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Ground survey of red lechwe in the Linyanti swamps and Chobe floodplains, northern Botswana

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A ground survey of red lechwe was carried out in the Linyanti swamps and the Chobe floodplains of northern Botswana in the dry and wet seasons of 2012 and 2013, respectively. We documented numbers, sex ratio and age structure of red lechwe within the linear strips of 25 km × 300 m along the Linyanti swamps and the Chobe floodplains. Results indicated a significant difference in the numbers of red lechwe between sites and seasons. About 66 and 755 red lechwe were estimated for Chobe in the dry and wet season, respectively, with 343 and 261 of them estimated for Linyanti in the dry and wet season, respectively. In Chobe, the red lechwe densities varied widely between seasons (9 red lechwe/km^2 – 101 red lechwe/km^2) compared with Linyanti, where the densities did not vary much between seasons (35 red lechwe/km^2 – 46 red lechwe/km^2). The lower densities of red lechwe in Chobe in the dry season when compared with the wet season suggest a possible seasonal shift in the distribution of red lechwe to the nearby Zambezi floodplains in Namibia.

Conservation implications: The higher number of red lechwe in the Chobe floodplains in the wet season indicates the potential of the floodplains as a habitat for this species in that season. The dry season shift in the distribution of red lechwe in Chobe presents an opportunity for local communities in Namibia to engage in tourism, whereas the return of the red lechwe to the floodplains in the wet season ensures protection of the animals as well as boosts the tourism potential of the Chobe National Park.

Introduction

Red lechwe (*Kobus leche leche* Gray) is one of the water-dependent terrestrial ungulates that have declined drastically over the past years over its range in southern Africa (Dipotso & Skarpe 2006; IUCN 2015). In Botswana, it is reported to have declined by 57% – 59% in the last 15 years, and now fluctuates between 26 000 and 33 000 animals (Chase 2011; DWNP 2012). Although the population is stable in the wetlands of Okavango Delta, it has reached lowest numbers in decades in the Linyanti swamps and the Chobe floodplains which are a part of the Upper Zambezi River Basin (Chase 2011; DWNP 2012). The reduction in the red lechwe numbers in the Chobe floodplains is attributed to human disturbance and competition for food and space from other ungulates that largely converge in large numbers along the Chobe floodplains in the dry season for the year-long surface water provided by the river (Dipotso & Skarpe 2006; Williamson 1990).

In semi-arid environments, wetlands such as the Okavango Delta, the Linyanti swamps and the Chobe floodplains provide a lifeline to many aquatic, semi-aquatic and terrestrial animals. However, these wetlands and the other ones in semi-arid regions are particularly vulnerable to drought, climate change and human pressure (Dugan 1992; Von Richter 1974). Because of human pressure and climatic effects, wetlands are now among the most threatened ecosystems of the world (Dugan 1992; Williams 1993). Populations of animal species that are dependent on these wetlands for water and forage resources also end up being affected by changes in the availability and quality of these resources (Lin & Batzli 2001). For example, non-migratory aquatic antelopes such as red lechwe may die in large numbers as depletion of surface water and food resources increases because of climate change effects and human pressure (Bell et al. 1973; Dobrouruka 1980; Williamson 1990).

Red lechwe prefers nutrient-rich aquatic grasses and sedges, and its population size often reflects the quality of the wetlands (Williamson 1990). Therefore, interspecific competition for forage can restrict their population growth (Von Richter 1974; Williamson 1990). Poaching and human disturbance are also key factors whose effects in combination or singular can contribute to a decline in ungulate numbers (Dipotso & Skarpe 2006; Hachileka 2003; O'Shaughnessy 2010; Spinage,

Williamson & Williamson 1989; Von Richter 1974; Williamson 1981). These disturbance factors can also cause biased sex ratios and age structures, and further suppress juvenile recruitment (Dobrouruka 1980; Milner, Nilsen & Andreassen 2007; Milner-Gulland et al. 2003). Along the Chobe floodplains in northern Botswana, wetland antelopes are continually being disturbed by tourism activities with over 50 motorised boats and 100 trucks being driven daily in and along the Chobe floodplains (Hachileka 2003). In Linyanti, the disturbance is relatively low as less than 25 vehicles a day are driven in the area (McIntyre 2014). The number of vehicles is limited by the long distance and deep sandy roads between Linyanti and the nearest towns, as well as the poor visibility caused by thick reeds in the swamps (McIntyre 2014; Williamson 1981).

