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Lelwel hartebeest in Kenya (© Y. de Jong & T. Butynski)

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Meetings and Updates

Saiga antelope workshop
A joint CMS-CITES Technical Workshop on Saiga Antelope took place 1-4 April 2019 on the island of Vilm, Germany. It was funded by the German Federal Ministry of the Environment and took place under the auspices of the Convention on Migratory Species Memorandum of Understanding on Saiga Antelope. The main purpose was to review progress under the MoU and recommend a revised 5-year work plan.

SSIG 2019
The annual meeting of the Sahelo-Saharan Interest Group took place 30 April-2 May 2019 in Carthage, Tunisia. A full and wide-ranging agenda included presentations on Scimitar-horned Oryx, genetics of Addax, Western Derby Eland, and planning sessions on reintroduction of Dorcas Gazelle and Dama Gazelle in Morocco, a conservation road map for Slender-horned Gazelle and progress on the restoration of Scimitar-horned Oryx to Chad. A visit was also organized to the reintroduction site for Cuvier's Gazelle in Jebel Serj National Park.

Forthcoming
The 18th CITES Conference of the Parties (COP18) will now take place in Geneva on 17-28 August 2019. Topics of antelope interest to be discussed include standing items on Saiga and Tibetan Antelope.

Species Survival Commission
The fourth SSC Leaders' Meeting will take place in Abu Dhabi in October 2019, generously supported by Environment Agency – Abu Dhabi. All Specialist Group Chairs, RLA Coordinators and Program Officers have been invited. ASG will be represented by Philippe Chardonnet and David Mallon.

Increasing the resilience of the dama gazelle: report from a conservation planning workshop in Al Ain
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With perhaps as few as 100 left in the wild the dama gazelle is one of the world's most endangered antelope species. With the theme of "increasing the resilience of the dama gazelle", a conservation planning workshop took place on 11-18th December 2018 in Al Ain, United Arab Emirates. Building on the 2013 workshop hosted by RZSS, and the Regional Action Plan for Chad and Niger developed in 2017, major stakeholders including governments, NGOs, research institutes and the *ex situ* community were brought together for the first time. The aim of the workshop was to review and update the objectives and actions published in the *Conservation Review of the Dama Gazelle (Nanger dama)* (RZSS & IUCN Antelope Specialist Group, 2014) and, in light of the urgency of the situation, identify and agree concrete actions to reduce the extinction risk of the dama gazelle both *in situ* and *ex situ*.

With the entire dama gazelle population being so small, the conservation options discussed during the workshop were particularly relevant to the IUCN 'One Plan' approach. Options include bringing small, isolated wild populations into breeding enclosures within a range state (from which offspring could be used for reintroduction and to supplement the captive breeding program), the supplementation of wild and semi-captive populations with captive-bred animals, translocation of animals between wild populations and the management of the three proposed subspecies as one population. The risks associated with each option were identified and discussed including genetic, disease, mortality and behavioral risks.

Some important outcomes of the workshop include to:

- Develop a training and capacity building program for range states based on requirements documented during the workshop.
- Rescue a small isolated population and establish a breeding herd in Chad.
- Implement specific transfers between captive populations to improve genetic diversity.
- Carry out a survey of captive and semi-captive populations into dama gazelle mortality.
- Karyotyping and further genetic analysis to be carried out.

There was also agreement that the dama gazelle cross-breeding experiment being conducted by Al Ain Zoo (reported in Gnusletter previously) is providing useful information and should be continued to produce more animals and an F3 generation. Also agreed was that in the absence of available *N. d. dama*, *N. d. ruficollis* would be an acceptable replacement for use in certain reintroductions or supplementations.

A comprehensive update of the status of the dama gazelle plus outputs of the workshop will be published in the summer. Various plans to implement some of the workshop recommendations are already being developed.

Dama Gazelle workshop participants at Al Ain Zoo (©Al Ain Zoo)

The workshop was hosted by His Excellency Ghanim Mubarak Al Hajeri, Director General of Al Ain Zoo, organized by Al Ain Zoo, ASG and the Royal Zoological Society of Scotland and facilitated by Dr. David Mallon (ASG Co-Chair) and Dr. Helen Senn (Head of Conservation and

Science Programs, RZSS). It was supported by the Sahara Conservation Fund and Al Bustan Zoological Centre.

The dama gazelle exhibit at the entrance to Al Ain Zoo (© Lisa Banfield)

Original Articles

First Camera-trap Record of Mountain Nyala (*Tragelaphus buxtoni*), an Endangered Ethiopian Endemic Antelope, in the Harenna Forest of Bale Mountains

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All photos © A. Asefa

Introduction

The Mountain Nyala (*Tragelaphus buxtoni* Lydekker (1911), a species endemic to Ethiopia, is the last large antelope to be discovered in Africa (Brown 1969). The species has only been recorded in three discrete mountain ranges (i.e. Harar, Arsi and Bale Mountains) in the south-eastern highlands of the country (i.e., east of the Great Rift Valley), where they exist in seven isolated populations (Malcolm and Evangelista 2011). Nearly, 75% of its habitat and population are known to occur in the Bale Mountains National Park (BMNP) (Asefa 2011, Malcolm and Evangelista 2011). This park has been recognized as a center of diversity and endemism across all biological taxa (Asefa 2011) and one of the global biodiversity hotspot areas (Myers et al. 2000).

The first reliable ecological study on the mountain nyala came from Brown's work who reported the existence of ~7000-8000 individuals (Brown 1969). Several studies have been conducted since then (Hillman 1986, Atickem et al. 2011, Mamo et al. 2012, Malcolm and Evangelista 2011, IUCN 2016) and reports suggest that the species has undergone considerable declines both in population number and distribution due to poaching and habitat loss. For example, a report on population data (estimated in the range of 3500-4000 individuals) made by Malcolm and Evangelista (2011) show a decline by a factor of half compared to Brown's (1969) earlier estimate. As a result, the mountain nyala is currently listed as endangered on the IUCN Red Data List threat category (IUCN 2016).

In the Bale Mountains, mountain nyala have been reported from the northern and north-western slopes, and central parts of the mountains, where they inhabit fairly open habitats, including Afromontane grasslands, heathland and heath forest, and montane woodland forests (Brown 1969, Hillman 1986, Atickem et al. 2011, Malcolm and Evangelista 2011, IUCN 2016). However, mountain nyala are thought to avoid inhabiting dense forests and have not previously been reported from the Harenna forest—a dense forest that covers the southern slope of the BMNP (Brown 1969, Hillman 1986, 1988, Malcolm and Evangelista 2011, Mamo et al. 2012). To our knowledge, evidence (e.g., species description, photo, etc) on the occurrence of the species in the forest has been lacking, despite the increasing trend in ecological expeditions conducted in the Harenna forest since 1980s. Bob Waltermire, previous warden of the BMNP in the 1970's, reported the species in the Harenna Forest (First author 2007, Pers. Comm.), but presence was not supported by physical evidence (photographs, droppings, or carcasses). Based on photographic evidence

from camera trapping surveys conducted in 2015 and 2016, we now report the first confirmed record of the presence, likely a breeding population, of mountain nyala in the Harenna forest of the BMNP.

Materials and methods

Study area

The Bale Mountains region [location: between (UTM 37N) 625000-890000 N, and 470000-635000 E] is situated in the southeastern highlands of Ethiopia. At the center of these mountains is the Bale Mountain National Park BMNP (718500-795000 N, and 555000-607500 E; Figure 1) which was established in 1970 primarily to conserve the Mountain Nyala and the endemic Ethiopian Wolf (*Canis simensis*) (Hillman 1986). BMNP has an area of 2200 km^2 and altitude ranges from 1500 to 4377 m (BMNP 2017). The Bale Mountains region can be divided into three sections: the northern slope (3000-3400 m) covered by montane grassland and montane woodland forest; the central peak and plateau (3800-4377 m) covered by ericaceous scrubland and afroalpine moorland; and the southern Harenna forest section (1500-3800 m) covered by dense montane forest (Hillman 1986). The region is characterized by a bimodal rainy season: heavy rains occur from July to October, and small rains from March to June (Hillman 1986).

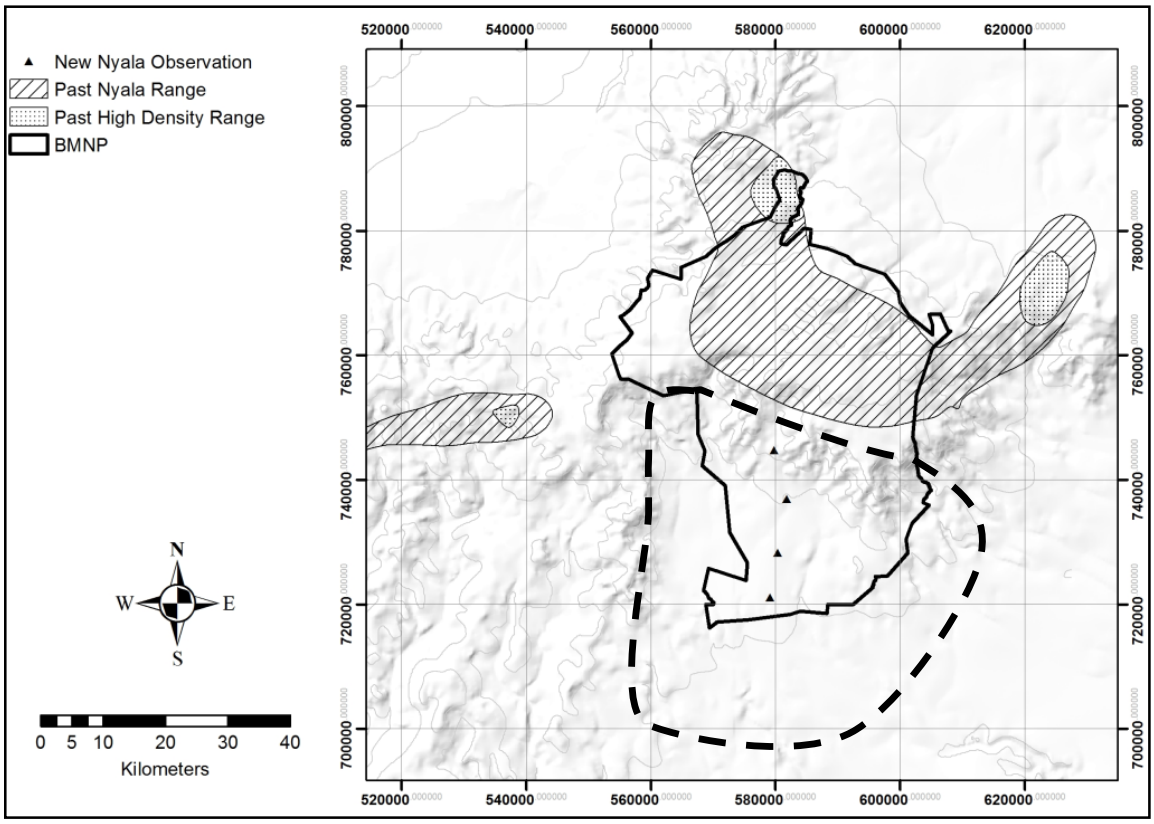

Figure 1. Map of the Bale Mountains region, showing boundary of the Bale Mountains National Park, past distribution of Mountain Nyala and our current new observation in the Harenna forest (the area enclosed by a dotted polygon).

The present surveys were carried out in the southern Harenna forest, covering an area of 7000 km^2 between altitudinal ranges of 1500-3400 m. This forest is the second largest moist tropical montane forest, and the only cloudy forest remaining in Ethiopia (BMNP 2017). Harenna forest has five vegetation zones which are primarily delineated along altitudinal gradient: *Ocotea-Olea-Podocarpus-Syzygium type* (1500-1700 m); *Syzygium-Polycias-Allophylus-Erythrina* (1700-2100 m); *Schefflera-Hagenia-Erythrina* (2100-2700 m); *Hagenia-Hypericum-Shefflera-Myrsine* (2700-3000 m); and *Erica arborea* trees (3000-3400 m) (Hillman 1986).

Data collection

The data used in this report were obtained from camera trap surveys of larger wild mammals in the Harenna forest of the BMNP in 2015 and 2016. Three camera trapping survey sessions have been undertaken to date. During the first session, in December 2015, 47 cameras were placed in a 2 km × 2 km grid (ten north-south × five east-west) for three months, between altitudes of 1493-1963 m. The second session, in April 2016, utilized ten cameras placed in a 1 km × 1 km grid (five north-south × two east-west) for 15 days in the northern section (i.e., near the upper tree limit) of the forest between altitudes of 2832-2950 m. And, the third survey, September 2016, utilized cluster sampling in which a total of 27 cameras were placed in 3 clusters of 9 cameras (i.e. in a 3 × 3 formation) each for 7 days, between altitudes of 1700-1786 m. Inter-cluster spacing was 2 km while intra-cluster camera spacing ~500 m.

We deployed White-flash Scout Covert Still Image Digital Video Cameras. They were placed along wildlife and/or human trails approximately 65-80 cm above and parallel to the ground on a tree on which they were tied with cables and locked secure with custom-built metal boxes. Time elapse functionality of the cameras was set to 24 hours, trigger speed to 5 seconds taking a sequence of 3 pictures per trigger (Cadman and González-Talaván 2014). From the first session only 13 (28%) cameras were retrieved, while all of them retrieved from the second and third sessions. Although several species, including large carnivores such as lion (*Panthera leo*) and leopard (*P. pardus*) were captured on the camera traps, we report here only the data pertaining to the mountain nyala.

Results

Overall, we captured 7 sets of 157 photos of mountain nyala from four cameras placed at different locations in the Harenna forest of the BMNP; from two cameras each during the 2015 and 2016 surveys (Figure 1, Table 1). In 2015 (the first survey session), we collected a set of 9 photos of an adult female from CAM #03 (37N 581870, 736884; altitude: 1932 m) captured on 21 December 2015 from 17:55-17:57 (Figure 2), and another set of 33 photos of 3 adult females from CAM #37 (579162, 721080; altitude: 1623 m) captured on 17 December 2015 from 16:43-16:45 (Table 1, Figure 3).

During the second survey session in 2016, we collected 4 sets of 112 photos from CAM #02 (579855, 744724; altitude: 2947 m). The first two sets were captured on 17 April 2016: a set of 25 photos of an adult female mountain nyala with her young offspring captured from 11:11-11:14 (Figure 4), and 26 photos of an adult male captured at 16:35 (Figure 5). The third set comprised of 59 photos of an adult female with her young offspring captured on 20 April 2016 from 18:25-18:39 (Figure 6). And, the fourth set comprised of 3 photos of an adult female captured on 24 April 2016 at 21:48 (Table 1). Although all these four sets of photos collected from CAM #02 were

captured on three different days (except the two sets captured on 17 April 2016) and within 3-4 days interval, it is unclear whether these photos were from the same individual or a group of animals. Finally, during the third trapping survey session, a set of 3 photos (but only half body captured; Figure 7) of an adult female were captured from camera CAM #C3_1 (580422, 728265), located at 1702 m in elevation, on 20 September 2016 at 18:30 (Table 1).

Discussion

Our data indicate that photos of mountain nyala were captured during all the three different trapping sessions, which were distributed over 10 months. They were captured in December, April and September (nearly at five-month intervals); these months encompass both the dry and wet seasons in the Bale region (BMNP 2017). Furthermore, the distance between locations of each pair of the four cameras where mountain nyalas were captured ranged between ~8-24 km and of the two cameras that captured mountain nyala photos during the first survey session (in 2015) was ~16 km (see Table 1, Figure 1). These results, and the presence of calves, likely indicates the presence of a resident breeding population of the species throughout the forest. With the exception of 25 photos (16%) captured between 11:11-11:14, the largest proportion of the photos (135, or 84%) were captured between 16:30-22:00, and no photos were captured before 11:00 and between 12:00-16:00 (Table 1). Although further studies are needed, the data suggest that their peak activity period in forest might be in the evening, which also agrees with the suggestion that mountain nyalas are largely nocturnal (Malcolm and Evangelista 2011).

