 1.761, while the lowest (Elandsvlakte) yielding a diversity score of 1.220. The results found could be attributed to the uneven distribution of elephant's in the southern part of the park. Elephants dominated two waterholes in the south (Soncana (606) and Tsoanafontein (1,246), thus significantly reducing the diversity score at those waterholes. Furthermore, the dominance of elephants at those two waterholes suggests that there is a consistent water supply, and elephants migrated to these two water sources from other waterholes (possibly Omuramba and Shiyambi) where they did not get sufficient water. This phenomenon was further supported by the roans and wildebeests' numbers in the southern part of the park.

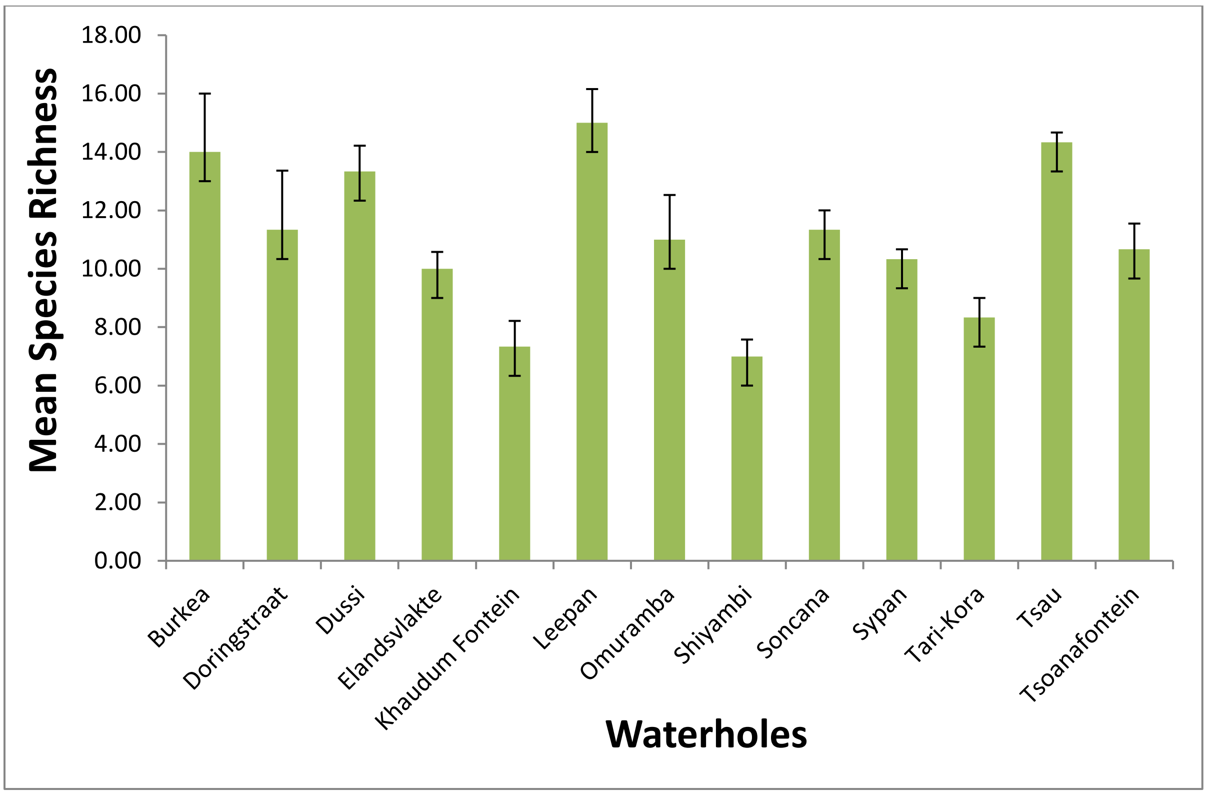

Figure 5: Shows the mean (indicated with a 95% confidence interval) species richness per 24 hours at the different waterholes.