We, therefore, undertook a cross-sectional ground survey in both the Linyanti swamps and the Chobe floodplains to document seasonal differences in numbers, distribution, sex ratios and age structure of the red lechwe populations in these two wetlands.

Methods

Study area

The study area comprises of the Linyanti swamps, which are flooded all year round, and the Chobe floodplains, which are sustained by the flood-pulsed backflow from the Zambezi River. The two wetlands are located 200 km apart along the Botswana-Namibia border (Hughes & Hughes 1992; Figure 1).

Data collection

Data were collected during the period of low flood (July–Sept.) in 2012 and of high flood (Feb.–May) in 2013. These periods also overlapped with rainfall season (Nov.–Apr.) and no rainfall season (July–Oct.), respectively. A distance sampling line transect method was used (Thomas et al. 2010). Along the Chobe floodplains, the line transect was set between Kabulabula and Ihaha, and in the Linyanti swamps it was set between King's Pool and Zibadianja Pool. The observation strip at each site covered an area of 7.5 km^2 (i.e. 25 km long and 300 m wide). Although the use of long and continuous transects may have violated the assumptions of the distance method which requires short and randomly placed transects, we believe the 25 km long transect we used at each site helped to reduce the chances of missing the isolated groups and individuals of this rare or uncommon red lechwe species.

The surveys were done for 6 days in each wetland, in one dry season of 2012 from 17 August to 04 September and in one wet season of 2013 from 16 February to 03 March. Each survey was carried out from 600 to 1000 h each day. There were two observers and one recorder. The vehicle was driven slowly at 20 km/h to minimise disturbance and was stopped at each sighting of the red lechwe. Because of good visibility and low speed of the vehicle, we counted all individuals seen. We used binoculars to determine the distance to the animals, group size, sex and age group of all the individuals sighted, and used a global positioning system unit to record animal locations. Juveniles were not sexed because of the difficulty in distinguishing between sexes in this group and were excluded in the calculations of the sex ratios. We classified juveniles as 0–1 year olds, sub-adults as 1–2 year olds and adults as over 2 years old with horns or body fully developed (Mason 1990).

Data analysis

The red lechwe population was estimated using distance sampling (ver. 6) set at 95% confidence interval (CI) (Thomas et al. 2010). We assumed that red lechwe were randomly placed along the floodplains and swamps, with no limitation to visibility because of habitat cover. The data were further analysed using the Generalised Liner Models (GLM), Poisson log-linear distribution and Wald chi-square tests to determine significant differences in the overall number sighted, number of females, males, juveniles, sub-adults, adults, and sex ratio between the two wetlands, and between wet and dry season. The 6-day data for each survey were aggregated to derive means for the sites. Means were considered significantly different at $p < 0.05$. We used GLM because it does not require count data to be transformed as transformation can distort the real picture (O'Hara & Kotze 2010).

