African Journal of Ecology

The drinking habits of the Lilian's lovebird and incidents of poisoning at waterholes

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Abstract

Use of poison to kill wildlife is a threat to biodiversity. Lilian's lovebirds *Agapornis lilianae* are among the fatalities at poisoned waterholes in Liwonde National Park, Malawi. Their population in Liwonde National Park (LNP) represents about 20% of the global population. We investigated the drinking habits of Lilian's lovebird, availability of natural waterholes and occurrence of poisoning incidents in LNP. Results showed Lilian's lovebirds congregate at waterholes in the dry season with flocks ranging from 1 to 100 individuals. Significantly larger flocks were seen in the dry than the wet season. Poisoning incidents/year ranged from 1 to 8 and were highest in the dry season. Lilian's lovebirds were killed at a mean of four poisoning incidents each year between 2000 and 2012. Number of lovebirds found dead at a poisoned pool ranged from 5 to 50 individuals. Currently about 32% of the Lilian's lovebird population is threatened by poisoning. Other species were also noted. There is a need for increased efforts in preventing this lethal activity in LNP.

Key words: Agapornis lilianae, conservation, Lilian's lovebird, Liwonde National Park, Malawi, poisoning

Résumé

L'usage de poison pour tuer la faune sauvage est une menace pour la biodiversité. Les inséparables de Lilian *Agapornis lilianae* comptent parmi les victimes des points d'eau empoisonnés dans le Parc National de Liwonde (LNP), au Malawi. Leur population dans ce parc représente quelque 20% de la population mondiale. Nous avons étudié ce que les inséparables de Lilian ont l'habitude de boire, la disponibilité des points d'eau naturels et l'incidence des empoisonnements au LNP. Les résultats indiquent que les inséparables de Lilian se rassemblent aux points d'eau à la saison sèche, en groupes qui peuvent compter de 1 à 100 individus. Les groupes observés en saison sèche sont significativement plus grands qu'en saison des pluies. Les cas d'empoisonnements allaient de 1 à 8 par an et étaient plus nombreux en saison sèche. On dénombre une moyenne de quatre incidents d'empoisonnements d'inséparables de Lilian par an entre 2000 et 2012. Le nombre d'inséparables trouvés morts près de points d'eau empoisonnés allait de 5 à 50 individus. D'autres espèces sont aussi victimes. Il faut intensifier les efforts pour empêcher cette activité létale au LNP.

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Introduction

Protected areas (PAs) safeguard biodiversity (Bruner *et al.*, 2001; Locke & Dearden, 2005) although the extent of their effectiveness is debated (Chape *et al.*, 2005; Hayes, 2006). Most national policies consider PAs an efficient method of *in situ* biodiversity conservation (Bruner *et al.*, 2001; Balmford *et al.*, 2002; Chape *et al.*, 2005; Hayes, 2006). Sub-Saharan Africa has over 1100 national parks and reserves Protected areas cover 14.7% of land in Africa (Deguignet *et al.*, 2014), and many of these face threats from expanding human populations, economic development, globalization and national governance (Lambin *et al.*, 2001; Newmark, 2008; Brink & Eva, 2009; Rudel, 2013). Controlling illegal hunting remains a challenge for most African PAs (Bruner *et al.*, 2001; Struhsaker, Struhsaker & Siex, 2005; Lindsey *et al.*, 2013). Recently, use of poison to kill wildlife has become a threat to wildlife inside and outside PAs (Ogada, 2014). Poisons used are cheap and easy to use on damage-causing animals and for harvesting (Kissui, 2008; Ogada, 2014).

Malawi is a landlocked country in eastern southern Africa. Habitat loss outside most of its PAs has caused their isolation (Newmark, 2008), producing 'green islands' in an agricultural and human dominated matrix. Liwonde National Park (LNP) is located in Malawi's south, which is densely populated with three times more people per unit area than the north (Mauambeta, Chitedze & Mumba, 2010). It is classified as a high value and high pressure PA (EU, 2010). It is the only location in Malawi with a resident, breeding population of the Lilian's lovebird *Agapornis lilianae*, a near-threatened small parrot, endemic to the Zambezian biome (Perrin, 2012).