Table 1: Shows all wildlife observed during the fool moon 72 hours waterhole game count

Khaudum National Park Waterhole Full Moon Game Count														
Species	Waterhole													Total
	Burkea	Doringstraat	Dussi	Elandsvlakte	KHA Fontein	Sypan	Leeupan	Omuramba	Shiyambi	Soncana	Tari-Kora	Tsau	Tsoanafontein	
Aardwolf	0	0	0	0	0	0	0	0	0	0	0	3	0	**3**
Bat-eard fox	0	4	0	0	0	0	0	0	0	0	0	0	0	**4**
Bateleur	0	0	0	0	0	1	26	1	0	0	0	3	0	**31**
Duiker	14	9	2	9	0	6	15	0	0	0	2	3	0	**60**
Eagle	2	0	6	0	0	4	11	0	0	0	0	6	0	**29**
Eland	13	24	21	26	138	1	17	2	96	8	1	7	1	**355**
Elephant	508	713	445	492	423	180	353	397	92	606	439	852	1,246	**6,746**
Gemsbok	150	8	95	56	102	59	59	1	1	0	7	149	0	**687**
Giraffe	18	0	3	0	2	0	0	0	2	0	0	16	0	**41**
Hyaena (Brown)	0	1	0	0	0	0	5	0	0	0	2	0	0	**8**
Hyaena (Spotted)	23	19	12	28	0	1	2	47	2	30	0	0	15	**179**
Honey Badger	3	0	3	0	0	0	1	0	0	0	0	0	0	**7**
Impala	6	0	1	0	0	0	0	1	0	0	1	0	106	**115**
Jackal	4	1	0	0	0	2	0	2	0	4	0	0	14	**27**
Kori-buster	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
Kudu	14	6	272	9	10	5	159	149	21	105	325	73	151	**1,299**
Leopard	0	2	1	1	0	0	2	1	1	0	1	2	1	**12**
Lion	0	5	5	0	7	0	7	0	0	0	0	7	2	**33**
Ostrich	20	0	0	4	7	0	0	1	5	18	0	3	8	**66**
Porcupine	0	0	0	0	0	0	0	0	0	0	1	1	0	**2**
Roan	218	272	65	8	271	211	387	49	18	96	45	350	65	**2,055**
Steenbok	13	2	0	19	0	1	10	2	0	0	2	9	0	**58**
Tsesebe	0	3	0	0	0	0	0	0	0	0	0	0	0	**3**
Warthog	52	49	28	27	8	78	46	46	19	25	58	104	22	**562**
Wild Dog	74	0	0	2	0	7	4	6	17	8	0	6	12	**136**
Wildebeest	165	290	87	1	181	409	44	0	0	1	0	55	216	**1,449**
V. Monkey	1	49	0	0	0	56	137	0	0	0	0	27	0	**270**
Vulture	6	0	0	0	0	2	3	144	0	0	1	6	0	**162**
Zebra	0	0	49	0	0	0	0	7	0	24	0	0	6	**86**
Total	**1,304**	**1,457**	**1,095**	**682**	**1,149**	**1,023**	**1,288**	**856**	**274**	**925**	**886**	**1,682**	**1,865**	
Species Richness	**19**	**17**	**16**	**12**	**10**	**16**	**19**	**16**	**11**	**11**	**14**	**20**	**14**	
Shannon diversity	**1.948**	**1.496**	**1.761**	**1.157**	**1.618**	**1.681**	**1.962**	**1.597**	**1.653**	**1.252**	**1.336**	**1.608**	**1.22**	

The estimated population of Khaudum National Park is presented in Table 2 below. Elephants are estimated to be the most abundant species in the park yielding 4,048 individuals, followed by roans (1,031) and gemsbok (917). Furthermore, elephant and roan numbers are likely to be more because not all water sources were covered during the game count. Multiple water sources occurring in Khaudum Omuramba, dug by elephants were not counted because they are spread across a large area. Tsessebe is the least distributed species in the park yield only 2 (male) individuals, however, the known population is 10 individuals (3 males and 7 females). It appears that Tsessebe numbers in the park are affected negatively (no increase) and literature suggests that they may be suffering from stochasticity**.**