Although our report confirms presence, it is not clear whether past reports on the absence of mountain nyala in the Harenna forest is because they have simply been overlooked during previous expeditions, or that their current presence is due to a recent range extension. If a range extension, what are the possible driving forces behind this range extension and the consequences thereof on the long-term persistence of the species in the Bale region? Given our experience and knowledge of ecological dynamics in the Bale Mountains region in the last two decades, we argue that the present observation of mountain nyala in the Harenna forest may be the result of a recent dispersal event, which could be attributed to anthropogenic habitat modification, both in their known ranges and in the Harenna forest. Human-induced disturbances such as cultivation, logging, settlement and grazing in the Bale Mountains, including in the Harenna forest, have been increasing in the last three decades, leading to severe habitat degradation, habitat loss and fragmentation (BMNP 2017). In the Harenna forest, these disturbances have resulted in forest openings and woodland habitats, which are atypical to mountain nyala's preferred habitats. It is, therefore, possible that, coupled to reduction of available habitats in its former range (northern and north-western slopes), the anthropogenic creation of forest openings might have attracted mountain nyala to colonize the Harenna forest. Reports from the northern slope of the BMNP (e.g., Atickem et al. 2011, IUCN 2016) also indicate due to increasing human settlement, cultivation and livestock grazing the mountain nyala have moved to higher altitude areas where human use is reduced. In conclusion, our report has provided new knowledge on the distributional range of the species, which may help promote further research and conservation of the mountain nyala under the rapidly changing environment in the Bale Mountains region. Further detailed, similar studies are needed to confirm whether there is a resident and/or breeding population and to know spatio-temporal abundance of the species in the forest.

Table 1. Summary of photos of Mountain Nyala captured by camera traps in the Harenna forest of the Bale Mountains, Ethiopia

Camera code	Location		Altitude (in m)	Date	Time	No. photos	Age/sex composition
	UTM X	UTM Y					
Cam #03	37N 581870	736884	1932	21/12/2015	17:55-17:57	9	1 adult female
Cam #37	37N 579162	721080	1623	17/12/2015	16:43-16:45	33	3 adult females
Cam #02	37N 579855	744724	2947	17/04/2016	11:11-11:12	8	1 adult female
				17/04/2016	11:12-11:14	17	1 adult female and 1 juvenile/calf
				17/04/2016	16:35	26	1 adult male
				20/04/2016	18:25-18:27	12	1 Juvenile
				20/04/2016	18:28	9	1 adult female
				20/04/2016	18:31-18:35	33	1 adult female and 1 juvenile/calf
				20/04/2016	18:39	5	1 adult female and 1 juvenile/calf
				24/04/2016	21:48	2	1 adult female
Cam #C3_1	37N580422	728265	1712	20/09/2016	18:30	3	1 adult female

Figure 2. An adult female Mountain Nyala captured on CAM #37 during the first trapping session in 2015.

Figure 3. Two adult female Mountain Nyalas captured on CAM #03 during the first trapping session in 2015.

Figure 4. An adult female Mountain Nyala with her calf captured on CAM #02 during the second trapping session in 2016.

Figure 5. An adult male Mountain Nyala captured on CAM #02 during the second trapping session in 2016.

Figure 6. An adult female and a calf Mountain Nyalas captured on CAM #02 during the second trapping session in 2016.

Figure 7. An adult female Nyala captured on CAM #C3_1 during the third trapping session in 2016.

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References

Asefa, A. 2011. Mammals of the Bale Mountains National Park, Ethiopia: A Compiled and Annotated Checklist. *Walia-Special Edition on the Bale Mountains:* 3-14.

Atickem, A., Loe, L.E., Langangen, Ø.O., Rueness, E.K., Bekele, A. and Stenseth, N.C. 2011. Estimating population size and habitat suitability for Mountain Nyala in areas with different protection status. *Animal Conservation* 14: 409-418.

BMNP 2017. General Management Plan of the Bale Mountains National park (BMNP), Ethiopia (2017-2027). BMNP, Dinsho, Ethiopia.

Brown, L.H. 1969. Observations on the status, habitat and behaviour of Mountain Nyala, *Tragelaphus buxtoni* in Ethiopia. *Mammalia* 33:545-597.

Cadman, M. and González-Talaván, A. (eds.) 2014. *Publishing Camera Trap Data—A Best Practice Guide*. Global Biodiversity Information Facility, Copenhagen, Denmark. Available online at http://www.gbif.org/orc/?doc_id=6045 (accessed 17 December 2016).

Hillman, J.C. 1986. Management plan of Bale Mountains National Park. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Hillman, J. C. 1988. The Bale Mountains National Park area, southeast Ethiopia, and its management. *Mountain Research and Development* 8:253-258.

IUCN SSC Antelope Specialist Group 2016. *Tragelaphus buxtoni* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: http://dx.doi.org/10.2305/IUCN.UK.2016-3. Downloaded on 12 December 2018.

Malcolm, J. and Evangelista, P. H. 2011. Observations on the status of the Mountain Nyala: 2000-2005. *Walia-Special Edition on the Bale Mountains* 39-52.

Mamo, Y., Bekele, A. and Mengesha, G. 2012. Habitat use of Mountain Nyala (*Tragelaphus buxtoni*, Lyddeker, 1911) in the Bale Mountains National Park, Ethiopia. *International Journal of Biodiversity Conservation* 4:642–651.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B., and Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.

Rise and fall of the Mhorr Gazelle in Bou Hedma National Park, Tunisia

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Introduction

A release project of Sahelo-Saharan antelope species was initiated in Tunisia in 1985. Initially, the project focused on two iconic taxa, the scimitar-horned oryx (*Oryx dammah*) and the addax (*Addax nasomaculatus*). In 1990, the Mhorr gazelle (*Nanger dama mhorr*) were included as part of a conservation program intended to restore the country's aridland biodiversity. The transfer of Mhorr gazelles to Bou Hedma National Park (BHNP) was considered as an introduction (Abaigar et al. 1997). There is evidence of former presence of dama gazelles in southern Tunisia from travelers' reports (Pervinquiere, 1912), and from images on Roman mosaics (Cano & Abaigar, 2003), however Bou Hedma NP seems to lie north of the species' indigenous range.

The first transferred group of five dama gazelles were obtained from different German zoos. In 1994, 14 individuals were obtained from the captive program based in Almeria, Spain. The two groups were the founders of the Mhorr gazelles released in BHNP. At present, just one individual (male) lives in the park today.

The intent of this study is: 1) to analyze the evolution of the Mhorr gazelle population released in BHNP 28 years ago, and 2) to determine the main causes of their decline.

Materials and methods

Bou Hedma National Park (BHNP) is located in central Tunisia (fig.1). It is characterized as a grass and shrub steppe strewn with *Acacia raddiana* trees. The site is considered as relic pre-Saharan savannah and may have hosted one of the last elephant populations in North Africa (Boudy, 1955; DGF, 1988). Due to its unique characteristics, the site has been protected since 1936. In 1980, it was declared a national park with the current size of 16,488 ha. The Park's area is divided into several protection zones extending between the mountains and the surrounding plain.

In addition to the Mhorr gazelles, BHNP is home to a native population of dorcas gazelle (*Gazella dorcas*) and reintroduced species such as scimitar-horned oryx, addax and, in the mountains, herds of Barbary sheep (*Ammotragus lervia*). Predators are represented by the North African wolf (*Canis anthus*), the caracal (*Caracal caracal*) and the striped hyena (*Hyaena hyaena*).

For this survey we analyzed the available official monitoring data from the time of arrival of the first Mhorr gazelles in 1990 until 2010. Supplemental information was extracted from

miscellaneous literature (Cammaerts, 2003; Jebali et al. 2012; Jebali & Zahzah, 2013) or obtained from our field observations.

Results

The Mhorr gazelle releases in BHNP began in 1990 with the transfer of 5 (2.3) gazelles from different German zoos (Table 1). Unfortunately, 4 (1.3) individuals died just few days after their arrival. An additional female transferred in 1991 died of exhaustion 3 days after arrival. In 1992, two more females from Zoo Berlin provided a limited boost to the small population, which recorded its first birth in 1993.

The gazelles were kept for two years in a 10-ha acclimatization enclosure and subsequently reproduced. In early 1994, the group reached 7 (3.4) individuals, which were released in the Integral Protection Zone N°1 (IPZ 1) that covered 2000 ha.

Figure 1: Location of Bou Hedma National Park in Tunisia.

Photo 1: A group of Mhorr gazelle in the Integral Protection Zone N°1, in 2018 (© Jon Hall, mammalwatching.com)

In October 1994, the last transfer of 14 (4.10) gazelles from the Estación Experimental de Zonas Áridas in Almería, Spain, notably increased the population. As in previous transfers the gazelles were kept in the same 10ha pen for five months and then released in the IPZ 1 to join the « German » gazelle group (photo 1).

Table 1: History of the founding herd of Mhorr gazelle (*Nanger dama mhorr*) population living in Bou Hedma National Park between 1990 and 1994 (compilation : A. Jebali)

Date	Received	Born	Dead	Death causes	Remaining
1990	5(2.3) from Germany	0	4(1.3)	**1**M : fight with the dominant male. **3**F : collision with the fence.	1M
1991	1(0.1) from Germany	0	1(0.1)	**1**F : exhaustion caused by the trip.	1M
1992	2(0.2) from Germany	0	0	-	3(1.2)
1993	0	1F	0	-	4(1.3)
1994	14(4.10) from Almeria	3(2.1)	0	-	21(7.14)

F: Female; M: Male

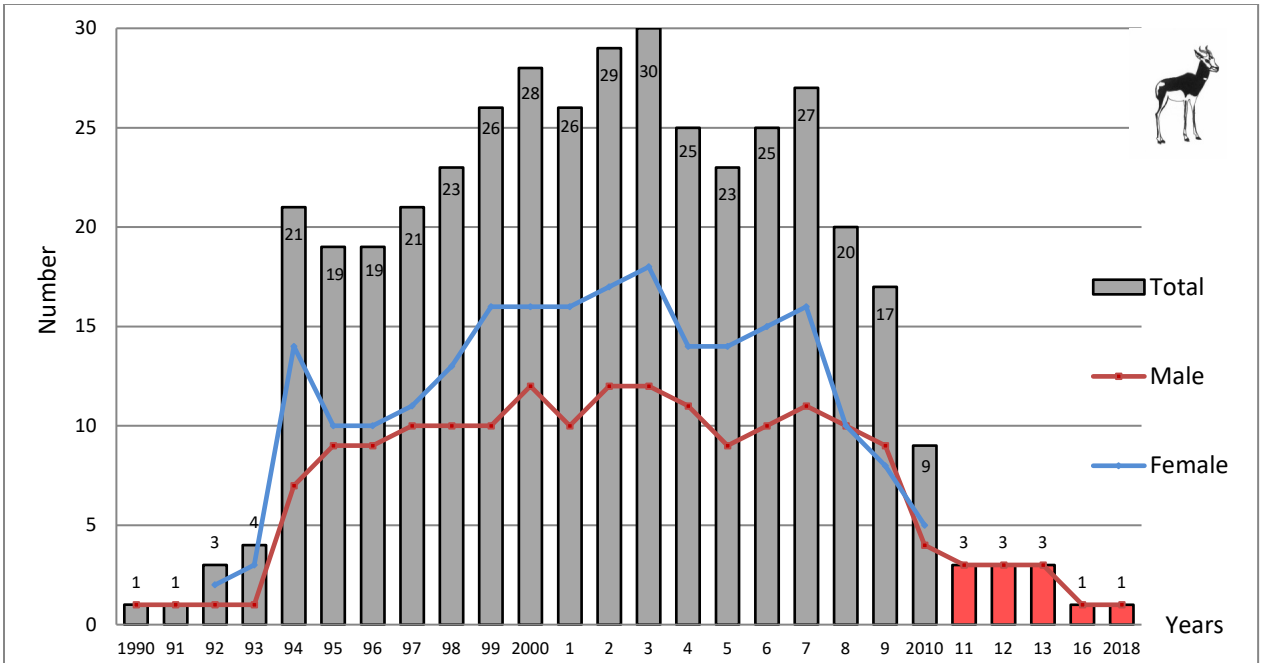

Figure 2: Annual population size of the Mhorr Gazelle (*Nanger dama mhorr)in* BHNP, Tunisia between 1990 and 2018

Figure 2 illustrates the evolution of the released Mhorr gazelle population in BHNP from 1990 to 2018. The graph shows the population reached a maximum of 30 individuals in 2003. This peak was followed by a fall in numbers during the years 2004-2005, followed by growth in 2006-2007. Since 2007 the Mhorr gazelle population has shown a steady, significant decrease, particularly between 2009 and 2011. A recent census (Jebali et al. 2012) confirmed this result. Only 3 males were found in 2012 (Fig. 2) and only one remained in 2018 (Photo 2). The number of females in the population was always higher than males until 2008 when the number of both sexes was equal. In 2009 the number of males was higher and by 2011 no females were left.

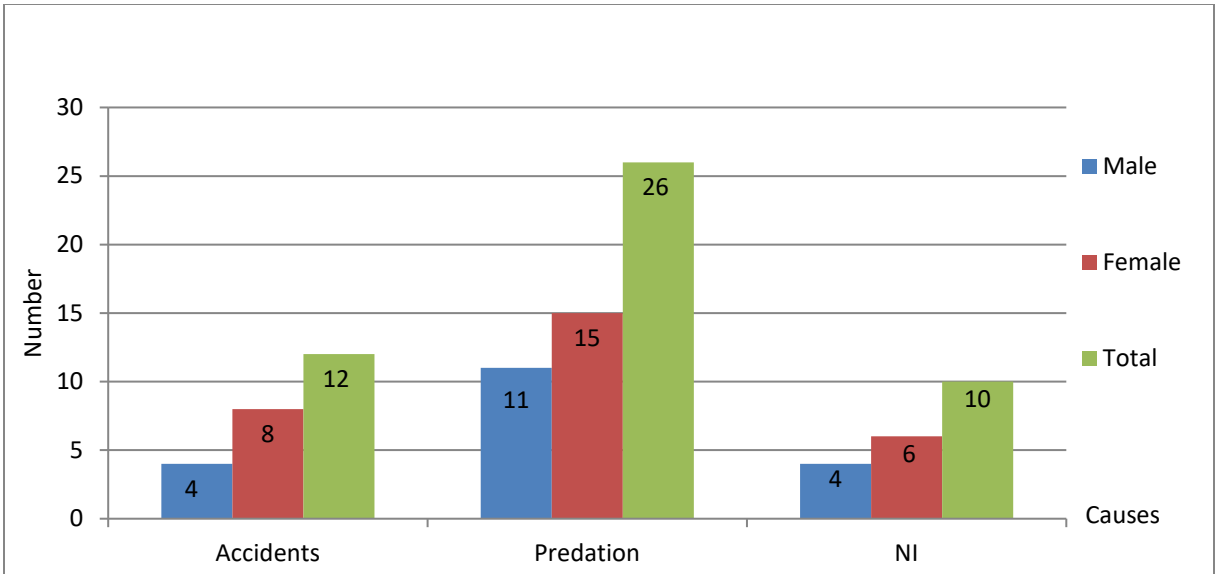

Figure 3: Death causes of the Mhorr gazelle (*Nanger dama mhorr*) in BHNP, Tunisia, between 1990 and 2010

Changes in the Mhorr gazelle population size for 21 years (1990-2010) show that:
- The number of deaths (48) exceeds that of births (41).
- The overall mortality rate is higher in females (n=29, 60.4%) than in males (n=19, 39.6%) and recorded data revealed that deaths were higher in juveniles than in adults.

According to the data, the main cause of mortality was related to predation events (n=26, 54.2%), followed by accidents (n=12, 25%). Moreover, there were 20.8% (n=10) non-identified cases.
- Recorded data show that females suffered more frequent attacks of predators during parturition following their isolation from the group.
- One quarter of deaths are attributed to accidents (25%), either during or as a result of, transfer or in the acclimatization enclosure (fighting between males, collision against the fence).