Parrots worldwide are threatened by habitat loss and illegal capture for the pet trade (Forshaw, 1989; Collar, 1997; Snyder *et al.*, 2000; Pires & Clarke, 2011; Perrin, 2012). In LNP, Lilian's lovebirds also face threat from illegal hunters poisoning of waterholes to catch small mammals and medium-sized birds for food (B. Msikuwanga, 2011, pers. comm.). Its impact on the lovebird population in LNP was unknown until recently. Black-cheeked lovebirds *A. nigrigenis* in Zambia also face threats from poisoned waterholes (Warburton, 2003); however, this is generally at water sources outside of PAs.

Lilian's lovebirds are mopane *Colosphermum mopane* woodland specialists closely associated with the distribution of rivers (Forshaw, 1989; Warburton, 2005; Perrin, 2012). They form large flocks around water sources (Forshaw, 1989; Dowsett-Lemaire & Dowsett, 2006), as observed in Fischer's lovebird *A. fischeri*, yellow-collared lovebird *A. personatus*, black-cheeked lovebird and rosy-faced lovebird *A. roseicollis* (Fry, Stuart & Urban, 1988; Forshaw, 1989; Warburton & Perrin, 2005; Perrin, 2012). Lilian's lovebirds' diet is largely grass seeds. They are highly dependent on free standing water (Fisher, Lindgren & Dawson, 1972; Del Hoyo, Elliot & Sargatal, 1997; Warburton, 2003); thus, poisoning of water sources poses a direct threat to their viability.

We investigated the drinking habits of Lilian's lovebirds in LNP, the availability of natural water sources, frequency of poisoning events and its possible impact on population numbers. We predicted that drinking habits of Lilian's lovebirds would be similar to those of the black-cheeked lovebird. We also expected that poisoning incidents would be highest during the dry season (May–October) and lowest during the rainy season (November–April).

Methods

Study area

Liwonde National Park (14°36′E to 15°03′S and 35°15′ to 35°26′E; 548 km^2) ranges from 474 to 921 m a.s.l. (Manongi, 2004). It has distinct rainy (November–April) and dry seasons (May–October). Average annual rainfall range is 401–999 mm (Dudley, 1994). LNP has a partially fenced boundary with no buffer zone (Thomson, 1998). In unfenced areas, boundaries are well known and marked using fire breaks. Land use bordering LNP is mainly agriculture. Mopane woodland is the dominant vegetation covering approximately 70% of its area (Hall-Martin, 1969; Dudley, 1994).

Lilian's lovebird drinking habits

We studied drinking by Lilian's lovebirds in the wet and dry seasons of 2010, 2012 and 2013. Drinking places were identified by LNP scouts and opportunistic searches. Three main waterholes in central LNP were monitored for lovebird drinking behaviour. We conducted full-day counts for 3 days at each waterhole at the peak of the dry season and in the wet season. Observations were made using a pair of binoculars (Lynx 8 × 42) and a telescope (Kowa 10X, Kowa Optimed Europe, Berkshire, UK). We recorded when lovebirds drank at the waterhole and flock size.

Waterhole availability and distribution after the rainy season

We surveyed 24 transects for the presence of natural waterholes in LNP from May to July and in October 2012. Transects were 2 km apart and covered the entire park. We recorded geographic locations of all natural waterholes encountered using a global positioning system (GPS, Etrex 10; Garmin, Olathe, KS, USA). Each waterhole was described as 'wet' (containing water) or 'dry' (not containing water). Locations were mapped using ARCGIS 10.1 (ESRI, 2012, Redlands, CA, USA).

Locations of waterhole poisoning

Monthly LNP patrol reports were obtained from LNP's law enforcement department. All reports from all camps in LNP (2000–2012) were examined for records of poisoned waterholes. Date, map coordinates and camp were recorded for each poisoning incident. ARCGIS 10.1

was used to map all of the poisoning localities and to correlate them spatially with LNP's vegetation, streams and natural waterholes. We noted that the actual numbers of lovebirds found dead at a poisoned waterhole was not recorded, so we administered a simple questionnaire to LNP scouts to estimate poisoning incidents and numbers of birds found dead at poisoned pools. The numbers of lovebirds killed each year could not be estimated because of the possibility of one incident being reported several scouts. Consequently, only data extracted from the scout reports (2000–2012) were used when calculating poisoning incidents on a monthly basis.