Results

Population size and distribution

The population estimate for red lechwe in the Linyanti swamps was 343 animals (distance sampling 95% CI: 186–634) in the dry season and 261 animals (distance sampling 95% CI: 153–443) in the wet season. This corresponds to a density of 46 red lechwe/km^2 in dry season and 35 red lechwe/km^2 in wet season. For the Chobe floodplains, the red lechwe population was estimated at 66 (95% CI: 23–192**)** and 755 (95% CI: 257–2219) animals in dry and wet seasons, respectively. Thus, the density was 9 red lechwe/km^2 in the dry season and 101 red lechwe/km^2 in the wet season. The CIs of the population estimate for the Chobe floodplains did not overlap, indicating no significant difference between dry and wet seasons (Figure 2). The means of the observed numbers of red lechwe, however, differed significantly between wetlands ($\chi^2 = 9.60$, $df = 1$, $p < 0.05$) and seasons ($\chi^2 = 3.91$, $df = 1$, $p < 0.05$). Within the Chobe floodplains, the mean number of animals differed significantly between seasons ($\chi^2 = 199.38$, $df = 1$, $p < 0.05$) with a higher number of red lechwe seen in the wet season than in the dry season. Within the wet season, the Chobe floodplains had a significantly higher number of red lechwe compared with the Linyanti swamps ($\chi^2 = 16.68$, $df = 1$, $p < 0.05$) (Table 1).

In terms of distribution, red lechwe in the Linyanti swamps were evenly distributed across the swamps throughout the year, whereas in the Chobe floodplains the animals were confined to one locality near Kabulabula in dry season, and widespread in wet season from Kabulabula to Ngoma (Figure 3).

Sex and age structure

The number of females differed significantly between wetlands ($\chi^2 = 13.98$, $df = 1$, $p < 0.05$) and seasons ($\chi^2 = 4.51$, $df = 1$, $p < 0.05$),