Discussion and Conclusion

As shown above, the Mhorr gazelle release project in Tunisia scarcely progressed in the beginning because of multiple deaths. Reasons for that seem to be linked to the period of acclimatization and the changes in conditions which occurred from zoo management to semi-wild management in large enclosure, and possibly from the stress generated by handling (Teixeira et al. 2007).

The reinforcement with Almeria's animals in 1994 gave an obvious boost to the small German herd, suggesting the importance of a high numbers of founders to initiate reintroduction projects (Ahlroth et al. 2003; Matson et al. 2004).

The data showed that reported predation was a major limiting factor of the Mhorr gazelle population in the park contributing to the loss of more than 50% of the gazelles. The mortality was relatively high for both sexes, however, females were affected more heavily. One explanation could be attacks by wolves against females when they isolated themselves from the herd to give birth (Conservator pers. comm.) resulting in the loss of the mother and her new-born.

The effects of handling related accidents at the beginning of the project caused the death of one quarter (25%) of the gazelles. In combination, handling related accidents and predation account for nearly 80% of the Mhorr gazelle mortality. Poaching and mismanagement may be part of unidentified causes of mortality, however this remains difficult to clearly quantify due to lack of reliable data.

Photo 2: The last Mhorr gazelle (a male) in Bou Hedma National Park, Tunisia, with a Scimitar-hormed Oryx (© Abdelkader Jebali).

In consideration of the heavy mortality among juveniles, the conspicuous population decline after 2007 may reflect the eventual death of adults finally reaching the end of their life span (Mungall, 2018). The acute decline since 2007 resulted in the functional extinction of the Mhorr gazelle in BHNP in early 2011.

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We would like to acknowledge the Direction Générale des Forêts (DGF) for its collaboration and thank all the people who facilitated the data collection. We thank Jon Hall for providing the Mhorr gazelle herd picture. The authors appreciate Elizabeth Cary Mungall of the Second Ark Foundation for her comments on the draft of this paper.

References

Abaigar, A. Cano, M. Espeso, G. & Ortiz, J. 1997. Introduction of Mhorr gazelle in Bou Hedma National Park, Tunisia. *International Zoo Year-Book* 35: 311-316.

Ahlroth, P. Alatalo, R.V. Holopainen, A. Kumpulainen, T. & Suhonen, T. 2003. Founder population size and number of source populations enhance colonization success in water striders. *Conservation Ecology*. 137: 617-620.

Boudy, P. 1955. *Description forestière de l'Algérie et de la Tunisie*. In vol 4, Economie forestière nord -africaine. Larose. 483p.

Cammaerts, D. 2003. *Gazella dama mhorr*: observations éco-éthologiques en conditions de semi-liberté d'un taxon éteint à l'état sauvage. Diplôme de DES en Gestion de l'Environnement. Belgique. 122p + annexes.

Cano, M. & Abaigar, T. 2003. Former presence of Mohor gazelle (*Gazella dama mhorr*) in Tunisia, as derived from its presence in Bardo's National Museum Roman Mosaïcs. Preceedings *of the Fourth Annual Sahelo-Saharan Interest Group*. Agadir, Morocco. pp: 40-42.

DGF (Direction Générale des Forêts). 1988. *Parcs nationaux de Tunisie: le Bou Hedma*. Imprimerie Arabe de Tunisie. 11p

Jebali, A. Tahri, J. & Gandour, H. 2012. Recensement et sex-ratio des antilopes Sahélo-sahariennes réintroduites dans les aires protégées du Sud Tunisien. Rapport Technique préliminaire N°1 pour EWA Conservation Committee et DGF. Unpublished report.12p.

Jebali, A. & Zahzah, K. 2013. Causes et trajectoires de mortalité chez deux gazelles réintroduites en Tunisie: la gazelle Mohor (*Nanger dama mhorr*) au parc national de_Bou Hedma et la gazelle de l'Atlas (*Gazella cuvieri*) dans le parc national de Bou Kornine. Rapport non publié pour la DGF. Unpublished report. 28p.

Pervinquière, L. 1912. *La Tripolitaine interdite – Ghadamès*. Hachette & Cie, Paris 215p.
Matson, T.K. Goldizen, A.W. & Jarman, P.J. 2004. Factors affecting the success of translocations of the black-faced impala in Namibia. *Biological Conservation*. 116: 359-365.

Mungall, E. C. ed. 2018. *The Dama Gazelles: last members of a critically endangered species*, Texas A & M University Press, College Station, TX, USA. 252p.

Teixeira, C.P. De Azeverde, C.S. Mendel, M. Cipreste, F. & Young, R.J. 2007. Revisiting translocation and reintroduction programmes: the importance of considering stress. *Animal Behaviour*. 73(1): 1-13.

Distribution, abundance, and natural history of Lelwel hartebeest (*Alcelaphus buselaphus lelwel* Heuglin, 1877) on Lolldaiga Hills Ranch, central Kenya

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Lelwel hartebeest (or 'Kenya highland hartebeest') (*Alcelaphus buselaphus lelwel*) (Heuglin, 1877) is an 'Endangered' subspecies (IUCN 2017; Figures 1 and 2). In Kenya, Lelwel hartebeest (henceforth, 'hartebeest') is now primarily restricted to Laikipia County were only about 1,000 individuals remain (Butynski and De Jong, in prep.). Hartebeest are strictly grazers that live in habitats dominated by grass, namely open and lightly wooded plains. They typically forage on short grass during the wet season and on long grass during the dry season in areas where drinking water is available (Gosling and Capellini 2013).

Figure 1. Adult male Lelwel hartebeest *Alcephalus buselaphus lelwel*, Lolldaiga Hills Ranch, Laikipia County, central Kenya (© Yvonne de Jong and Tom Butynski).

Figure 2. Adult female Lelwel hartebeest *Alcephalus buselaphus lelwel,* Lolldaiga Hills Ranch, Laikipia County, central Kenya (© Yvonne de Jong and Tom Butynski).

On Lolldaiga Hills Ranch (*ca.* 200 km²; *ca.* 1,700-2,300 m asl; www.lolldaiga.com), eastern Laikipia County, central Kenya, the altitudinal range known to be occupied by hartebeest is *ca.* 1,750–2,100 m asl. The 'Extent of Occurrence' (IUCN 2012) during August 2013–March 2019 was *ca*. 73 km², or *ca.* 37% of Lolldaiga Hills Ranch (hereafter, 'Lolldaiga'; Figure 3).

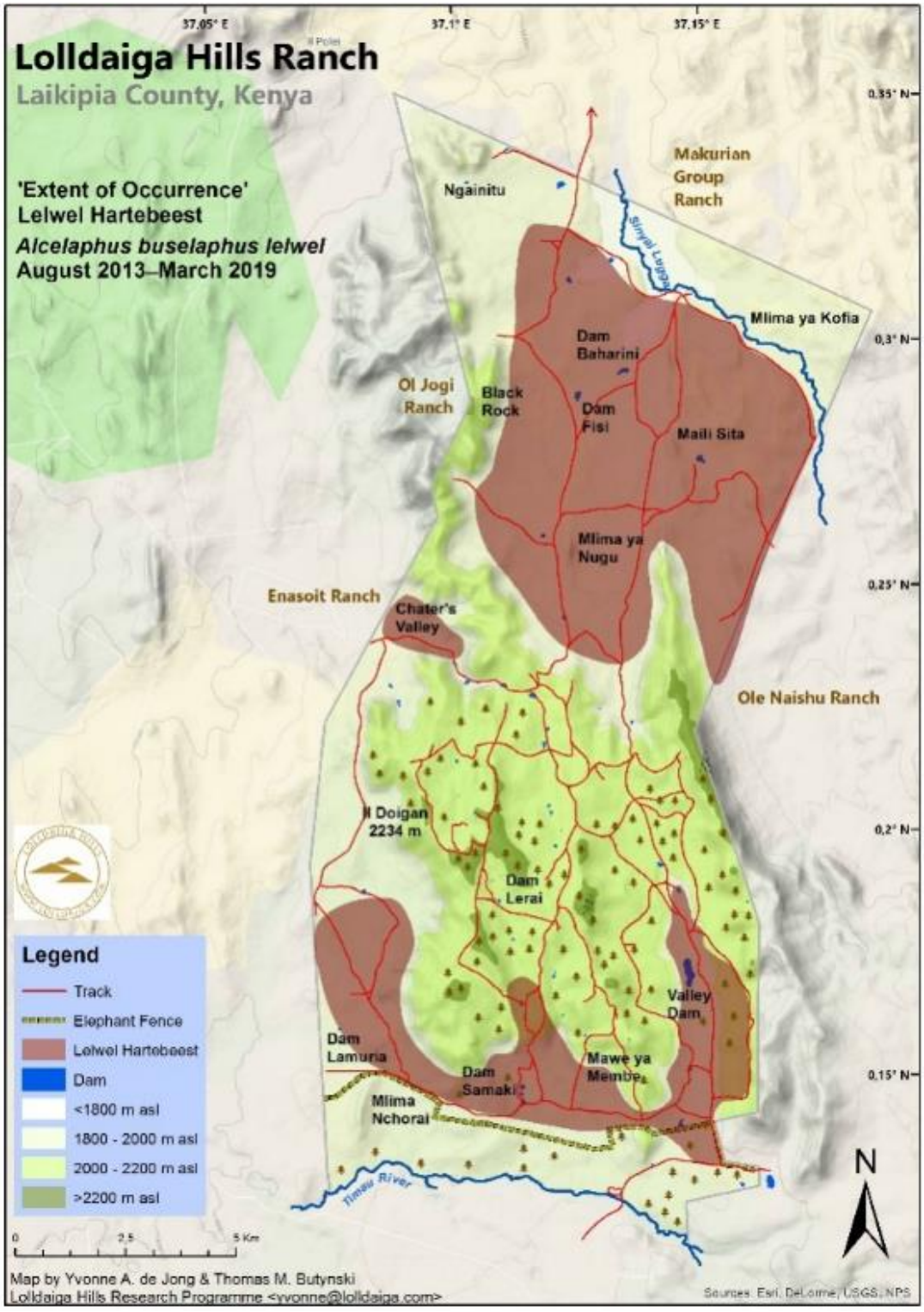

Figure 3. Distribution of Lelwel hartebeest *Alcephalus buselaphus lelwel* on Lolldaiga Hills Ranch, Laikipia County, central Kenya (August 2013–March 2019). Map by the authors.

Hartebeest were absent on Lolldaiga from at least 1960 until about 1982. Numbers peaked at about 100 individuals towards the end of the 1990s and remained at this level until around 2010 (Robert Wells, pers. comm.). The number of hartebeest on Lolldaiga varied greatly from August 2013 through March 2019; there were as many as 39 individuals in 2013 but none during much of 2018 (Table 1). Thus, density within the 'Extent of Occurrence' varied from no hartebeest to 0.5 hartebeest/km². These changes in numbers on Lolldaiga appear to be largely because hartebeest moved freely to the east onto and off of the contiguous Ole Naishu Ranch (*ca*. 125 km²) and to the west onto and off of the contiguous Enasoit Game Sanctuary (*ca.* 17 km²; Figure 3) as grazing conditions and the availability of water dictated. At least some of the change is, however, due to predation, as approximately 20 lion (*Panthera leo*), 30 leopard (*Panthera pardus*), 12 cheetah (*Acinonyx jubatus*), 200 spotted hyaena (*Crocuta crocuta*), and three packs of wild dog (*Lycaon pictus*) used Lolldaiga during this period. All five of these species kill hartebeest of all ages. Black-backed jackal (*Canis mesomelas*) and olive baboon (*Papio anubis*), both common on Lolldaiga, kill new-born calves (Gosling 1969, Gosling and Capellini 2013).

Year	**Number of hartebeest**
2013	16–39
2014	20–35
2015	17–22
2016	9–12
2017	20–23
2018	0–8
2019	19–22

Table 1. Approximate range in the number of Lelwel hartebeest *Alcelaphus buselaphus lelwel* on Lolldaiga Hills Ranch, Laikipia County, central Kenya, during each year from August 2013 through March 2019.

Size of hartebeest herds on Lolldaiga during 2013–2019 ranged from 2 to 23 individuals. Mean herd size was *ca.* 8 individuals. The number of herds on Lolldaiga at any one time varied from none to five, and the number of lone adult males on territories ranged from none to two.

Thirty-two calves are known to have been born during this period. Calves that lack horns are <1 month of age (Figure 4; Gosling 1969). The monthly distribution of births is as follows: 1 January; 3 February; 6 March; 7 April; 2 May; 1 June; 7 October; 4 November; 1 December. No new-born calves were observed during July–September. As such, there appears to be two birth seasons, both focused on the two wettest periods (April–May and October–November). This bimodal pattern of calving is also documented for Coke's hartebeest (*Alcelaphus buselaphus cokii*) in Nairobi National Park, central south Kenya (Gosling 1969). Calving one to two months (February–March) prior to, and during, the wettest period (April–May) helps to ensure that there is abundant green grass and water during lactation and early weaning and, again, 7–8 months later when calves are fully weaned (Gosling 1969, Kok 1975).

A gestation of about 8 months (Gosling 1969) means that hartebeest on Lolldaiga mate mainly during July–October and March–April.

Figure 4. Adult female Lelwel hartebeest (*Alcephalus buselaphus lelwel*) with new-born calf, Lolldaiga Hills Ranch, Laikipia County, central Kenya (© Yvonne de Jong and Tom Butynski).

Figure 5. Adult female Lelwel hartebeest (*Alcephalus buselaphus lelwel*), Lolldaiga Hills Ranch, Laikipia County, central Kenya. This female is probably pregnant (© Heather Wall).

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References

Butynski, T.M. and De Jong, Y.A. In prep. Distribution and abundance of Lelwel hartebeest *Alcelaphus buselaphus lelwel* (Heuglin, 1877) in Laikipia County, central Kenya.

Gosling, L.M. 1969. Parturition and related behaviour in Coke's hartebeest *Alcelaphus buselaphus cokei* (Günther). *Journal of Reproduction and Fertility* (Supplement) 6: 265–286.

Gosling, L.M. and Capellini, I. 2013. *Alcelaphus buselaphus* hartebeest. In: J. Kingdon and M. Hoffmann (eds). *Mammals of Africa, Volume VI. Pigs, Hippopotamuses, Chevrotain, Giraffes, Deer and Bovids,* pp. 511–526. Bloomsbury, London, UK.

IUCN. 2012. *IUCN Red List Categories and Criteria: Version 3.1*. Second edition. Gland, Switzerland. Available at: https://portals.iucn.org/library/sites/library/files/documents/RL-2001-001-2nd.pdf. (Accessed: 09 April 2019).

IUCN. 2017. *Alcelaphus buselaphus ssp. lelwel*. *The IUCN Red List of Threatened Species* 2017. Available at: https://www.iucnredlist.org/species/816/50181544. (Accessed: 09 April 2019).

Kok, O.B. 1975. Behaviour and ecology of the red hartebeest (*Alcelaphus buselaphus caama*). *Nature Conservation, Bloemfontein, Orange Free State Provincial Administration, Miscellaneous Publication* No. 5.

Figure 6. Adult male Lelwel hartebeest (*Alcephalus buselaphus lelwel*), Lolldaiga Hills Ranch, Laikipia County, central Kenya (© Yvonne de Jong and Tom Butynski).

Update on antelope status in Niokolo Koba National Park, Senegal

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Located in the Sudano-Guinean zone, Niokolo-Koba National Park is characterized by a wide diversity of habitats and the presence of several large waterways, including the Gambia river, and ponds over an area of 913,000 ha. Amongst these habitats, you can find gallery forests, floodplains, dry forests, rocky hills and barren bowés which are home to the widest diversity of large antelope in West Africa, including the last wild population of Western Derby Eland. Based on its remarkable diversity of wildlife and habitats, the Niokolo-Koba National park was classified as a World Heritage Site in 1981. However, over the last 3 decades the park has been subject to many pressures such as poaching, bushfire, encroachment on agricultural land and livestock mainly due to mismanagement and was finally inscribed on the list of World Heritage in Danger list in 2007. Despite a dramatic decline in large mammal population sizes during the last decades (Howard et al. 2007; Renaud et al. 2006), the guild of large antelopes is still present except for the korrigum (*Damaliscus lunatus korrigum*) according to East (1999) and IUCN (2017).