Estimating proportions of populations at risk with poisoning

Georeferenced poisoning incidents were inserted as point features on the LNP map. There are no spatial dispersal data available specific to Lilian's lovebirds. However, rosy-faced lovebirds are known to move distances between 1 and 4.5 km (Ndithia & Perrin, 2006). We therefore assumed 4 km as the possible distance that Lilian's lovebirds would fly to drink. A 4 km buffer was created in ARCGIS 10.1 for each of the reported poisoning spots. Where buffers intersected, one buffer was created encompassing the intersecting points.

Areas of mopane woodland in buffer zones were calculated as Lilian's lovebirds only roost and breed in mopane trees (Mzumara, 2014, Mzumara, Perrin & Downs, 2014). Thus, their abundance is largely determined by the availability of this vegetation type. Probability of a waterhole causing death of Lilian's lovebirds and average number of lovebirds poisoned at a waterhole were used to estimate number of lovebirds at risk of poisoning per year. The current population of Lilian's lovebirds in LNP approximates 4000 individuals or 17 lovebirds km^{-2} (Mzumara, 2014). Statistical analyses were conducted using STATISTICA (ver. 7; Tulsa, OK, USA).

Study limitations

We were unable to test the probability of finding all poisoned lovebirds at waterholes. Scavengers and experience of observers affect the number of dead birds found (Schutgens *et al.*, 2014). We were also unable to determine the time taken for lovebirds to be killed following exposure to pesticide. We assumed that the impact of poison was immediate (Ogada, 2014). The estimates for the proportion of the population at risk are based on a lovebird species that is not closely related Lilian's lovebird. There is no information to defend the similarities in distance. However, it is the only lovebird species where spatial dispersal has been studies.

Results

Lilian's lovebird drinking habits

Lilian's lovebirds drank from different water sources in LNP. These varied from dambos (grassy wetland areas) along the Shire River, big artificial waterholes in the rhino sanctuary and small natural waterholes in mopane and mixed woodland habitats. During the wet season, lovebirds drank from the natural waterholes in the mopane woodlands and at small pools on the roads and in grassland areas. No lovebirds were observed drinking from the Shire River channel. In northern LNP, Lilian's lovebirds drank from mud pans and dambos on the banks of Lake Malombe. Lilian's lovebirds only drank from stationary water whose quality varied from clear to muddy/algae infested (T. Mzumara, pers. obs.).

The number of observations of Lilian's lovebird drinking at the three monitored waterholes differed significantly between the wet (n = 91) and dry seasons (n = 208) (Mann–Whitney *U*-test, $P < 0.05$). No lovebirds were recorded at the three main waterholes in the wet season (January–April). Lilian's lovebirds began visiting these waterholes in the rhino sanctuary from May of each year. Flock sizes at waterholes ranged from 1 to 30 individuals (Fig. 1). The most frequently seen flock size was 1 or 2 individuals (28%). Significantly larger flocks (mean ± SE) were seen in the dry season (12 ± 0.1 individuals) compared with the wet season (7 ± 0.1 individuals, Kolmogorov–Smirnov test, $P < 0.025$).

In the dry season, the number of Lilian's lovebirds drinking in the mornings, afternoons and evenings differed significantly (Kruskal–Wallis test: $P = 0.0195$). More lovebirds were seen in the mornings between 06.00 hours and 09.00 hours and in the evenings between 15.00 hours and 18.00 hours. Flock size ranged from one to 100 + individuals. Mean flock size was significantly different in the three periods of the day (Fig. 2, Kruskal–Wallis test, $P < 0.01$). The largest lovebird flocks were seen during the evening hours (17.00 hours–17.59 hours) (mean = 43 ± 2.0 lovebirds) and early morning