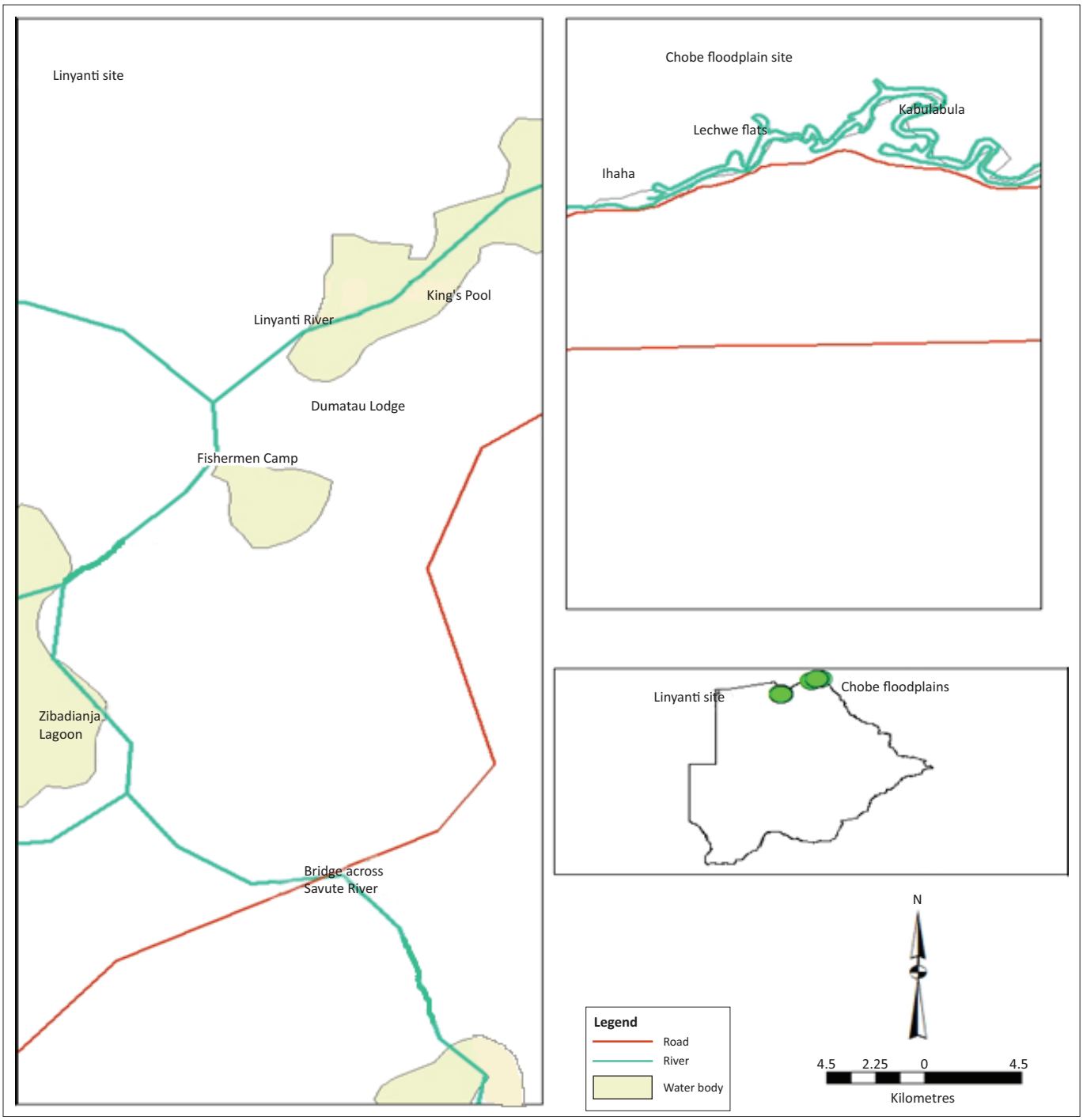

FIGURE 1: Map of the study area, showing Linyanti swamps (left) and Chobe floodplains (top right).

with more females seen in the Chobe floodplains than in the Linyanti swamps, and in wet than in dry season. In the dry season, more males were sighted in the Linyanti swamps than in the Chobe floodplains ($\chi^2 = 4.65$, $df = 1$, $p < 0.05$). Within the Chobe floodplains, the number of males ($\chi^2 = 49.79$, $df = 1$, $p < 0.05$), females ($\chi^2 = 149.57$, $df = 1$, $p < 0.05$) and overall sex ratio ($\chi^2 = 11.10$, $df = 1$, $p < 0.05$) differed significantly between seasons. In the Linyanti swamps, only the number of females ($\chi^2 = 6.04$, $df = 1$, $p < 0.05$) differed between seasons.

There was significant difference in the number of adult red lechwe between wetlands ($\chi^2 = 8.97$, $df = 1$, $p < 0.05$) and seasons ($\chi^2 = 4.28$, $df = 1$, $p < 0.05$). Number of sub-adults ($\chi^2 = 4.72$, $df = 1$, $p < 0.05$) only differed between wetlands, whereas that of juveniles differed only between seasons ($\chi^2 = 4.56$, $df = 1$, $p < 0.05$). There were more adults ($\chi^2 = 135.08$, $df = 1$, $p < 0.05$) and sub-adults ($\chi^2 = 60.92$, $df = 1$, $p < 0.05$) in the Chobe floodplains than in the Linyanti swamps. In the Linyanti swamps, more juveniles were seen in the wet than dry season ($\chi^2 = 16.10$, $df = 1$, $p < 0.05$). Between seasons, the change in number of juveniles in the Linyanti swamps was 168%, whereas for the Chobe floodplains it was only 28% and less significant. Age ratios did not differ between the wetlands and seasons.

Discussion

Population size and distribution

Variations observed in the number of red lechwe were influenced by location and season. The flood-pulsed Chobe floodplains experienced a larger variation in numbers between seasons when compared with the year-long flooded Linyanti swamps. The population estimate of red lechwe within the surveyed 7.5 km^2 area of the Chobe floodplains ranged between 66 and 755 animals (9 red lechwe/km^2 – 101 red lechwe/km^2), whereas for the Linyanti swamps the estimate ranged between 261 and 343 animals (35 red lechwe/km^2 – 46 red lechwe/km^2). The year round abundance and availability of surface water and aquatic vegetation around the Linyanti swamps probably availed quality forage and habitat conditions needed by red lechwe (Von Richter 1974; Williamson 1981), hence less variation in the densities and distribution between seasons. Similarly, in the Bangweulu swamps in Zambia, when resources are plentiful especially in the wet season, black lechwe tends to be less mobile but evenly distributed with no discrete clusters across the swamps (Thirgood et al. 1994). In the early 1980s, Williamson (1981) carried out some aerial surveys in which he observed a much larger and more stable population of red lechwe in the Linyanti swamps than in the Chobe floodplains. Therefore, we did not expect the Linyanti swamps to have a lower number of red lechwe than the Chobe floodplains. Unlike ground surveys, aerial surveys can provide a much wider aerial view of the landscape and can pick up groups or individual animals which ground surveys may be limited in picking. Thus, it is possible that the lower numbers we observed in our study could be a consequence of limited access and visibility over the Linyanti swamps which much of them are on the Namibia side. Furthermore, anecdotal records indicate the area between Selinda Camp and the Kwando Lagoon Camp on the western side of the Linyanti swamps as another concentration area of red lechwe, a habitat which our transect did not cover.