Thanks to the financial support of UNESCO, a technical assistance mission was carried out in 2015 to design a new monitoring system based on a combination of several methods: ground surveys (vehicle and foot) and camera trapping (Rabeil 2015). Systematic ground surveys were conducted since 2016 and a grid of camera trapping evolved over the years according to the number of camera traps available. For the first ever time, in 2018, a full set of monitoring methods were used to assess the status of the Niokolo-Koba National Park and we were able to provide results from a combined aerial and ground survey and 6 months of camera trapping (77 camera traps). The combined ground (vehicle and foot) and aerial survey was funded by Randgold in the framework of their support to the Senegalese wildlife authorities (Direction des Parcs Nationaux du Sénégal). Randgold is a mining company working on the Massawa project located in the Kedougou region, 40 km from Niokolo-Koba NP.

The objective of the aerial survey was to assess the Park status in terms of human pressure and estimate large ungulate populations with a limited amount of time which excluded the possibility to carry out a complete aerial census. The method chosen to fulfil the present objective was to fly a constant effort transect survey, sampling the entire study zone (913,000 ha) at an evenly distributed 22% coverage. This was done using standard fixed strip-width survey methods (Norton-Griffiths 1978). Survey transects were set 4 km apart, with an average altitude of 131 m, and sample strip-width 450 m on either side of the aircraft, giving an expected 900 m combined strip-width for each transect. The average speed was 147 km/hour and observation conditions were good over the aerial survey period with a clear weather, just a little bit hazy early in the morning. In the absence of a radar altimeter, we used information provided by the Air Navigation Pro application.

We present here the main results regarding the population estimate for some large mammal species from the camera trapping survey and the combined ground (vehicle and foot transects) and aerial survey carried out in February 2018 in Niokolo-Koba National Park (Senegal). For further information, please see the final technical report (Rabeil et al. 2018).

Aerial Survey Results

Common Waterbuck (© Thomas Rabeil)

Because the scale of the survey was large and the size of ungulate species population known to be low (see Renaud et al. 2006), small sample sizes were anticipated. For this reason, a lognormal estimator was used to derive statistical confidence limits from our sample estimates of target species population sizes. This method has the advantage of being constrained to report asymmetric confidence limits which are greater than zero and is suitable for small data sets with low precision (Milner-Gulland and Rowcliffe 2007). In the table below we added the results from the 2006 aerial survey (40% coverage) for comparison.

Though it is not based on the same methodology, figures for most of the antelope species are very similar, indicating the antelope populations are stable in Niokolo-Koba except for roan antelope which has doubled its population over the last 12 years. These figures must be taken into account very carefully because population estimates based on aerial survey are relatively reliable for some species like roan antelope, buffalo and hartebeest, but not for others like oribi or bushbuck due to their socio-ecological and behavioral features (Jachmann 2002).

Common Duiker (© Thomas Rabeil)

Buffon's Kob (© Thomas Rabeil)

Western Hartebeest (© Thomas Rabeil)

	2018 aerial survey			2006 aerial survey
Species	**Low estimate**	**High estimate**	**Estimate**	**Total counting**
Western Hartebeest	32	141	67	149
Buffalo	372	753	529	457
Red-flanked Duiker	325	429	373	89
Common Duiker	192	271	228	258
Waterbuck	218	478	323	10
Bushbuck	223	325	269	132
Roan Antelope	1 451	2 076	1 735	710
Oribi	37	78	53	45
Warthog	396	557	470	1041

Table 1. Summary of population estimate with Lognormal method based on aerial survey data collected in 2018 and comparison with results from 2006

Ground survey - vehicle transects results

We used Distance© sampling to provide population estimates from vehicle transects according to a standardized protocol developed in 2015 (Rabeil 2015). A total of 576 km split into 6 itineraries was repeated 3 times over a period of 6 days in order to reach a minimum of 40 observations per species as recommended by Buckland et al. (1993). Figures from Distance sampling provided relevant information which once again must be analyzed carefully due to the known biases and limitations of the estimate calculation. We can see the huge difference between results from ground and aerial survey. Without getting into the details regarding comparison methods, aerial surveys underestimate populations (Jachmann, 2002) except when focused on a single species like elephant (Norton-Griffiths 1978).

	Ground survey – vehicle transects, February 2018		
Species	**Low estimate 95% -Cl**	**High estimate 95% +Cl**	**Estimate**
Red-flanked Duiker	13 046	6 401	9 138
Common Duiker	3 219	1 532	2 221
Kob	4 579	1 642	2 742
Waterbuck	2 063	1 062	4 008
Bushbuck	15 867	9 895	12 530
Roan Antelope	7 538	1 878	3 763
Oribi	5 501	2 505	3 713
Warthog	4 910	8 904	6 612

Table 2. Summary of population estimates using Distance sampling based on vehicle transects.

Ground survey – foot transects results

Foot transects of 5 km were designed according to blocks within Niokolo-Koba NP. A total of 1,440 km was surveyed by foot over an 8-day period. The method Distance sampling in line-transect was used here to provide population estimates and confidence limits. Only 4 antelope species (roan antelope, bushbuck, warthog and oribi) had enough direct observations to calculate a population estimate.

	Distance sampling line-transect, February 2018		
Species	**Low estimate 95% -Cl**	**High estimate 95% +Cl**	***Population Estimate***
Roan Antelope	1 375	6 021	2 877
Bushbuck	269	4 502	3 011
Warthog	8 366	15 395	11 347
Oribi	2 119	3 581	3 116

Table 3. Summary of population estimate with Lognormal and Distance sampling methods based on foot transects.

Population estimate method comparison

The table below highlights disparities between population estimate according to the calculation method used which can be helpful to select the appropriate method by species to assess population trend and species status.

Species	Population estimates, Niokolo-Koba National Park, February 2018		
	Aerial survey	*Ground survey*	
		Vehicle-transect	*Foot-transect*
Roan Antelope	1 735	3 773	2 877
Bushbuck	2 014	12 530	3 011
Warthog	470	6 612	11 347
Oribi	53	3 713	3 116

Table 4. Population estimate method comparison between aerial survey and ground (vehicle & foot transect) surveys.

Camera trapping results

Seventy-seven camera traps were deployed within the park based on a systematic grid analysis methodology (Figure 1).

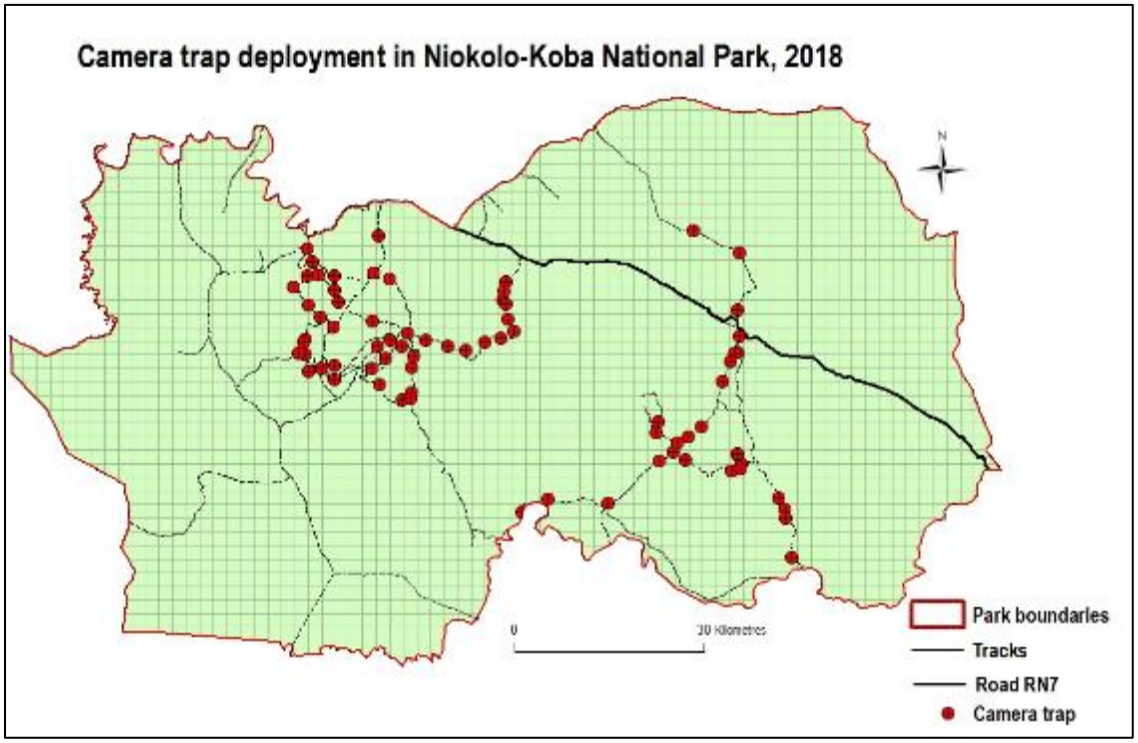

Figure 1: Map of camera traps deployed in Niokolo-Koba National Park in 2018.

The unit of 2x2 km was selected according to 2017 camera trap records with a focus on 5 flagship species: Derby Eland, Wild Dog, Lion, Leopard and Chimpanzee, which explains the camera trap distribution. Only 3 cameras did not work at all during the whole deployment, a relative performance of 96%. For the rest of the cameras the number of functional days varied from 5 to 172 days (the full period of deployment). 50% of the cameras were operational for at least 100 days which is considered ideal to calculate the species richness and provide accurate trapping rates

and occupancy. Trapping rates are calculated as 'events / 100 days' using cameras that operated for more than 50% of the target survey period. An event is the presence of a species in front of the camera using the time lapse of 60 minutes. It is important to mention that these data provide indicators about the distribution of the species within the sampled area. The camera trapping rate provides a simple index of relative abundance under the assumption that, all things being equal, species will trigger cameras more frequently when they are numerous, and vice versa. Of course, many things can perturb this simple relationship, not least the chance effects of camera position in relation to important food or other resources (e.g. proximity of fruiting trees or undetected pathways, human presence, etc.), which can easily distort photo frequencies for reasons unrelated to abundance alone. We used the software Camera Trapping Analysis Tool developed by the Zoological Society of London to analyze the data (Amin et al. 2017).

Figure 2 illustrates the trapping rates of 6 large-antelope species in the Niokolo-Koba National Park. The roan antelope has the largest relative abundance within the sampled area and triggered the cameras 4 times more than kob and 10 times more than Western Derby eland.

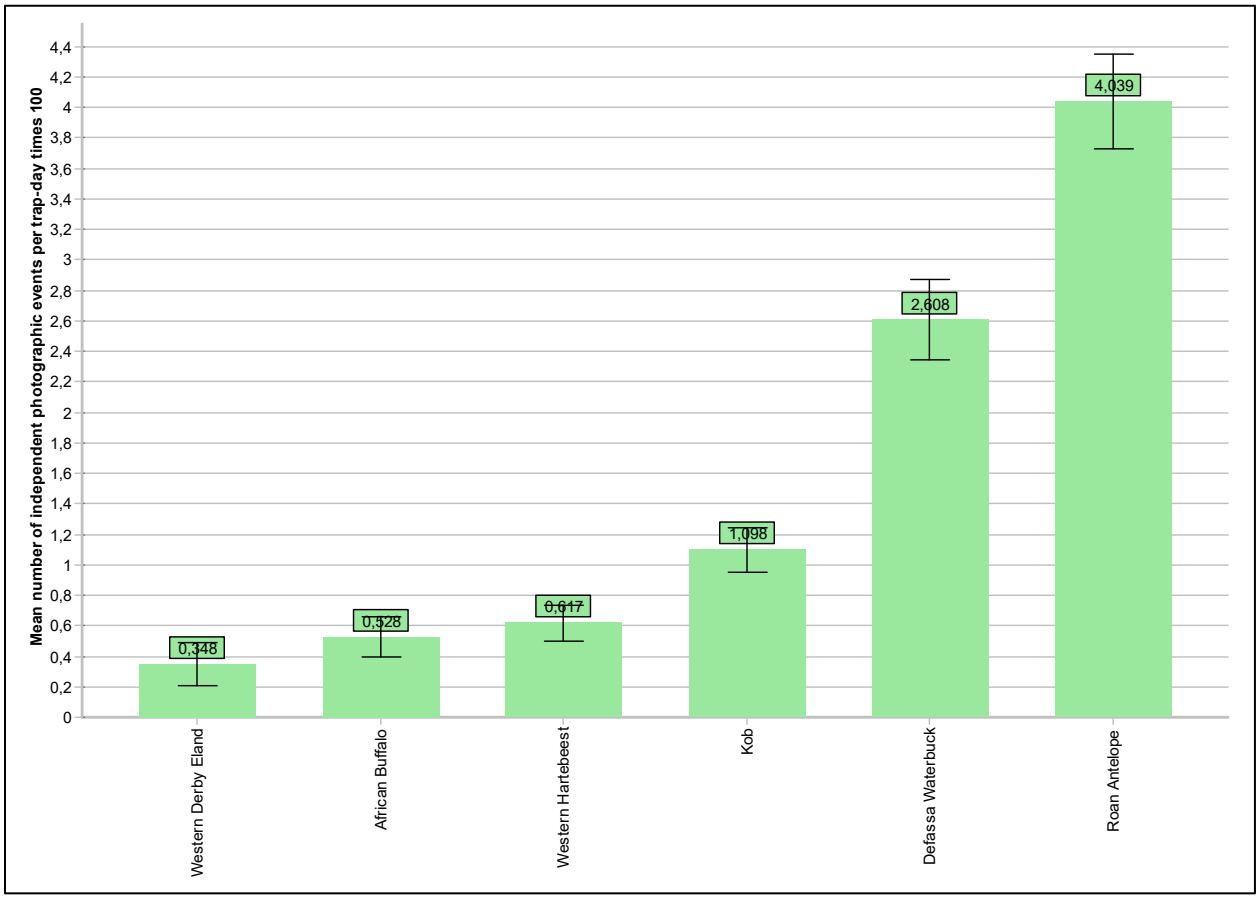

Figure 2: Large-antelope species trapping rate in Niokolo-Koba National Park, 2018.

Although Western Derby eland was the least photographed species amongst the large-antelopes of the Park, its trapping rate was relatively high in one specific area (Assyrick-Mansafara) compared to the same large antelope species (Figure 3). Large herds of Western Derby Eland (with more than 40 individuals) were photographed several times at the Mansafara pond. Individual identification analysis based on these photographs is ongoing to provide accurate figures of the last wild population of Western Derby eland (IUCN SSC/ASG, 2017).