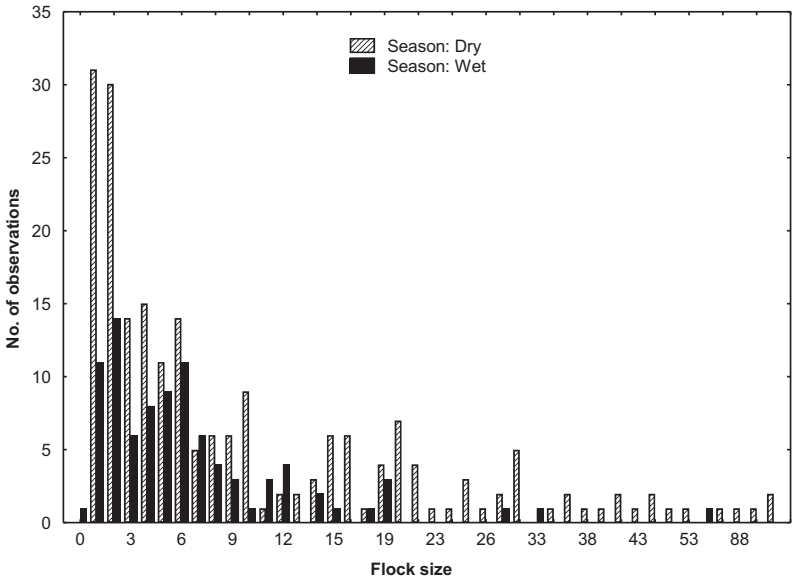

Fig 1 Frequency of Lilian's lovebirds flock sizes observed drinking in the wet and dry season at waterholes in Liwonde National Park, Malawi

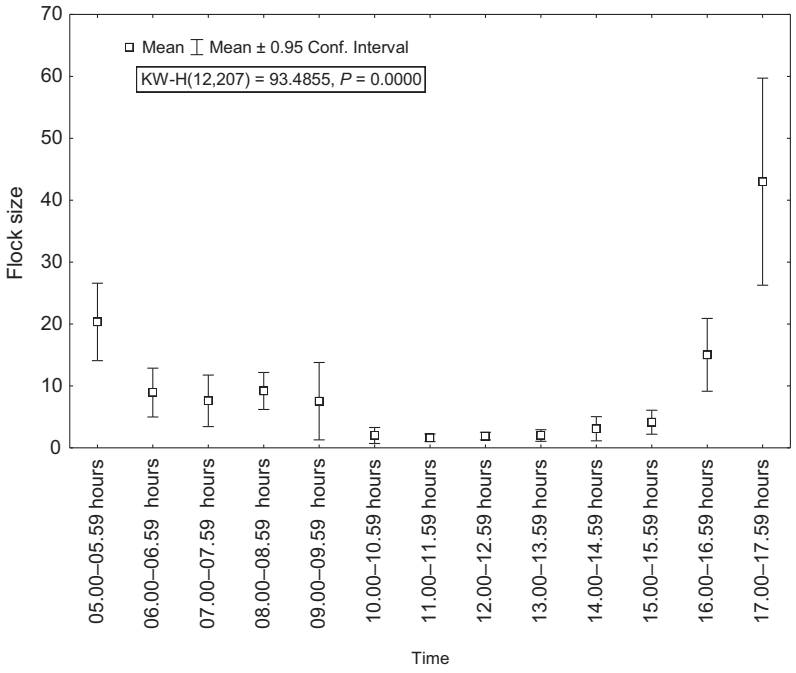

Fig 2 Variability of mean flock sizes of Lilian's lovebirds at different times of day at waterholes in Liwonde National Park, Malawi

(mean = 20 ± 0.7 lovebirds). At midday, very few observations were made of lovebirds drinking.

Lilian's lovebirds avoided drinking at waterholes when there were large mammals present; other species recorded drinking at a waterhole with the lovebirds were all birds (Table 1). When there were mammals drinking at a waterhole the lovebirds were seen flying over.