Table 2: Shows the population estimate of Khaudum National Park

Khaudum National Park Population Estimate															
		Waterholes													
Species	**DF**	**Burkea**	**Doringstraat**	**Dussi**	**Elandsvlakte**	**Khaudum Fontein**	**Khaudum (Sypan)**	**Leeupan**	**Omuramba**	**Shiyambi**	**Soncana**	**Tari-Kora**	**Tsau**	**Tsoanafontein**	**Total**
Duiker	4	19	12	-	12	-	8	20	-	-	-	3	4	-	**78**
Eland	4	17	32	28	35	184	1	23	3	128	11	1	9	1	**473**
Elephant	1.8	305	428	267	295	254	108	212	238	55	364	263	511	748	**4,048**
Gemsbok	4	200	11	127	75	136	79	79	1	1	-	9	199	-	**917**
Giraffe	4	24	-	4	-	3	-	-	-	3	-	-	21	-	**55**
Impala	2.9	6	-	1	-	-	-	-	1	-	-	1	-	102	**111**
Kori-buster	4	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Kudu	2	9	4	181	6	7	3	106	99	14	70	217	49	101	**866**
Ostrich	4	27	-	-	5	9	-	-	1	7	24	-	4	11	**88**
Roan	1.5	109	136	33	4	136	106	194	25	9	48	23	175	33	**1,031**
Steenbok	4	17	3	-	25	-	1	13	3	-	-	3	12	-	**77**
Tsessebe	2	-	2	-	-	-	-	-	-	-	-	-	-	-	**2**
Warthog	2	35	33	19	18	5	52	31	31	13	17	39	69	15	**377**
Wildebeest	2	110	193	58	1	121	273	31	-	-	1	-	37	144	**969**
Zebra	1.5	-	-	25	-	-	-	29	4	-	12	-	-	3	**73**
Total		**878**	**854**	**743**	**476**	**855**	**631**	**738**	**406**	**230**	**547**	**560**	**1,090**	**1,158**	

The introduction of red hartebeest into the park from Nyae-Nyae conservancy is presumably preventing Tsessebe from breeding. Red hartebeest bulls are stronger and bigger in size and tend to push-out the Tsessebe bull from the breeding herds preventing successful breeding. The different management objectives and strategies of the two adjacent conservation areas (Nyae-Nyae and Khaudum National Park) could hinder successful conservation in the park. There is thus an urgent need to harmonise and collaborate on management strategies to ensure optimum conservation efforts of rare and endangered species. The overall abundance of predators observed during the game count in the park was 409 individuals, namely: Spotted hyaena (43.77%), wild dogs (33.25%), lions (8.07%), jackal (6.60%), leopard (2.93%) and brown hyaena (1.96%). Other interesting observations comprised of honey badgers (1.71%), Bat-eared fox (0.98%) and Aardwolves (0.73%).

The game count data plays a crucial role for incorporation into the existing Knowledge-Based Water Management Strategy (KBWMS) of the park as presented below in Figure 6. Water