Western Derby Eland (© Direction des Parcs Nationaux)

Western Derby Eland (© Direction des Parcs Nationaux)

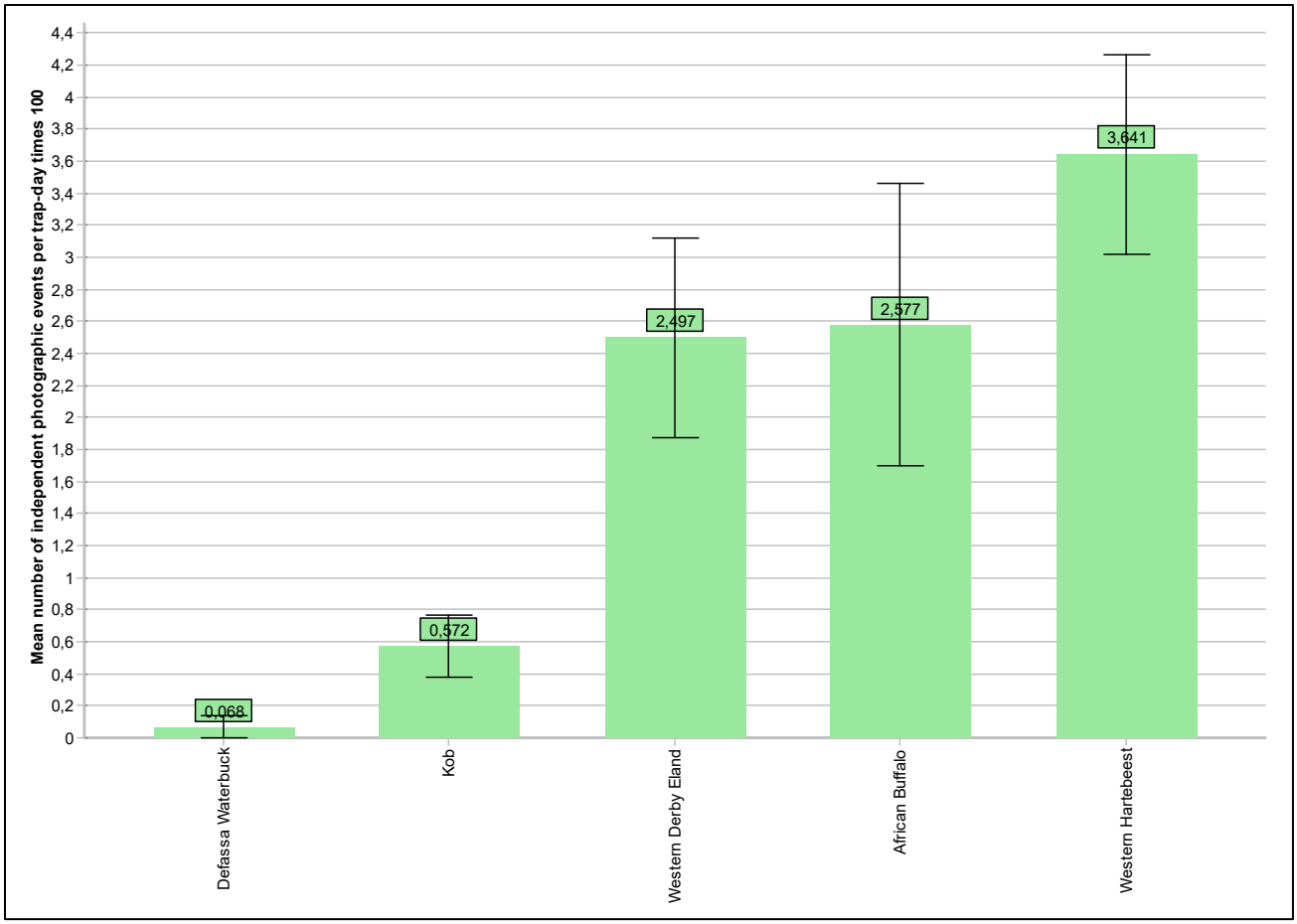

Figure 3: Large-antelope species trapping rate in Assyrick-Mansafara area, 2018.

Regarding smaller species, bushbuck and warthogs were the most photographed species within the sampled area which is not surprising based on the estimate ground surveys. This said, it does not mean bushbucks are more numerous than warthogs as indicated from the vehicle-transect survey, because we compare trapping rate and not numbers of individuals per event. This estimate disparity between the methods emphasizes how unreliable it is to focus only on one method to provide accurate figures for population estimates.

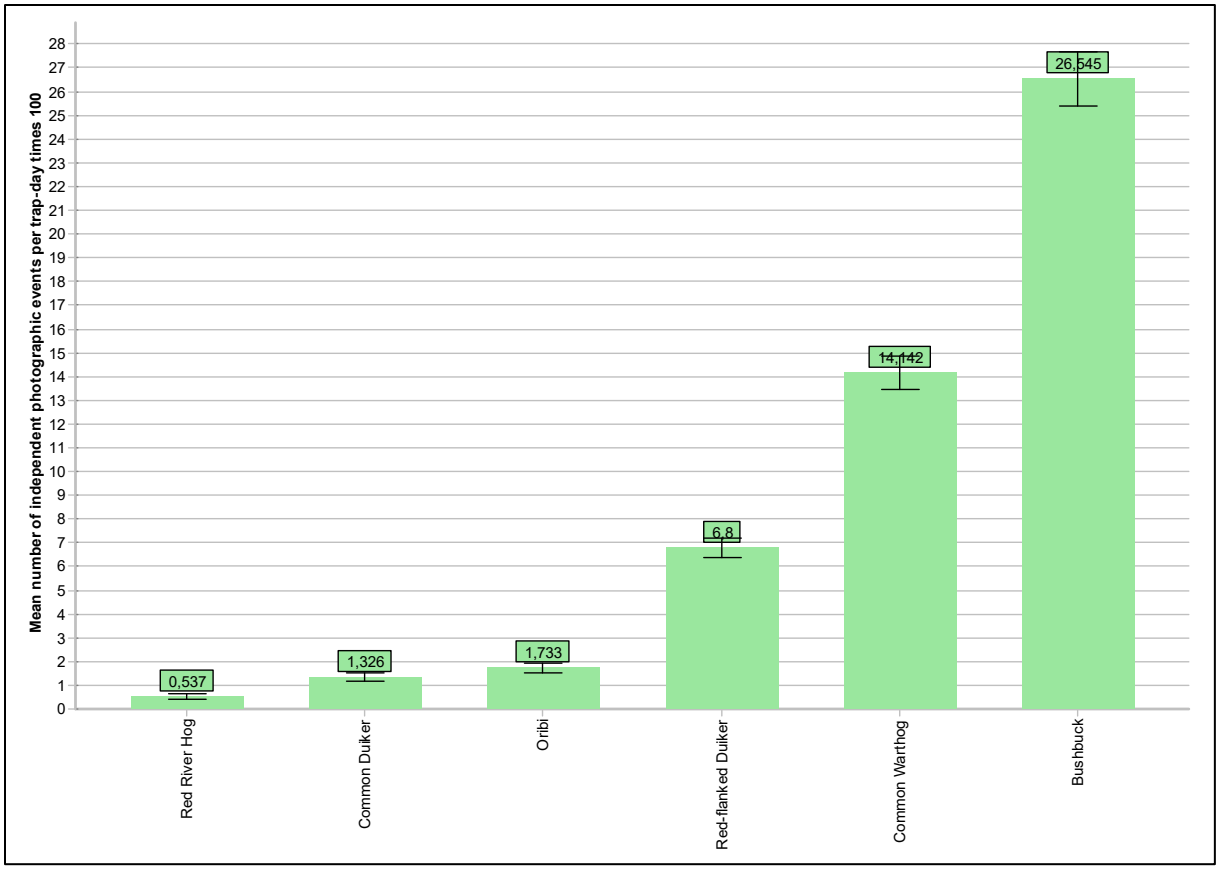

Figure 4: Small-antelope species trapping rate in Niokolo-Koba National Park, 2018.

Red-flanked Duiker (© Direction des Parcs Nationaux)

Red River Hog (© Direction des Parcs Nationaux)

West African Bushbuck (© Direction des Parcs Nationaux)

Oribi (© Direction des Parcs Nationaux)

It is important to note that antelope predators are present in the Park with high relative abundance in comparison to other protected areas in West Africa though these species are suffering an important decline (e.g. Western lion is listed as Critically Endangered on the IUCN Red List). Though it is risky to compare figures while methodologies used are different, the combined naïve occupancies (proportion of area occupied by a species, MacKenzie et al. 2006) of lion (0.42) and leopard (0.37) in Niokolo-Koba NP seem to be the highest in West Africa protected areas along with the one in Pendjari National Park in Benin (Adibio 2017).

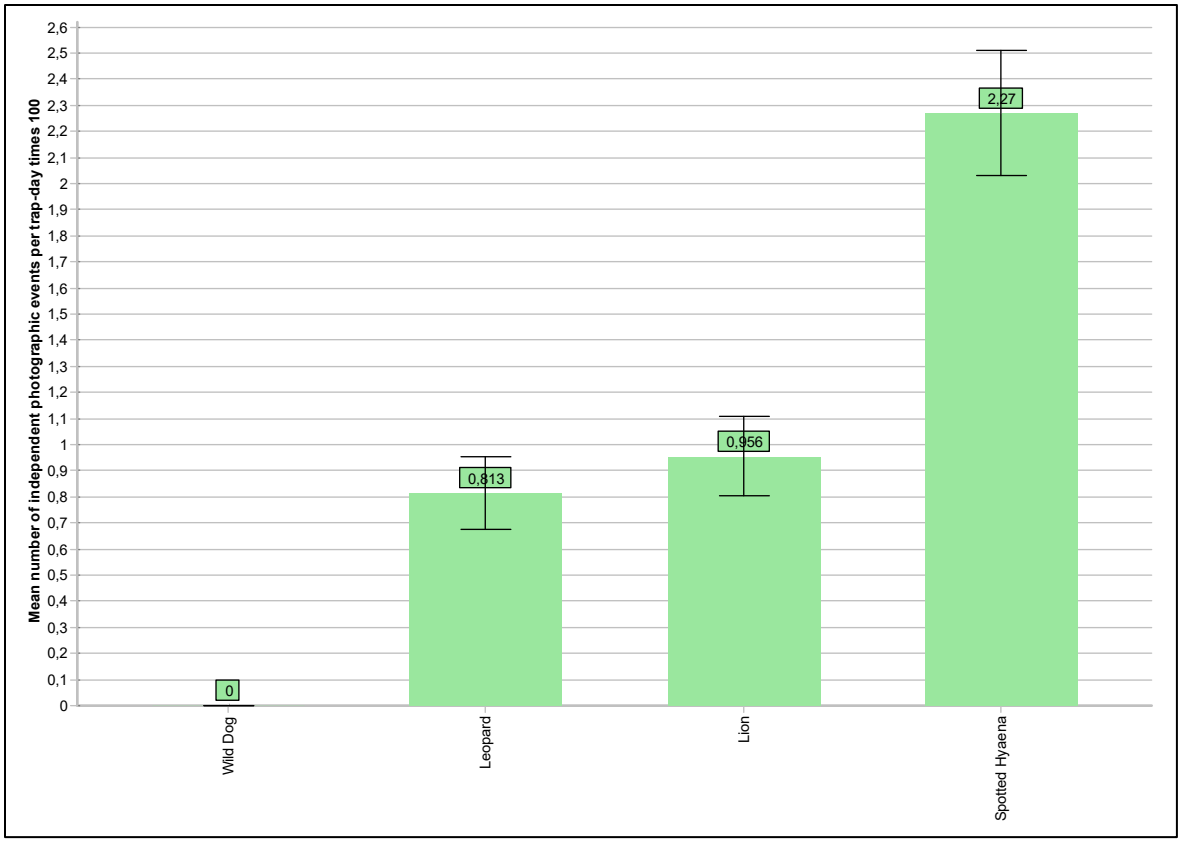

Figure 5. Large-carnivore species trapping rate in Niokolo-Koba National Park, 2018.

Conclusion

For the first time, thanks to the support of Randgold and UNESCO, a combined aerial, ground and camera trapping survey was carried out in the Niokolo Koba NP in Senegal to provide information about distribution and relative abundance of large mammals, including the 5 flagship species: Lion, Leopard, Wild Dog, Derby Eland and Chimpanzee.

The results of the different surveys highlight:

- There is still a very good diversity of large mammals in the Park, including antelopes, probably the biggest diversity in the savannah ecosystem amongst the protected areas in West Africa though elephants are almost extinct according to the very few data collected during the survey (2 indirect sightings of 1 elephant track collected during foot-survey and few images from camera trap deployed by DPN and Panthera since 2016).
- Estimates of large mammal populations derived from ground and aerial surveys must be treated very carefully. They must be seen as good indicators to assess trends over the time and good tools to assess management efficiency.
- Derby eland are only distributed in the Assyrick area with a relatively high trapping rate in the Mansafara loop, likewise Western hartebeest. Some pictures showed 40 individuals with a good proportion of calves and juveniles, indicating a good breeding rate of this population. The results outline the need to implement urgently appropriate conservation activities while the population is still healthy with more than 100 individuals, in all

likelihood. A collaring operation would help to improve knowledge about the distribution and the limiting factors related to population expansion in number and home range.

- The conservation status of western hartebeest is alarming with an ongoing decline (IUCN SSC/ASG, 2017) and we recommend to increase monitoring effort by collaring a dozen individuals to improve knowledge about their distribution and threats in the Park.
- Based on the trapping rates, the relative abundance of wild dog is very low compared to the other large carnivore species (leopard and lion). Conservation effort, including specific monitoring, should focus primarily on wild dog amongst large carnivore species. Considering the conservation status of this species in Africa and in particular the ongoing decline in West Africa, and the unique genetic characteristics of this isolated population, an emergency conservation program should be carried out.
- Lion and leopard are well distributed in the park "except or less" along the Gambia River, probably due to the disturbance from human activities (illegal livestock, traditional mining, etc.). Since the sampled area along the river was very small, this must be considered carefully. Though it is not possible to provide accurate estimate of the lion and leopard populations based on these results, the conservation status of these populations seems to be good. The limiting factors for increase are certainly related to prey densities and human disturbance in some areas.
- Based on the trapping rates, the relative abundance of African wild dog is very low compared to the other large-carnivore species (leopard, lion and spotted hyena). Conservation effort, including a specific monitoring, should focus primarily on African wild dog amongst large carnivore species. Considering the conservation status of this species in Africa and in particular the ongoing decline in West Africa, and the unique genetic characteristics of this isolated population, an emergency conservation program should be carried out.
- In terms of threats, bushfires are a huge problem in the Park. Many fires (36) were recorded during the aerial survey and though it has not been calculated with accuracy, several hectares of burnt habitat were observed.
- The mining activities in the area of Mako (eastern side of the park) have a substantial impact on biodiversity. Though official mining activities carried out by Torogold have a negative impact (primary and secondary) on biodiversity due to its proximity to the park boundary, they are controlled and assessed by the park staff with a series of offset measures beneficial to the park management like support for anti-poaching and monitoring. In comparison, traditional mining activities in this area and along the Gambia river which are totally illegal, represent a higher risk for wildlife and its habitat but also for the neighboring communities because of water pollution.

  As a result of these combination of human activities, in particular illegal mining activities, the lowest diversity of wildlife is found in this part of the park.

Bibliography

Adibio. (2018). *Suivi des lions dans les parcs nationaux du complexe W-Arli-Pendjari*. Rapport final, 34 p.

Amin, R., Davey, K. T. and Wacher, T. (2017). *Camera trap data management & analysis package*. Zoological Society of London.

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. (1993). *Distance sampling: Estimating of biological populations.* Chapman and Hall, London.

East, R. (compiler). (1999). *African Antelope Database 1998*. IUCN, Gland, Switzerland and Cambridge, UK

Jachmann, H. (2002). Comparison of aerial counts with ground counts for large African herbivores. *Journal of Applied Ecology* 39: 841-852.

Howard, W., Wangari, E., Rakotoaisoa, N. (2007). *Mission report - UNESCO/IUCN joint monitoring mission to Niokolo Koba National Par*k, Senegal. Available from: http://whc.unesco.org/document/8951

IUCN SSC Antelope Specialist Group. (2017). *Damaliscus lunatus ssp. korrigum*. *The IUCN Red List of Threatened Species* 2017: e.T6238A50185772. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T6238A50185772.en. Downloaded on 10 May 2019.

IUCN SSC Antelope Specialist Group 2017. *Alcelaphus buselaphus ssp. major*. *The IUCN Red List of Threatened Species* 2017: e.T817A50181578. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T817A50181578.en. Downloaded on 15 May 2019.

IUCN SSC Antelope Specialist Group 2017. *Tragelaphus derbianus ssp. derbianus*. *The IUCN Red List of Threatened Species* 2017: e.T22056A50197188. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T22056A50197188.en. Downloaded on 15 May 2019.

Henschel, P., Bauer, H., Sogbohoussou, E. and Nowell, K. 2015. *Panthera leo West Africa subpopulation*. *The IUCN Red List of Threatened Species* 2015: e.T68933833A54067639. http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T68933833A54067639.en. Downloaded on 15 May 2019.