Table 1 Birds observed drinking with Lilian's lovebirds at waterholes in Liwonde National Park, Malawi

English Name	Scientific name
Southern grey-headed sparrow	*Passer diffusus*
Southern long-tailed starling	*Lamprotornis mevesii*
Cape turtle dove	*Streptopelia capicola*
Greater blue-eared starling	*Lamprotornis chalybaeus*
Red-eyed dove	*Streptopelia semitorquata*
Yellow-eyed canary	*Serinus mozambicus*
Grey-headed parrots	*Poicephalus fuscicollis*
Wattled starlings	*Creatophora cinerea*
Red-billed oxpeckers	*Buphagus erythrorhynchus*
White-browed sparrow-weavers	*Plocepasser mahali*
Laughing doves	*Spilopelia senegalensis*

Distribution and availability of natural waterholes

A total of 175 waterholes were recorded along transects in LNP during the study (Fig. 3); most (65%) were in mopane woodland. The number of 'wet' naturally occurring waterholes encountered during transect walks decreased by 95% from May (n = 65) to October (n = 3).

Occurrence of poisoning incidents

Thirty-one poisoning incidents were reported in LNP between 2000 and 2012. The number recorded differed significantly between the north, central and southern parts of LNP (Kruskal–Wallis, $P > 0.001$). Most poisoning incidents (81%, 25) were from the south of LNP (Fig. 3). This area had four places with repeated poisoning incidents over several years; they were Namandanje Dam, Nachibwira Dam, Mwalasi and Bilira waterholes.

All poisoning incidents reported were inside the park boundaries. However, park staff stated that communities may poison lovebirds in agricultural fields outside the park in older to protect their crops. No poisoning incidents were found in the scout reports from 2000 to 2004. Waterhole poisoning in LNP was reported in all months of the year except for January, March and December between 2005 and 2012. Poisoning occurred mainly during the dry season (May–October). The highest numbers of poisoning incidents at waterholes were in October, September and May (Fig. 4), and in 2008 (n = 9). This was also the only year with reports in the months of February and April (Fig. 5). As predicted, poisoning incidents had a negative relationship with the LNP average monthly rainfall (Fig. 5).

Only thirteen poisoning locations from the patrol reports were georeferenced. Most of these were waterholes in mopane woodland (n = 9), two in riverine thicket, one in tall grass-tree savannah and one in mixed savannah woodland. Isolated waterholes were the main target for poisoning (n = 12) rather than water present along streams (n = 1). The sum of all the vegetation areas covered by the 4 km buffers was 250.7 km^2, of which the total mopane woodland area was 152.2 km^2. Assuming the current density estimate of 17 Lilian's lovebirds km^{-2} of mopane woodland (Mzumara, 2014), this area hosts approximately 2587 individuals. As the mean number of poisoning incidents/year is 4, we can assume 50% of these individuals (1294 lovebirds) are at risk of encountering a poisoned waterhole each year (particularly during the wet season when lovebirds do not drink too far away from their roost/breeding sites). This represents 32% of LNP current lovebird population. The proportion of lovebirds at risk will be greater in the dry season as these waterholes cater for lovebirds from a much larger area.

Forty-five (of a possible 69) questionnaires were completed by scouts and staff at LNP. Most (69%, n = 31) had encountered waterhole poisoning in LNP. The mean number of poisoning incidents per year (2004–2013) where Lilian's lovebirds were found dead was 4. Lilian's lovebirds found dead at a pool varied from 5 to 50 individuals with a mean of 17 ± 0.32 lovebirds. One respondent caught a poacher with 500 dead lovebirds confirmed by a photograph in a law enforcement report (Labuschagne, 2002). However, the report did not state whether all the 500 birds were from one waterhole or several.

The most commonly used poison at waterholes was Temik® (Aldicarb, Bayer CropScience AG, Monheim am Rhein, Germany), a widely used carbamate pesticide for rats (*Rattus* sp.) in crops and homes. Natural poisons made from *Euphorbia* sp. and *Triphosia* sp. tree species are also used but were not recorded in LNP (i.e. resulting in dead animals or plants). Usually, evidence of the poison used at a waterhole is found in adjacent areas. A range of other species were also found dead at poisoned water (Appendix 1).