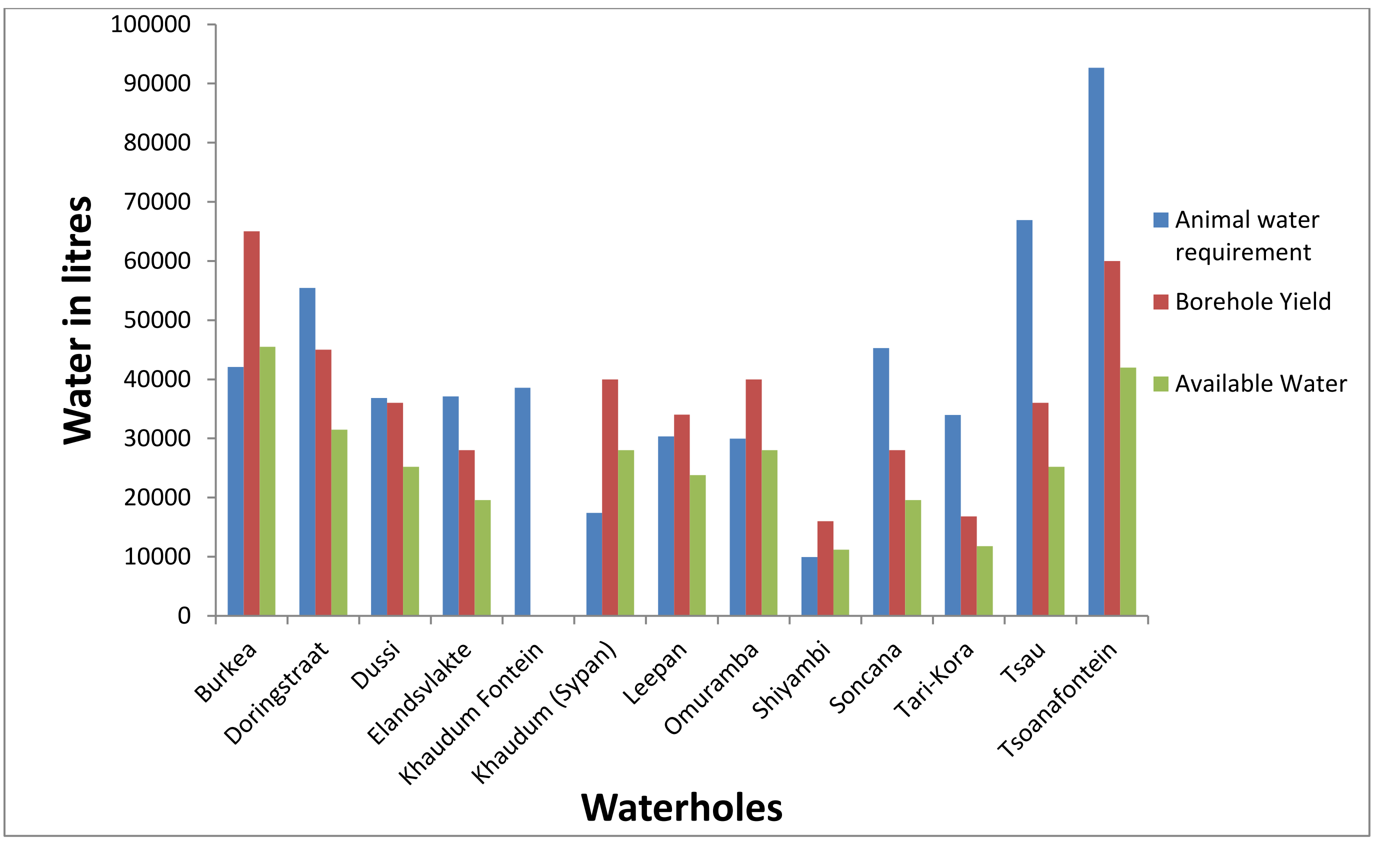

Figure 6: Water utilisation of wildlife, available water and borehole yield in the park

requirements of wildlife in the park was calculated and compared to the yield of the boreholes in the park. It is understood that about 30 % of the total water from the borehole is lost into the mud pool and from evaporation. Only two waterholes (Burkea and Sypan) were able to meet the water needs of the different wildlife species (Figure 6). At present, the majority of the boreholes in the park are not able to meet wildlife water demand, requiring the implementation of KBWMS to ensure that wildlife at those waterholes has water. Four waterholes are significantly stressed, requiring an additional 50,661.50 litres (Tsoanafontein), 41 739.50 litres (Tsau), 25,655.50 litres (Soncana) and 22,232 litres (Tari-Kora) of water to be able to sustain wildlife.

Conclusion

The 72-hour full moon game count in Khaudum National Park was conducted in October 2019, with 13 waterholes covered. This is a crucial tool for determining wildlife population and understanding the dynamics of wildlife in KNP. It helps guides conservation priorities in the park and helps evaluate wildlife responses towards implemented management activities. Management activities in the southern part of the park were found to have a negative impact on the abundance of rare and endangered species in the park. The limited availability of water in the southern part of the park resulted in a lower abundance of roans in that part of the park. Furthermore, the unavailability of collaborative forums with the neighbouring communal conservancy resulted in the introduction of the red hartebeest, which is negatively affecting Tsessebe in the park. Generally, wildlife water demand is not sufficiently met, with the exception of two waterholes. This requires a continues implementation of the Knowledge Base Water Management Strategy to mitigate this challenge.

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