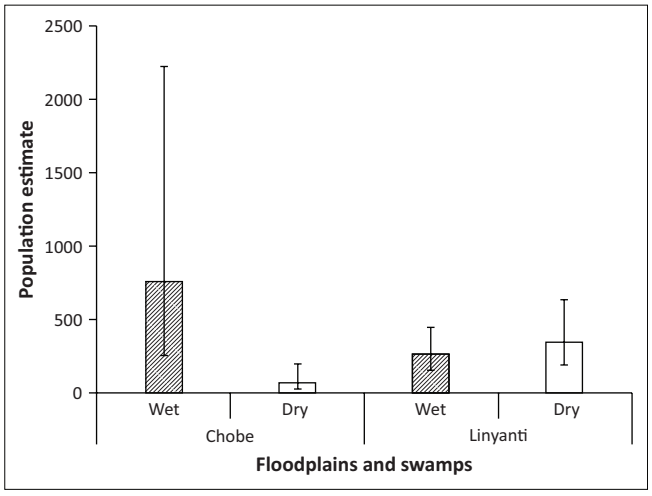

FIGURE 2: Population estimate of red lechwe in the Chobe floodplains and the Linyanti swamps in the wet and dry season.

The large seasonal variation in red lechwe numbers in the Chobe floodplains was also not expected in our study. The variations in the Chobe floodplains could have been caused by a combination of factors that include competition with other ungulates over space and predation rates by lion (*Panthera leo*) which are usually higher in the dry than wet season (Halley & Mari 2004). These factors have the potential to cause a temporary displacement of red lechwe from the floodplains (Dipotso & Skarpe 2006; Halley & Mari 2004; O'Shaughnessy 2010; Spinage et al. 1989). Shortage of quality food can also cause many of the red lechwe to seasonally move to nearby sites which may be offering better quality food (McIntyre 2014). In Zambia, black lechwe become highly mobile in the dry season when resources become scarce, and form discrete herds that move quickly across sites in search for green forage (Thirgood et al. 1994). In Botswana, there are currently no studies reporting on shifts in distribution of red lechwe along the Chobe floodplains or nearby Zambezi basin. However, observations made through aerial surveys indicate the presence of red lechwe in areas far from the floodplains and in the nearby Zambezi floodplains (Chase 2011; DWNP 2012), but these surveys did not attribute the sighting of isolated groups to migration or shift in the distribution away from the Chobe floodplains. In comparison with aerial surveys, our ground surveys were limited in detecting where the red lechwe were in the dry season in the Chobe floodplains. A longitudinal survey would have been much effective in providing a long-term coverage, in-depth understanding and convincing comparison of population dynamics of red lechwe between the two wetlands. Despite this limitation, our findings indicate a possibility of dry season emigration of many red lechwe from the Chobe floodplains to the nearby Zambezi floodplains, and immigration into the Chobe floodplains in the wet season. We doubt if red lechwe would move and stay for over a week in the nearby woodlands, given that it is a semi-aquatic species that prefers habitats with plenty of surface water and aquatic forage (Bell et al. 1973; Von Richter 1974). Our ground surveys were also able to locate an isolated and larger herd of red lechwe consisting of more than 119 animals in the wet season in the Chobe floodplains which had not been detected by any survey done in the last decade (e.g. by Chase 2011; DWNP 2012). Herd sizes observed in the past surveys were lower (e.g. 41–80 animals) (Chase 2011) when compared with those observed in our ground survey done 3 years later. A single

TABLE 1: Population estimate, sex and age ratios of red lechwe (*Kubus leche leche*) in the Chobe floodplains and the Linyanti swamps, and between seasons.