Discussion

Lilian's lovebirds drank from diverse water sources. They drank in the early morning and late afternoon similar to the black-cheeked lovebird in Zambia (Warburton & Perrin, 2005). However, the mean flock sizes at waterholes

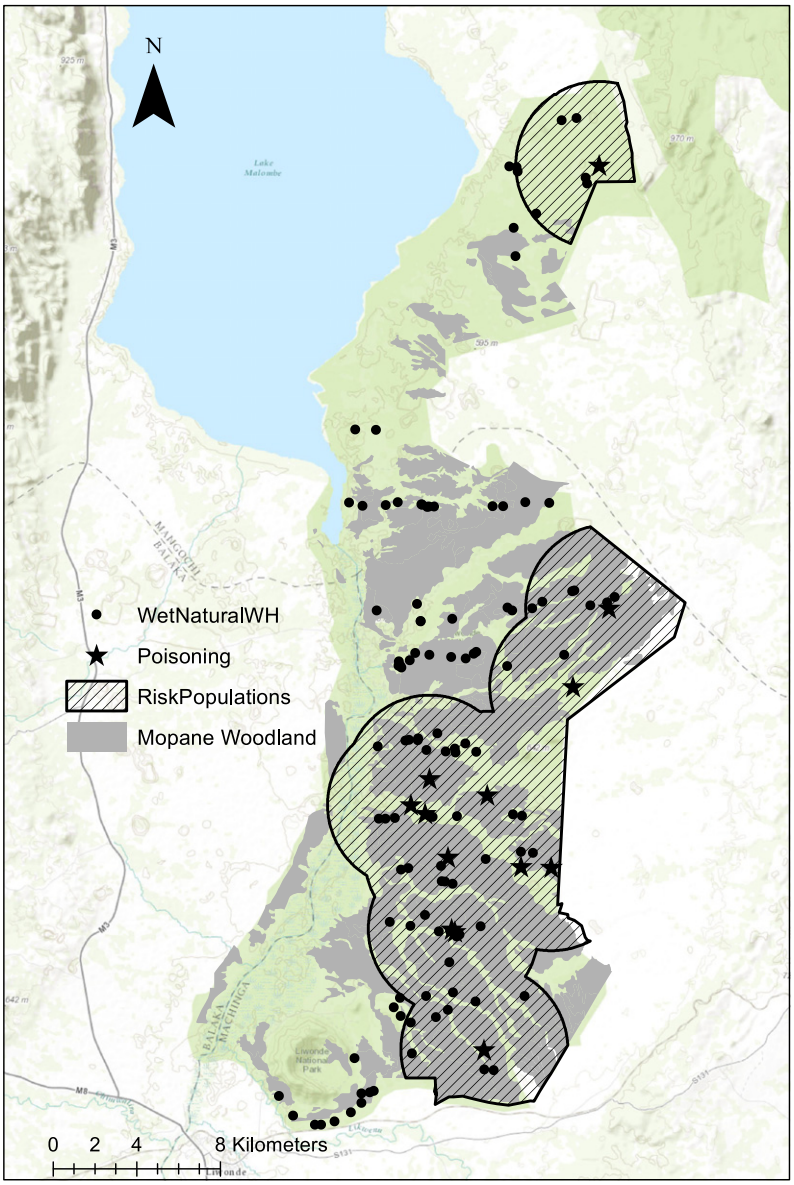

Fig 3 Spatial distribution of poisoning incidents at waterholes reported between 2005 and 2012 in Liwonde National Park, Malawi. (Circles are the 4 km buffer areas)

in LNP for the Lilian's lovebird during these peak times of the day differed to those for the black-checked lovebird. While larger flocks of black-cheeked lovebirds were seen during the early morning at drinking sites, larger flocks of Lilian's lovebirds were seen drinking in the late afternoon.

The absence of Lilian's lovebirds at monitored waterholes in LNP from January to May confirmed their use of alternative water sources in LNP during the wet season. The lovebirds used a diverse range of accessible waterholes on roads, by river banks, along streams or isolated ones in mopane woodlands. They avoided waterholes when large mammals were present. Black-cheeked lovebirds also avoid waterholes with human or livestock disturbance (Warburton & Perrin, 2005).