MacKenzie, D. I., Nichols, J.D., Royle, J. A., Pollock, K. H., Bailey, L. L. and Hines, J. E. 2006. *Occupancy estimation and modelling*. Elsevier, Amsterdam.

Milner-Gulland, E. J. and Rowcliffe, J. M. (2007). *Conservation and Sustainable Use. A Handbook of Techniques*. Oxford University Press. Techniques in ecology and conservation series.

Norton-Griffiths, M. (1978) Counting Animals, 2nd edn (ed. J.J.R. Grimsdell), p. 139. *African Wildlife Foundation Technical Handbook No. 1*. African Wildlife Foundation, Nairobi, Kenya.

Rabeil, T. (2015). *Inventaire de la grande faune du Parc National du Niokolo Koba au Sénégal*. Mission d'assistance Technique du Centre du Patrimoine Mondial de l'UNESCO, 39 p.

Rabeil, T., Gueye, M., Hejcmanová, P., Greffrath, R. and Cornut, D. (2018). *Inventaire combiné terrestre et aérien, Parc National du Niokolo-Koba, Sénégal*. Rapport d'inventaire, Direction des Parcs Nationaux du Sénégal, Dakar, 73 p.

Renaud, P. C., Gueye, M. B., Hejcmanová, P., Antonínova, M. and Samb, M. (2006). *Inventaire aérien et terrestre de la faune et relevé des pressions au Parc National du Niokolo Koba: Plan of Urgence, Report Annex A*. Ministère de l'Environnement et de la Protection de la Nature Protection – African Parks Foundation, Dakar.

Estimating forest antelope population densities using distance sampling with camera traps: Blue Duikers in the Dja Faunal Reserve, Cameroon

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Abstract

1. Monitoring the status of forest antelopes is a critical conservation need, however they are difficult to monitor using traditional methods for forest mammals. The use of camera-trapping as a survey tool for medium-to-large terrestrial mammals has become increasingly common over recent years, especially in forest habitats.
2. We extend the method of Howe *et al.* (2017) to images generated from camera trap surveys and use an estimate of the overall proportion of time animals are active to correct for bias in the density estimate from the 24-hour camera trap survey dataset.
3. We obtained reliable density estimate of the blue duiker (*Philantomba monticola*) in the northern sector of the Dja Faunal Reserve, Cameroon. The estimate was at the higher end of documented estimates across the species range, however these estimates, derived using traditional direct or indirect methods of population sampling, are more likely to be underestimated.
4. We plan to test the camera trap distance sampling method on other common and rare forest antelope species recorded in the study, and evaluate the method using the combined forest antelope species dataset with species body mass as a covariate in the model.

Keywords: antelope, animal abundance, camera trapping, distance sampling, *Philantomba monticola*

Introduction

Antelopes and other artiodactyl species constitute a significant component of forest and woodland ecosystems both in terms of biomass (White 1994) and ecological services (Feer 1995). Many species are increasingly threatened by habitat loss and hunting for bushmeat (East 1999). Forest antelopes are primary targets for the trade in bushmeat (Wilkie & Carpenter 1999; Fa *et al.* 2005) and have undergone major local and regional declines as a result (e.g. van Vliet *et al.* 2007). Therefore, monitoring the status of forest antelopes is a critical conservation need. However, forest antelopes are difficult to monitor using traditional methods for forest mammals as many species are solitary and inactive during the day, most species are shy and spend long periods concealed in dense vegetation, and the spoor and droppings of many species are difficult to identify to species with confidence (van Vliet *et al.* 2008). Here, we present a method based on distance sampling with camera traps capturing images to obtain density estimates of forest antelopes.

Materials and methods

Each deployed camera (sampling point k) in a survey is treated as a point transect. The cameras are programmed to record a set number of images at a fixed time interval t_i between images when triggered and with a quiet time period t_q between triggers. The temporal effort for each camera is

then equal to the camera operation period T_k divided by $(x \,.\, t_i) + t_q$ where x is the number of images per trigger. This represents the maximum possible number of triggers. The spatial coverage is the fraction of a circle covered by a camera which is given by horizontal angle of view (field of view - FOV) divided by 360 degrees (or two radians). The overall sampling effort at a camera is the temporal effort multiplied by the spatial coverage.

Observations of animals of interest are the first detection in triggers. The standard assumptions of distance sampling hold (Buckland *et al*. 2001). These are 1) animals at the sampling point are detected with certainty; 2) animals are detected at their initial location, prior to any movement; 3) distances are measured accurately. In addition, animals are spatially distributed in the area to be sampled according to some random process and randomly placed points are sampled. The first assumption could be violated by (i) animals passing beneath the camera field of view, (ii) failure to identify the species because only part of the animal is visible, and possibly (iii) the delay between the time the sensor is activated and the time the first image is recorded. This violation may be detectable during exploratory analysis in the form of fewer than expected detections close to the sampling point, and bias can be avoided via left-truncation. For the second and third assumptions, the distance to the animal in only the first image in a trigger sequence is included in the analysis and in order to accurately assign animals in images to distance intervals, at camera deployment reference images are taken to record a set of horizontal distances and angles from the camera using a measuring tape and a pole. Systematic (with random origin) or random camera trap survey designs are consistent with the assumption that sampling points are placed independently of animal locations. Camera orientations could be selected randomly, or the same orientation could be used for all cameras. Small deviations from the location and orientation selected by design (e.g. to avoid an obscured field of view) would not bias estimates provided field staff do not intentionally target habitat features known to be either preferred or avoided by the animals.

Density estimate of blue duikers in the northern sector of the Dja Faunal Reserve, Cameroon

We used the point transect distance sampling method to estimate the density of blue duikers (*Philantomba monticola*) within the northern sector of Dja Faunal Reserve (Fig. 1). Forty Bushnell Trophy Aggressor Low Glo cameras were deployed in a grid with 2-km camera spacing from 22 January 2018 to 8 May 2018. A single camera was placed at a height of about 30 cm as close to the grid sampling point as possible, with a consistent field of view and with a chance of detecting animals. The cameras were programmed to take three images per trigger. The cameras took images at one second interval and a two second delay between triggers. The camera FOV was 35 degrees (0.097 radians) and all cameras used an infrared flash to minimize startling the animals.

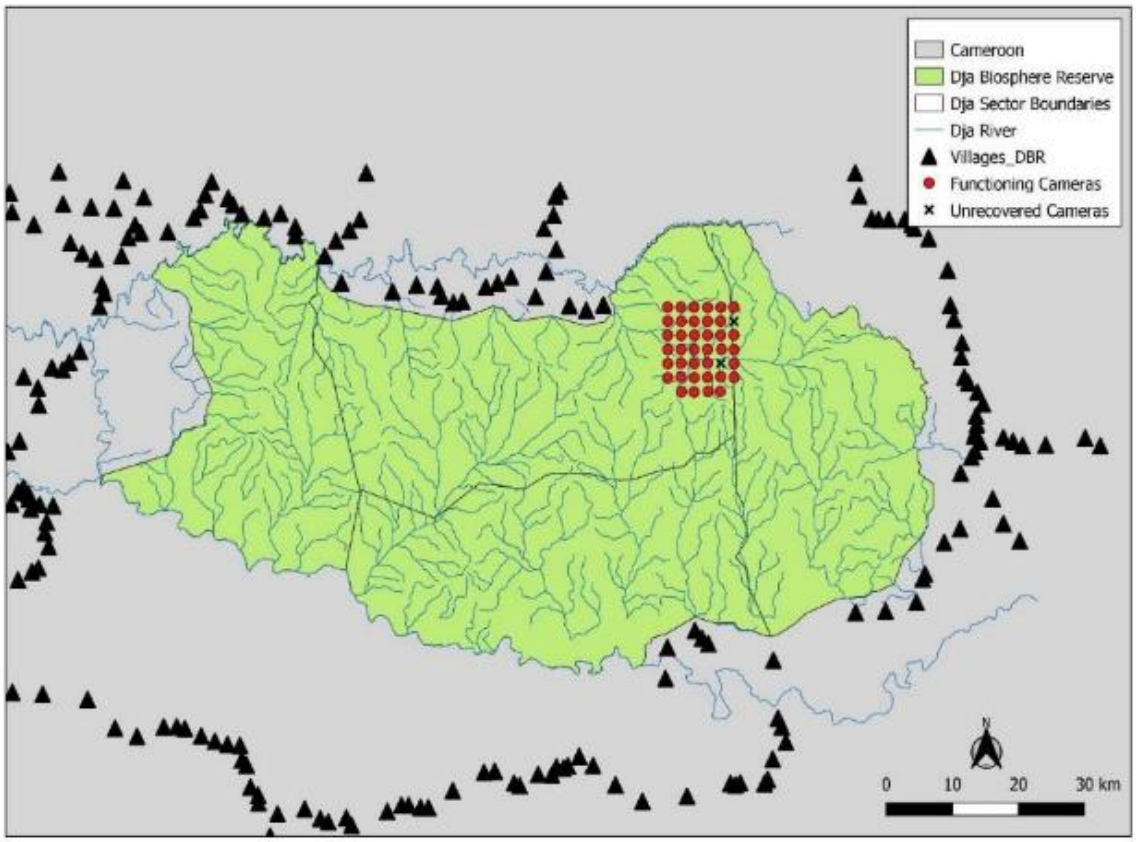


Figure 1. Location of the 40 camera traps deployed in a grid with a 2 km camera spacing within the study area in Dja Faunal Reserve, Cameroon.

During installation of each camera, we took reference images with a one-meter long pole placed at horizontal distances of 1, 1.5, 2, 3, 4, 5 and 6 m from the camera at 0 degrees and 15 degrees either side of the centre of the FOV. We assigned the nearest animal in the first image of a trigger consistently to 0-2 m, 2-3 m, 2-4 m, 4-5 m, 5-6 m and beyond 6 m (Fig. 2).

Figure 2. Top: example photo of the calibration process; Bottom: example of a photo of a blue duiker with distance bands marked in colored dots and reference lengths written alongside. This individual is categorized in distance band 3-4 m as the feet, below the midpoint of the body, fall between in the 3 m and 4 m calibration points.

Results

We recovered 38 cameras and all the cameras recorded images of blue duikers. We obtained 7,039 observations of the distance between blue duikers and cameras. Blue duikers were always active when detected. Encounter rates were highly variable among locations, but did not exhibit an obvious spatial pattern across the study area, and there was no evidence of spatial autocorrelation (Moran's I $P = 0.526$; Fig. 3).

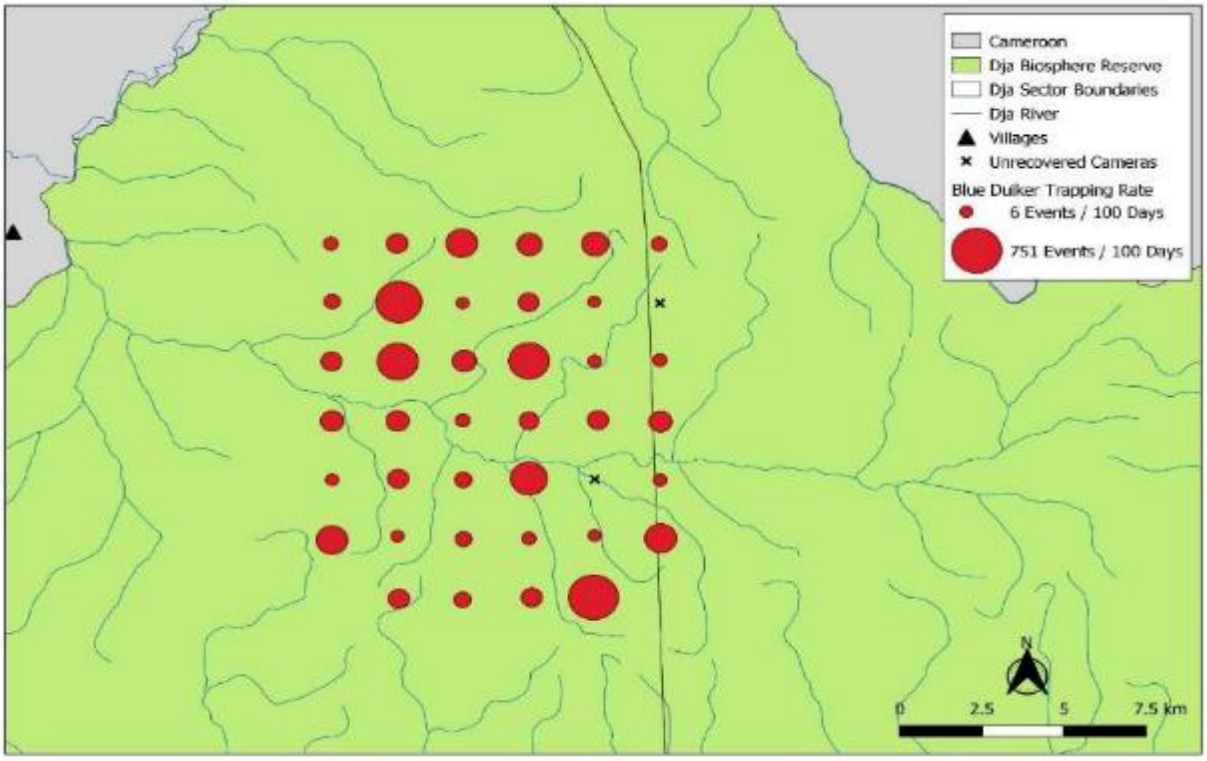


Figure 3. Variation in encounter rates (number of triggers per 100 trap days) of blue duikers among 38 camera trap locations in the northern sector of Dja Faunal Reserve, Cameroon, 2018 (range 0.06–7.51). The areas of the red circles are proportional to the encounter rates.

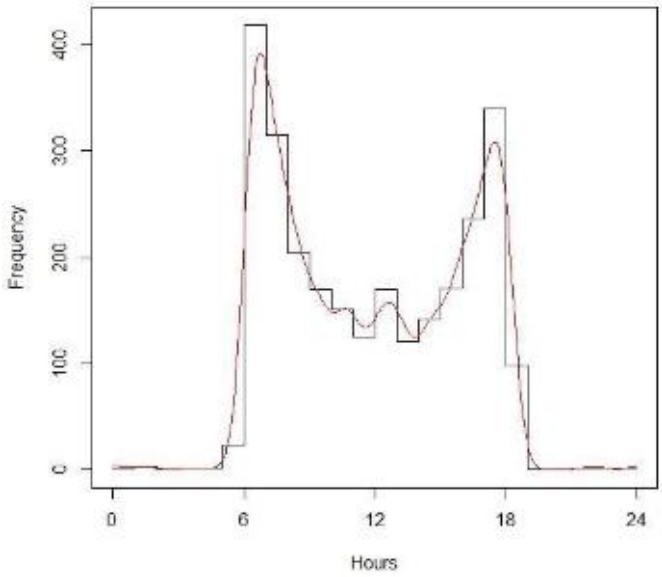


Figure 4. Activity pattern of blue duikers in the northern sector of the Dja Faunal Reserve, Cameroon, 2018. Black steps are frequencies of trigger times and red curve is the fitted circular kernel distribution.

Blue duikers show a crepuscular activity pattern (Fig. 4) so we first assumed that all animals were available during peak activity pattern (06.30-08.30 h and 16.30-18.30 h) and derived temporal effort and distance observations accordingly. We also used the 24-hour dataset to estimate density. We then divided this estimate with the proportion of time active calculated from detection data using the 'activity' package in R statistical software package (Rowcliffe *et al*. 2014).

We fitted point transect models in program Distance (version 7.0; Thomas *et al*. 2010). We considered models of the detection function with the half-normal, hazard rate and uniform key functions with up to 5 cosine, simple polynomial and Hermite polynomial adjustment terms. Adjustment terms were constrained, where necessary, to ensure the detection function was monotonically decreasing. We selected among candidate models of the detection function by comparing AIC values, acknowledging the potential for overfitting because many observations were not independent.