Habitat	Season	Largest group size observed per sighting (N)	Mean population (mean ± s.e.)	Sex ratio (male: female)	Juvenile: Sub-adults	Juvenile: Adults
Chobe floodplains	Wet	119	30 ± 0.7^{aa}	1.2 ± 0.3^{aa}	1:1	1:11
	Dry	33	9 ± 1.1^{bb}	3.2 ± 0.4^{ab}	1:8	1:27
Linyanti swamps	Wet	37	11 ± 0.4^{ca}	3.5 ± 0.3^{aa}	1:6	1:17
	Dry	34	13 ± 0.6^{db}	2.7 ± 0.3^{aa}	1:1	1:6

$^{a, b, c, d}$, The first different superscript alphabets within a column indicate significant difference between all the means within the column ($p < 0.05$), and the second different superscript alphabets denote significant difference between seasons per location.

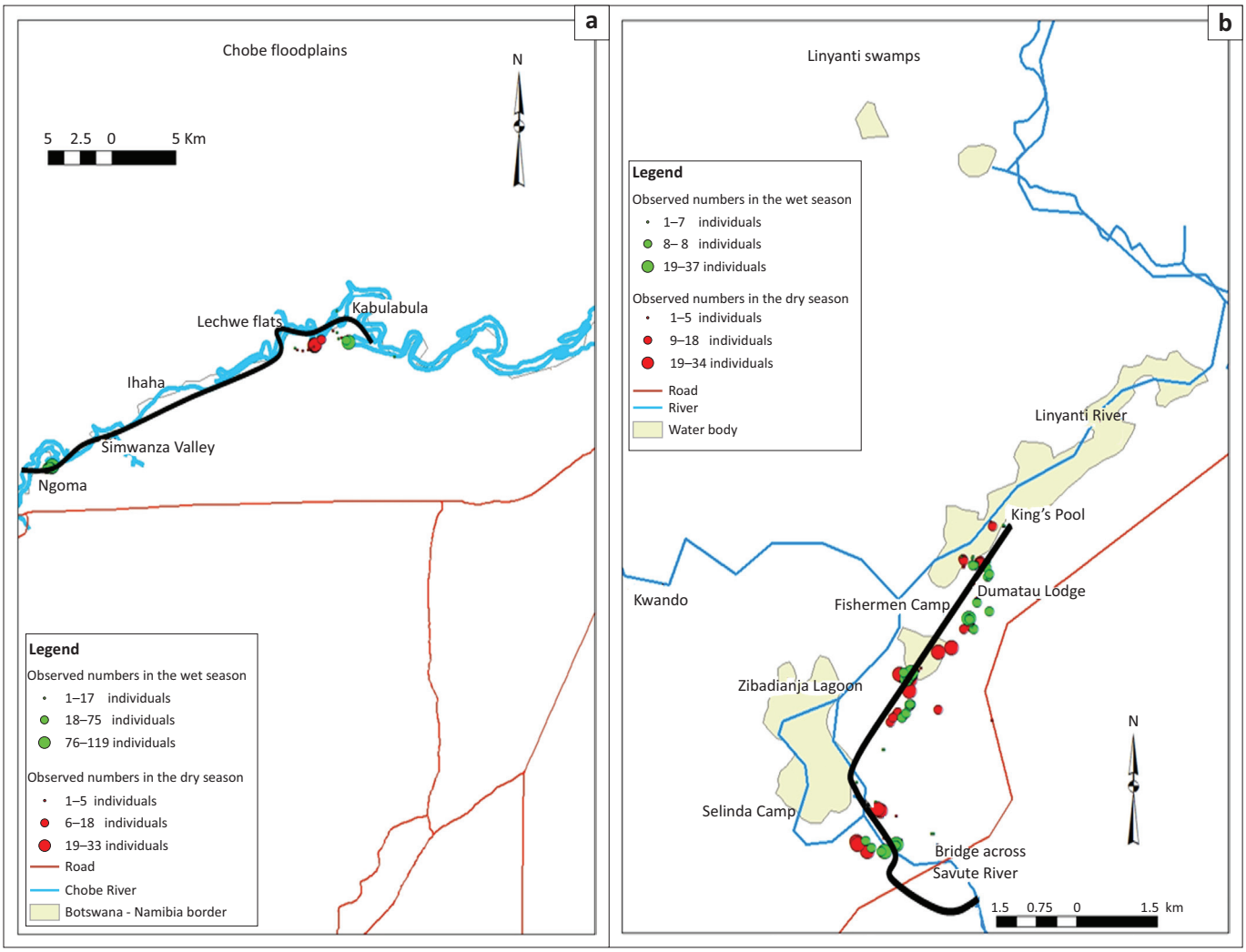

FIGURE 3: Transect layout (black bold line) and observations of red lechwe made along the (a) the Chobe floodplains and (b) the Linyanti swamps.

group size of 119 red lechwe seen in our ground surveys gives hope that the numbers of red lechwe in the Chobe floodplains may still be larger than previously thought, especially when one considers that ground surveys generally under-estimate population sizes. Recent aerial surveys had estimated the population of red lechwe in the Chobe floodplains to be around 19 animals (95% CI: 0–38) (DWNP 2012), from 399 animals estimated in 2010 (95% CI: 97–701) (Chase 2011).

Sex and age structure

Sex ratios may not make much sense especially for polygynous ungulates such as red lechwe, where only a few reproductive males can mate and fertilise many females (Holand et al. 2006; Milner et al. 2007; Milner-Gulland et al. 2003). However, sex ratios are nonetheless critical as the number of males may reach a threshold below which conception time would be delayed and calving rates reduced (Holand et al. 2006; Milner et al. 2007). In our study, there was no significant difference in the overall male-to-female ratio between habitats. Age ratios also did not differ between sites.

The short duration of our study and the limited distribution of the transects in the study sites gave us only a snapshot of the numbers, sex and age structure of red lechwe in these ecologically threatened wetlands, and future surveys that aim to have detailed knowledge of the red lechwe should be long term and also cover the area between Selinda and Kwando on the western side of the Linyanti swamps.