The number of naturally occurring 'wet' waterholes in LNP reduced from May to October. Consequently, Lilian's

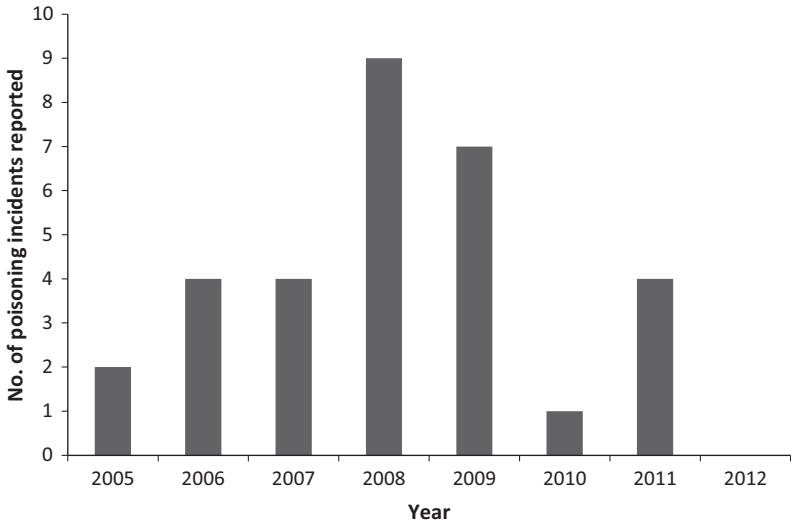

Fig 4 Total number of reported poisoning incidents extracted from scout reports in Liwonde National Park, Malawi between 2005 and 2012

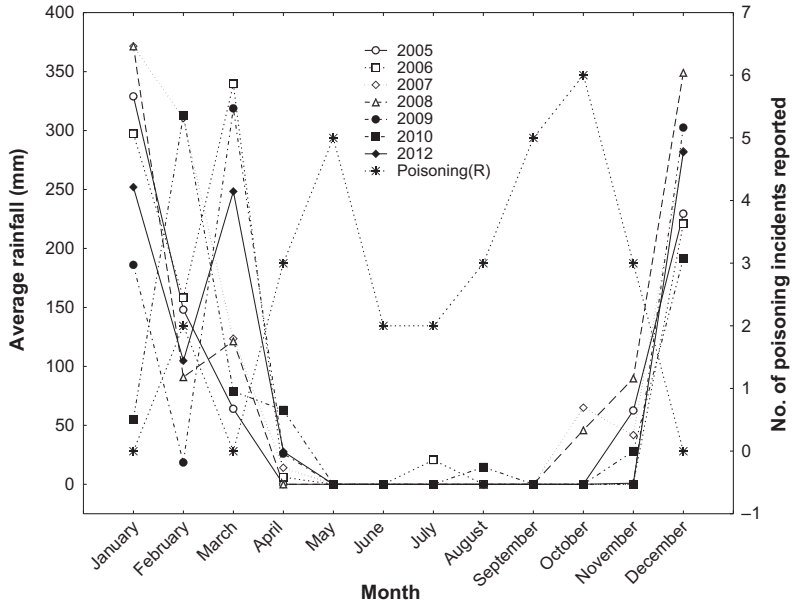

Fig 5 The inverse relationship between average rainfall in Liwonde National Park, Malawi and the number of poisoning incidents at waterholes reported by park staff

lovebirds congregated at the few available waterholes during the dry season. Forming large flocks, especially pre- and postroosting at waterholes makes the Lilian's lovebirds in LNP very vulnerable to waterhole poisoning. We did not investigate the times when illegal hunters were most active in LNP, but they likely follow the activities of their target species. Lilian's lovebirds preferred to use mostly standing water sources, and this further increases their threat from poisoning of waterholes.

Lilian's lovebirds also face risk from poisoning events recorded in the wet season when the lovebirds drink in smaller flocks because they spend more time in LNP feeding

on grasses (Mzumara, 2014). The amount of rainfall that LNP receives affects the availability of natural waterholes in the park. In 2008, poisoning was reported in February when LNP is generally still flooded making it difficult for poachers to trap mammals. However, LNP scouts explained that dry spells within the rainy season allow the park to be dry enough for illegal hunters to use poison at waterholes. We were unable to explore this possibility further, however, it brings into perspective climate change, its impacts on precipitation and how this may increase poisoning incidents and consequently the effect on Lilian's lovebird LNP population. Current climate models suggest a mean rainfall ranging from a 2% decrease and 5% increase in areas around LNP (McSweeny, New & Lizcano, 2007). An increase in rainfall will increase available waterholes thus decreasing poisoning incidents.