Exploratory analyses revealed no evidence of paucity of observations between 0 and 2 m or data issues with variation in visibility distances between cameras. The detection function was not monotonically decreasing for all models except hazard rate model with no adjustment terms and half normal model with no adjustment terms and four simple polynomial adjustment terms, so these models were considered for estimation. The hazard rate model with no adjustments minimized AIC with a chi square goodness of fit test $P >> 0.05$ and was used to estimate density for both datasets.

Fitting circular distribution to the blue duiker activity pattern resulted in a proportion of time active of 0.29 (SE: 0.01; 95% CI: 0.27 - 0.31) (Fig. 4). We subsequently divided the density estimate from the 24-hour dataset with this value to obtain the corrected density estimate considering the proportion of time animals are active. We obtained the 95 percent confidence interval by combining the confidence intervals of the two estimates. This approach depends on the key assumption that all individuals in the sampled population are active at the peak of the daily activity cycle.

Detection probability was ~1 within 4 m and ~0.35 at 6 m (Fig. 5). Effective detection radii were 5.41 (SE: 0.032; 95% CI: 5.35 - 5.47) and 5.46 (SE: 0.048; 95% CI: 5.37 - 5.56) for the 24-hour and peak activity datasets, respectively.

We expected to significantly underestimate density where we assumed blue duikers were active 24 hours (Table 1). Including an independent estimate of the proportion of time active in the model fit to the 24-hour dataset yielded a higher estimate (Table 1).

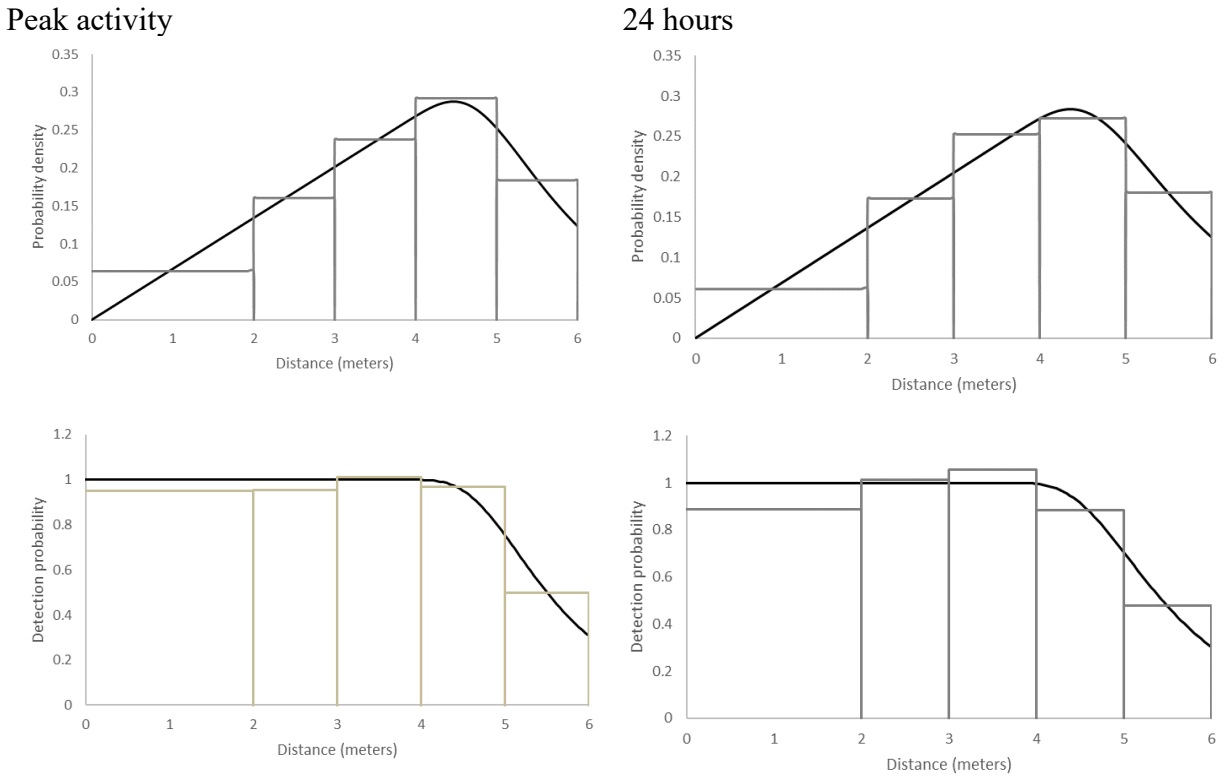


Figure 5. Probability density functions (top) and detection probability (bottom) as function of distance from hazard-rate point transect model fitted to peak activity data (left) and 24-hour data (right) for blue duikers in the northern sector of the Dja Faunal Reserve, 2018. The histograms of the observed distances are also shown.

Table 1. Density of blue duiker in the northern sector of the Dja Faunal Reserve, 2018, estimated using the peak activity and 24-hour datasets accounting for animal availability.

Dataset	Density estimate (per km^2)	Coefficient of Variation (CV)	95% Confidence Interval (CI)
Peak activity	30.847	18.21%	21.40 - 44.46
24-hour data	11.55	16.60%	8.27 - 16.13
24-hour data with proportion of time active	40.29	-	26.7 – 60.7

Discussion

In this study, we have extended the method of Howe *et al.* (2017) to images generated from camera trap surveys and have used an estimate of the overall proportion of time animals are active to correct for bias in the density estimate from the 24-hour camera trap survey dataset. The distance sampling method requires at least 60-80 observations to fit detection models (Buckland *et al.* 2001) and the use of the whole 24-hour dataset would allow accurate density estimates to be obtained for rarer populations. In our study, the density estimate of 40.29 blue duikers / km^2 in the northern sector of the Dja Faunal Reserve is similar to documented estimates across the species range (5-

35 / km^2; Hart & Kingdon 2013). These estimates were derived using traditional direct or indirect methods of population sampling and are thus more likely to be underestimated (Waltert *et al*. 2006; Bowland & Perrin 1995).

We are in the process of testing the camera trap distance sampling method on other common and rare forest antelope species recorded in the study. There may exist for certain antelope species a level of rarity or patchy dispersion below which accurate population density estimates from camera trap imagery may not be obtained. Similarly, there may be a threshold of overall effort (that is, the number and dispersion of cameras and the number of trap days) below which this approach no longer provides reliable estimates for a given species. We will also be evaluating the method using the combined forest antelope species dataset with species body mass as a covariate in the model.

Acknowledgements
We thank the Ministry of Forests and Wildlife (MINFOF) Cameroon for the support for this project. In particular, we would like to thank the late Conservator Hilaire Ndinga of the Dja Faunal Reserve. We also thank the MINFOF ecoguards and local porters who accompanied the survey teams in the field.

References

Bowland A.E. & Perrin M.R. (1995). Temporal and spatial patterns in blue duikers *Philatomba monticola* and red duikers *Cephalophus natalensis*. *Journal of Zoology* 237: 487–498.

Buckland S.T., Anderson D.R., Burnham K.P., Laake J.L., Borchers D.L. & Thomas L. (2001). *Introduction to Distance Sampling: Estimating Abundance of Biological Populations*. Oxford University Press, Oxford, UK.

East R. (1999). *African Antelope Database 1998*. IUCN/SSC Antelope Specialist Group. IUCN Gland, Cambridge.

Fa, J.E., Ryan, S.F. & Bell, D.J. (2005). Hunting vulnerability, ecological characteristics and harvest rates of bushmeat species in afro-tropical forests. *Biological Conservation* 121: 167–176.

Feer F. (1995). Seed dispersal in African forest ruminants. *Journal of Tropical Ecology* 11: 683–689.

Hart, J.A. & Kingdon, J. (2013). *Philantomba monticola*. In J. Kingdon & M. Hoffman, eds. *Mammals of Africa Volume VI Pigs, Hippopotamuses, Chevrotain, Giraffes, Deer and Bovids*. London: Bloomsbury Publishing, pp. 228–234.

Howe, E.J., Buckland, S.T., Despres-Einspenner M. & Kuhl H.S. (2017). Distance sampling with camera traps. *Methods in Ecology and Evolution* 8: 1558–1565. Available at: http://doi.wiley.com/10.1111/2041-210X.12790.

Rowcliffe, J.M., Kay, R., Kranstauber, B., Carbone, C. & Jensen, P.A. (2014). Quantifying levels of animal activity using camera trap data. *Methods in Ecology and Evolution* 5(11): 170–1179. Available at: http://doi.wiley.com/10.1111/2041-210X.12278.

van Vliet, N., Nasi, R., Emmons, L., Feer, F., Mbazza, P. & Bourgarel, M. (2007). Evidence for the local depletion of bay duiker *Cephalophus dorsalis*, within the Ipassa Man and Biosphere Reserve, north-east Gabon. *African Journal of Ecology* 45: 440–443.

van Vliet, N., Zundel, S., Miquel, C., Taberlet, P., & Nasi, R. (2008). Distinguishing dung from blue, red and yellow-backed duikers through non-invasive genetic techniques. *African Journal of Ecology* 46: 411–417.

White, L.J.T. (1994). Biomass of rain forest mammals in the Lopé Reserve, Gabon. *Journal of Animal Ecology* 63: 499–512.

Wilkie, D.S. & Carpenter, J.F. (1999). Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation, *Biodiversity and Conservation* 8: 927–955.

Waltert, M., Herber, S., Riedelbauch, S., Lien, J. & Mühlenberg, M. (2006). Estimates of blue duiker (*Cephalophus monticola*) densities from diurnal and nocturnal line transects in the Korup region, south-western Cameroon. *Molecular Ecology* 44: 290–292.

Antelope News

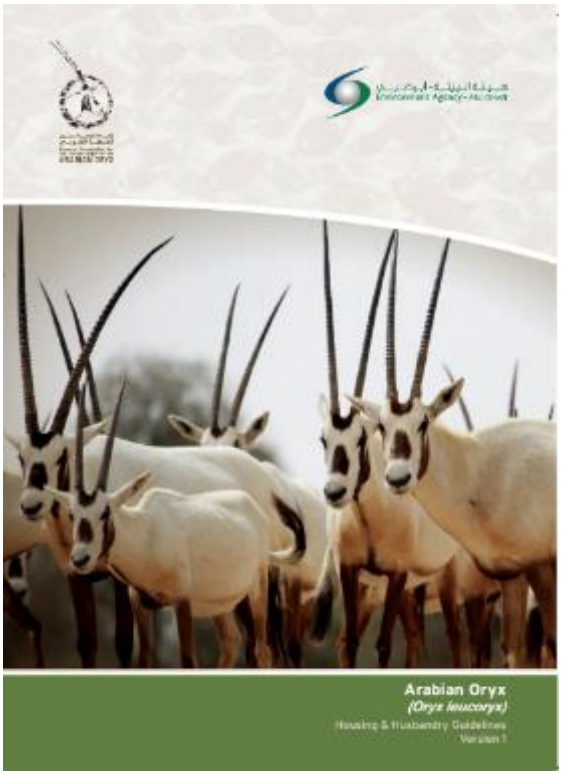
Arabian oryx husbandry guidelines

These guidelines were recently published by Environment Agency – Abu Dhabi, in collaboration with Al Ain Zoo, Al Bustan Zoological Center and Marwell Wildlife following an expert workshop held in Abu Dhabi.

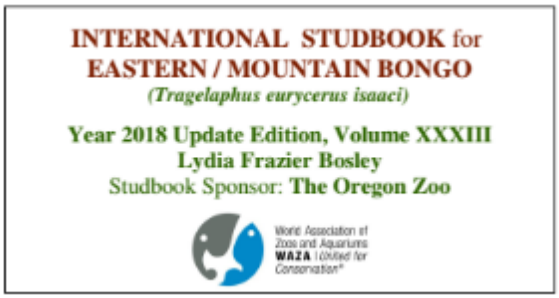
De Kock, M., Al Qarqaz, M., Burns, K., Al Faqeer, M., Chege, S., Lloyd, C., Gilbert, T., Alzahlawi, N., Al Kharusi, Y.H., Chuven, J., Javed, S. and Al Dhaheri, S. (2018). *Housing and Husbandry Guidelines for the Arabian Oryx (Oryx leucoryx).* Available from: *https://www.arabianoryx.org/.../ORYX%20Housing%20and%20Husbandry%20Guidelines*

Lesser Kudu studbook

The Lesser Kudu European Studbook 2018 was published by Zoo Basel in Switzerland in January 2019. It is compiled by Beatrice Steck, the EAZA / European Studbook Keeper. It contains sections on biological data, current status, history of the ex-situ population, current research, demography and genetics of the ex situ population, summary of holders and pedigree details.



Mountain Bongo International Studbook



The latest updated version of the studbook was distributed to bongo holders and others in April 2019. It is produced by Lydia Bosley and sponsored by Oregon Zoo. The cover photo (above) is kindly provided by Paul Reillo of the Rare Species Conservancy Foundation.

First record of Lowland Bongo in Uganda

Chester Zoo's Africa Field Programme and the Uganda Wildlife Authority have reported the first record of lowland bongo (*Tragelaphus eurycerus eurycerus*) in Uganda during a camera-trap survey of Semuliki National Park on the border with the Democratic Republic of Congo. The bongo was one of more than 30 mammal species identified among 18,000 photos, including elephants, chimps, buffalos and leopards. Jonathan Kingdon's Uganda country account in Part 1 of the IUCN Antelope Global Survey and Regional Action Plan covering East and Northeast Africa (1988) says "Bongo [mountain bongo *T. e. isaacii*] formerly occurred in the rainforests on Mount Elgon where it was exterminated in 1913-14. It is possible that it once occurred in south-west Uganda in the Bwamba [Semuliki] forest, which is contiguous with the vast Ituri forest of Zaire". However there has been no confirmation of the species' presence until the recent camera trap records. Semuliki Forest Reserve was created in 1932 and upgraded to national park status in 1993. It covers 220km² and is the only tract of true lowland tropical forest in East Africa. The national park lies in the Semuliki Valley on the remote, western side of the Ruwenzori Mountains and is dominated by the eastern most extension of the Ituri Forest of the Congo Basin. This is one of the most ancient and biodiverse forests in Africa and is one of the few to survive the last ice age, 12,000-18,000 years ago. Semuliki is home to numerous Central African bird and mammal species.

Sources: https://www.bbc.co.uk/news/science-environment-45633272 (29 September 2018).
http://www.ugandawildlife.org/other-parks/semuliki-national-park

Lowland bongo in Semuliki Forest, Uganda (© Chester Zoo)

Suni: first record in Nyika National Park, Malawi

Suni *Nesotragus moschatus* is distributed from the Boni-Dodori forests on the Kenya-Somalia border southwards to KwaZulu-Natal. The range includes Lengwe NP in southern Malawi. Suni was confirmed for the first time in the northern part of the country when it was captured on camera traps in Nyika NP (3200km^2) in June-July 2017, in the afromontane vegetation zone.

Source: Byrne B, Stone EL, Mgoola WO, Uzal A. First confirmed record of suni (Neotragus moschatus) and rusty-spotted genet (Genetta maculata) in Nyika National Park, Malawi. African Journal of Ecology 2019; 00:1–4. https://doi.org/10.1111/aje.12607

Hirola update

As part of the second phase of the 5-year Hirola Habitat Restoration Project, work has begun on recruitment and training of range restoration technicians, manual clearance of invasive trees within core hirola areas, and seeding the cleared areas with five native grass species. Native grasses are well adapted to the arid environment but are mostly outcompeted by the invasive *Acacia refeciens*. Six restoration islands measuring 500 x 500 m have been identified then each one subdivided into 27 plots 149 m long x 43 m wide, separated by 10-m buffer strips. The aim is to compare the growth of the five native grasses against other grass species and to measure dispersal rates of native species from the plots to surrounding areas.

Another project involves a soil seed bank assessment to evaluate the occurrence of seeds in different soil types, and to research the influence of edaphic factors on the growth of grass seedlings within core areas. Soil samples are transported to an offsite greenhouse at the Fafi Girls Secondary School in Bura. Plastic germination trays are filled with 1 cm of soil (44 trays with each soil type having 11 replications).