Conclusion

The numbers of red lechwe in the Chobe floodplains varied widely between seasons, with higher numbers observed in the wet season than in the dry season. In the dry season, red lechwe were mostly restricted to fewer locations within the floodplains. In the Linyanti swamps, the numbers did not fluctuate widely over space and time. The findings of this study suggest that the Linyanti swamps and the Chobe floodplains still have the potential as habitats for red lechwe, and conservation efforts should be directed at minimising factors that limit forage and surface water availability in the two areas (e.g. in Bell et al. 1973). The seasonal variations in the red lechwe population in the Chobe floodplains may be because of disturbance from tourism activities, competition with other herbivores, displacement by predators or variability in forage availability because of seasonal rainfall and flood pulse. These possible disturbances to red lechwe need to be

investigated further as they have important implications for the conservation of this globally near-threatened antelope.

Conservation implications

A better understanding of the seasonal and spatial distribution of red lechwe in the Chobe floodplains is critical to mapping and conserving key resource areas that supplement and complement each other to maintain a viable red lechwe population, and which can subsequently boost tourism on Botswana side. The understanding will further guide the nature of conservation projects that may be initiated by local communities living within the Kavango-Zambezi Transfrontier Conservation Area. It is, therefore, imperative that longitudinal studies on population dynamics of red lechwe should be done.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

P.G. conceived and designed the study, performed fieldwork, analysed the data and wrote the manuscript. G.S.M. supervised the work from conception to manuscript writing.

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