As the majority of poisoning incidents in LNP were at natural waterholes along transects, these transects provide a tool for improved monitoring. We recommend regular use to monitor poisoning events. Four areas repeatedly poisoned each year need increased patrols to apprehend poachers. Use of camera traps to cover unmanned periods at high risk should be explored.

Use of poison for poaching is a threat to biodiversity in PAs. Poisoning incidents in LNP pose a risk to 32% of Lilian's lovebirds and other wildlife. During the wet season, the lovebird's widespread distribution and wide use of water sources exacerbates this problem as waterholes are difficult to monitor. Capture of black-cheeked lovebirds for the pet trade is a threat in Zambia (Warburton, 2003), Zimbabwe (Couto, 1996) and Mozambique (Parker, 2005). In Malawi, there are currently no records of Lilian's lovebirds being captured for the pet trade. Therefore, the current main threat might be poisoning of waterholes in LNP.

One in eight bird species in the world is threatened with extinction (BirdLife, 2013). Recently 25 Africa bird species have been up-listed to higher categories of threat in the IUCN Red List (BirdLife, 2013). Human-induced threats are one of the main reasons for this. The LNP Lilian's lovebird population represents about 20% of the estimated global population (Birdlife, 2012). Consequently, increased law enforcement patrols to prevent poisoning incidents and so conserve this population are required.

Acknowledgements

We thank the following for financial and technical assistance: The University of KwaZulu-Natal, Department of National Parks and Wildlife in Malawi, Strunden Papageien Stiftung, African Bird Club, BirdLife International, The Love Bird Society, Chicago Board of Trade Endangered Species (CBOT), Hippo View Lodge, Shire Lodge, Mvuu Camp, Wildlife and Environmental Society of Malawi.

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Appendix 1

Summary of incidents of waterhole poisoning involving Lilian's lovebirds between 2004 and 2013 in Liwonde National Park, Malawi (questionnaire responses).

Year	Place	Month	No. of Lilian's lovebirds found dead	Other species found
2004		November	10	Vervet monkeys *Chlorocebus pygerythrus*
		August	8	Bushbuck *Tragelaphus scriptus*
		October	6	Weavers *Ploceus* sp.
		September	5	[illegible]ning doves ~~*Zenaida macroura*~~
2005		August	20	Waterbuck *Kobus ellipsiprymnus*
		September	18	Greater kudu *Tragelaphus strepsiceros*
		October	15	Weavers *Ploceus* sp.
		November	12	
		November	5	Common duikers *Sylvicapra grimmia*
2006	Namandanje Dam	October	40	Sable *Hippotragus niger*, impala *Aepyceros melampus*, weavers *Ploceus* sp., other birds
		September	22	Sable *Hippotragus niger*
			21	
		November	17	Baboon *Papio cynocephalus*
		October	12	Vervet monkeys *Chlorocebus pygerythrus*
		August	5	Bushbuck *Tragelaphus scriptus*
2007		August–December	25	Baboon *Papio cynocephalus*
2008		August–November	15	Baboon *Papio cynocephalus*
	Lower Mwalasi	September	7	
2009	Lower Mwalasi	August	20	Warthog *Phacochoerus africanus*
	Dam seven	November	10	
		August–November	9	Greater kudu *Tragelaphus strepsiceros*
2010	Middle Namandanje	November	21	
	Upper Bilila hole	August	10	Birds, vervet monkeys *Chlorocebus pygerythrus*
		August–November	6	Weavers *Ploceus* sp.
2011	Ntulira	June	50	Buffalo *Syncerus caffer*
	Namandanje Dam	Ocober	30	Hippo *Hippopotamus amphibius*, weavers *Ploceus* sp., dove *Columbidae*
	lower Namandanje	July	16	
		August–November	5	Southern ground-hornbills *Bucorvus leadbeateri*
2012	Nachimbwila	September	8	No dead animals, Waterhole found having just recently been poisoned
2013	Namisangu	July	50	
	Mtemankhalamba	May	20	Reedbuck *Redunca arundinum*

(*Manuscript accepted 17 January 2015*)

doi: 10.1111/aje.12216