Ishaqbini Hirola Sanctuary was designed to be predator-proof, but local rangers have for long believed that leopards could climb the almost 2-m high perimeter fence. A camera trap has now confirmed that they can do this! *Source: Hirola Project Newsletter December 2018.*

Gazelles released in Algeria

A news broadcast on TV Algérienne on 26 February reported the release of 500 gazelles, brought from Dubai, United Arab Emirates, into the Réserve d'Ajdar in the Wilaya of Nâama. This is the third release of gazelles from UAE at this site in the past 2 years. The gazelles were reported to be 'reem' (*Gazella leptoceros*), the same name being used in the Arabian Peninsula for *Gazella marica*.

Source: https://www.facebook.com/274924419212346/posts/2213343845370384/

Malawi Government statement on trophy hunting

Malawi has taken several positive steps in conservation in recent years, including strengthening the Wildlife Act. There has been some recent debate on the introduction of trophy hunting inside Malawi's protected areas. However, in response to a petition, the Government has issued the following statement: "We can confirm that the trophy hunting component of the proposal in question was not approved by the government. Whilst new legislation (under sections 54 and 95) does include some hunting provisions, the Government of Malawi would like to remind citizens, residents and tourists that hunting of protected species, or hunting of any species within a protected area, is a wildlife crime. The Government of Malawi is committed to uphold this law." The hunting provisions referred to here are 'as may be necessary in defence of human life or property'.

Source: https://www.lilongwewildlife.org/government-statement-on-trophy-hunting/ (23.12.2018)

Namibia bans imports and exports of antelopes

The Ministry of Environment and Tourism has made an "Announcement of prohibition on importation of large predatorş and alien species of wild animals: Nature Conservation Ordinance, 1975". (Government Notice no. 87). This prohibits imports of large predators and other species, including Duiker, Eland, Hartebeest, Greater Kudu, Gemsbok, Springbok, Steenbok, Blesbok, Bontebok, Bushbuck, Nyala, Mountain Reedbuck. The Notice also prohibits exports of the endemic Black-faced Impala and Damara Dik-dik. This measure will go a long way towards controlling the movement of non-indigenous species to sites outside their natural range. The inclusion of 'all colour varieties' is especially welcome.

Source: Government Gazette of the Republic of Namibia No. 6892 (30 April 2019).

New National Parks in Tanzania

In February 2019 the Tanzanian Parliament approved the upgrading of five game reserves to national park status (Biharamuro, Burigi, Kimisi, Ibanda and Rumanyika GRs) This brings the total number of national parks managed by the Tanzania National Parks Authority (TANAPA) to 22. TANAPA manages the nation's current 17 national parks (which cover about 15% of the country's area), but it does not have a mandate over other sites such as the Selous Game Reserve (managed by Tanzania Wildlife Management Authority) and Ngorongoro Conservation Area (managed by the Ngorongoro Conservation Authority).

Source: https://www.newtimes.co.rw/africa/tanzania-national-parks

Kilombero Catchment Management Plan

The Kilombero Valley in Tanzania is an important site for antelopes as it holds up to 75% of the global population of puku (*Kobus vardonii*). The valley contains a Ramsar Site, Kilombero Nature Reserve, and connects to the Udzungwa Mountains National Park in the largest block of the Eastern Arc Mountains, which are a key site for the endangered Abbott's Duiker (*Cephalophus spadix*). Kilombero Valley is also a major food- producing region. The entire Kilombero catchment is facing several threats, including pollution, declining water levels, habitat conversion and degradation, overgrazing, poaching and loss of wildlife corridors. The Kilombero Catchment Forum was formed in 2017 to address these challenges and promote sustainable management of water resources. It is led by the Rufiji Basin Water Board in collaboration with the African Wildlife Foundation (AWF) and is made up of key stakeholders representing the government, communities, civil society organisations, NGOs and the private sector. A stakeholder workshop was held on 31 July–1 August 2018 to develop the Kilombero Catchment Management Plan (KCMP), organised by AWF and Rufiji Basin Water Board as part of the IUCN-led Stabilizing Land Use Project (PLUS) which is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The KCMP runs from August 2018 to August 2021 and is intended to benefit biodiversity and all of those who depend on a healthy landscape.
Source: *https://www.iucn.org/news/forests/201902/over-600-species-and-countless-livelihoods-depend-a-plan-future-kilombero-catchment?utm_campaign=2315301_IUCN%20SSC%20Species%20e-bulletin%20February%202019&utm_medium=email&utm_source=IUCN&dm_i=2GI3,1DMHX,40EJJ1,4J58Y,1&utm_campaign=website&utm_source=sendgrid.com&utm_medium=email*

Saiga News

Published by the Saiga Conservation Alliance twice a year and available in six languages: English, Russian, Chinese, Mongolian, Kazakh and Uzbek. Issue #24 (autumn 2018/winter 2019) is now available. It contains a detailed analysis of the proposal to include saiga in CITES Appendix I, results of the aerial census in Kazakhstan, updates and articles on saiga conservation from across the range.
Available from: www.saiga-conservation.com

Sandscript

Sandscript is published twice a year by the Sahara Conservation Fund. Issue #24, fall 2018, contains articles on pastoralists and conservation in Ouadi Rimé-Ouadi Achim Faunal Reserve, Chad (site of the scimitar-horned oryx *Oryx dammah*) reintroduction; dama gazelle conservation; translocation of West African Giraffe *Giraffa camelopardalis peralta* to Gadabeji Biosphere Reserve in Niger; the ostrich recovery project and Egyptian vultures.
Available from: www.saharaconservation.org

Conservation Frontlines

This is a quarterly E-magazine (and frequent news updates) new e-journal that aims to promote sustainable hunting, including 'utilitarian' and 'recreational' hunting. Contributions include articles on the ethics of hunting and insight into the motivations of hunters and discuss the complexities surrounding incentive-driven conservation. Non-hunters can discover the wide-ranging facets of hunting and its conservation linkage. Although they may remain less than totally

comfortable about hunting, CF aims to catalyse positive exchanges between non-hunting and hunting conservationists.
Available from: https://www.conservationfrontlines.org

Rare antelope being killed to make scarves. *Available from: National Geographic, April 2019*
https://www.nationalgeographic.com/animals/2019/04/tibetan-antelope-killed-to-make-luxury-scarves/

Recent Publications

Cross-boundary human impacts compromise the Serengeti-Mara ecosystem
Michiel P. Veldhuis, Mark E. Ritchie, Joseph O. Ogutu, Thomas A. Morrison, Colin M. Beale, Anna B. Estes, William Mwakilema, Gordon O. Ojwang, Catherine L. Parr, James Probert, Patrick W. Wargute, J. Grant C. Hopcraft, Hans Olff (2019).
Science 363: 1424-1428.

Abstract
Protected areas provide major benefits for humans in the form of ecosystem services, but landscape degradation by human activity at their edges may compromise their ecological functioning. Using multiple lines of evidence from 40 years of research in the Serengeti-Mara ecosystem, we find that such edge degradation has effectively "squeezed" wildlife into the core protected area and has altered the ecosystem's dynamics even within this 40,000-square-kilometer ecosystem. This spatial cascade reduced resilience in the core and was mediated by the movement of grazers, which reduced grass fuel and fires, weakened the capacity of soils to sequester nutrients and carbon, and decreased the responsiveness of primary production to rainfall. Similar effects in other protected ecosystems worldwide may require rethinking of natural resource management outside protected areas.

Wild ungulates in a human dominated landscape: Their population structure, density and biomass in Western India
Dhawal Mehta and V.C. Soni (2018). dhawalbmehta@hotmail.com
International Journal of Ecology and Environmental Sciences 44 (3): 319-329.

Abstract
The population structure, density and biomass of three species of ungulates - Nilgai (*Boselaphus tragocamelus*), Wild Pig (*Sus scrofa*) and Chinkara (*Gazella bennetti*) were studied in ten grasslands of Central Saurashtra, Western India during 2011-12 using the distance sampling method. The total transect length involving all the study sites was 38.44 km which was walked for a total of 16 times resulting in a sampling effort of 615.04 km. The mean group size at all the sites for Nilgai, Wild Pig and Chinkara were 5.403±0.95 (SE), 7±0.63 (SE) and 5.4±0.63 (SE) respectively. Average estimated densities of 40.52 Nilgai km-2, 50.58 Wild Pig km-2 and 1.64 Chinkara km^{-2} were recorded from all sites. The sex ratios were usually biased towards females except in some cases in Nilgai. The Nilgai and Chinkara were usually seen to be solitary or form small herds while Wild Pigs were more gregarious forming herds of more than 6 individuals. The group size in all three species did not vary between sites and between seasons. The average wild ungulate biomass at all the studied grassland sites was computed to be 4569.95 kg km^{-2}.

Current data on the reproduction of Four-horned Antelope *Tetracerus quadricornis* in zoological parks.
Gérard Dubost, Stéphane Labes & Armelle Lutz (2019).
Journal of Threatened Taxa 11(3): 13295-13303. DOI: 10.11609/jot.4163.11.3.13295-13303
(open access)

Abstract: The Four-horned Antelope (*Tetracerus quadricornis*) is currently facing numerous dangers throughout its natural range. The major threats include human overpopulation, deforestation, and degradation of its habitat. It is classified as Vulnerable on the IUCN Red List. Now, this species is rare or even absent in most zoos. Given the threats encountered by this

species in the wild, its reproduction was analyzed from animal data obtained in European and Indian zoological parks during 39 consecutive years from 1977 to 2016. There was an average of 1.42 new-borns per litter. Twins were more numerous than singletons. Sexual maturity in females did not occur before 18–36 months of age. Most females, however, reproduced for the first time much later, on average at 6–7 years of age and more than half of females produced only one litter. In females that raised their young, new fertilization generally took place 101 days after the preceding birthing. In Indian zoos, where temperatures vary little between seasons, births were numerous in September–February, especially in September–November when rainfall decreases, contrary to deaths that occurred predominantly in June–August during peak rainfall. In European zoos, most litters occurred in December–February. Thus, Four-horned Antelopes maintain part of the birth season of their native countries, despite unfavourable local climate conditions. Deaths of individuals also occurred mainly in December–February in European parks, i.e., during the coldest season. Globally, more males than females died during the first month of life as in other species, but not so after that age. On the whole, there is a low reproductive success in populations of the Four-horned Antelope under managed care compared to other ruminant species. This could partly be due to husbandry and management procedures of individuals in these parks. This raises the question of the possibility of reintroducing individuals into the wild from ex situ livestock.

Four-horned antelope in New Delhi Zoo (© ASG)

Identification of African antelope species: Using thermographic videos to test the efficacy of real-time thermography.

Anne E. Goodenough, William S. Carpenter, Lynne MacTavish, Charles Theron, Matthew Delbridge, Adam G. Hart (2018).

African Journal of Ecology 56(4): 898-907.

Abstract

Real-time thermography using the live-view function of a thermal camera has considerable potential to improve surveys of nocturnal wildlife relative to traditional spotlighting, while also decreasing disturbance. However, ability to identify species accurately is paramount. We use video as a proxy for real-time thermography to test African antelope identification accuracy among 34 observers of differing experience. Overall accuracy was 41% but there were substantial species-specific differences (e.g. wildebeest (*Connochaetes taurinus*) = 81%; reedbuck (*Redunca arundinum*) = 12%). Observer experience was significantly positively related to accuracy (inexperienced = 30%; expert = 61%) with experienced observers being better able to use subtle movement and behavioural information to identify animals. However, the effect of experience was inconsistent between species: even experts found some species challenging (e.g. waterbuck (*Kobus ellipsiprymnus*) where coat patterning was invisible thermographically). Self-assessed confidence did not correlate with accuracy. Observers who were good at identifying species were also good at assessing group size. We conclude that real-time thermography is not a "magic bullet" and the understanding of species-specific effectiveness is vital. However, for some species and some groups of observers, accuracy can be extremely high (e.g. 100% for expert observers viewing wildebeest). Tailored training is essential for real-time thermography to be a reliable field technique.

Population density estimates of forest duikers (*Philantomba monticola* & *Cephalophus* spp.) differ greatly between survey methods.

Towa Olivier, William Kamgaing, Kadiri Serge Bobo, Daniel Djekda, Keumbeng Blondel, Vasco Azobou, Bobo Réné Hamadjida, Moaga Yannick Balangounde, Kamdem Joel Simo, Hirokazu Yasuoka (2018).

African Journal of Ecology 56(4): 898-907.

Abstract

Estimating duiker populations is essential for conservation programmes in Central Africa, but what the most reliable survey method is remains unclear. We estimated forest duiker population densities in Southeast Cameroon using three line-transect methods: dung counts and diurnal direct observation over 338.2 km, and nocturnal direct observation over 334.7 km. Nocturnal observations resulted in 59.8 and 9.0 individuals km^{-2} for the blue duiker (*Philantomba monticola*) and red duikers (*Cephalophus callipygus*, *C. dorsalis*, *C. leucogaster* and *C. nigrifrons*), respectively, which were much higher than estimates by dung counts and diurnal observation. Only dung counting was applicable for the yellow-backed duiker (0.8 individuals km^{-2}), due to low encounter rates obtained by the other methods. We argue that nocturnal observation is the most accurate method because the torchlight can pick out duikers' eyes even if the animals are shy and hiding and because multiple counts are unlikely. By contrast, the other methods probably underestimate densities due to poor visibility and reliance on dung production and decay rates calculated in different areas. These results can affect figures used in wildlife management decisions, such as the maximum sustainable yield of game animals, which generally have been based on densities estimated using a single survey method.

Using camera trap data to characterise terrestrial larger-bodied mammal communities in different management sectors of the Dja Faunal Reserve, Cameroon.

Tom Bruce, Rajan Amin, Tim Wacher, Oliver Fankem, Constant Ndjassi, Madeleine Ngo Bata, Andrew Fowler, Hilaire Ndinga, David Olson (2018).

African Journal of Ecology 56(4): 759-776 (open access).

Abstract

Camera trap surveys can be useful in characterising terrestrial larger-bodied mammal communities in Central Africa forests. Two 40-trap, minimum of 100 days, survey grids conducted in the Dja Faunal Reserve of southern Cameroon showed differences in the mammal communities of two sites 32 km apart. Mammal richness, diversity, guild structure, body-size patterns and relative abundance of taxa were measured by trapping rates and occupancy of the two mammal communities. One of the survey sites was (a) less rich in terrestrial mammal species; (b) missing disturbance-sensitive felids and white-bellied duiker (*Cephalophus leucogaster*, subsp, *leucogaster* Gray, 1873); (c) greater in abundance of some disturbance-tolerant species; and (d) lower in abundance of larger-bodied species. Several indicators suggest a higher hunting pressure at this site, and this may be a contributing factor to these differences.

A camera trap assessment of the forest mammal community within the transitional savannah-forest mosaic of the Batéké Plateau National Park, Gabon.

Daniela Hedwig, Ivonne Kienast, Matthieu Bonnet, Bryan K. Curran, Amos Courage, Christophe Boesch, Hjalmar S. Kühl, Tony King (2018).

African Journal of Ecology 56(4): 777-790 (open access).

Abstract

Monitoring populations in areas of ecological transition is crucial to understanding species distributions, but also a critical conservation tool. We used camera trapping to investigate the forest mammal community in the Batéké Plateau National Park (BPNP) in Gabon, a transitional landscape that experiences severe poaching. We compiled a species inventory, investigated group sizes and activity patterns of observed species, and conducted an initial test to evaluate whether ecological gradients within this landscape influence species occurrence. Based on 6612 images and videos recorded at 40 locations during 5,902 camera days, we identified 31 mammal species, including eight classified as threatened according to the IUCN. We detected lion (*Panthera leo*), which was thought to be extinct in Gabon, and mandrill (*Mandrillus sphinx*), for which BPNP was thought to be outside of their natural range. Our findings suggest that BPNP supports a low species richness compared to more forested protected areas. We found no changes in species composition of the forest mammal community with increasing distance from the continuous Gabonese rainforest, but a potential decrease in abundance for some species. Continued survey efforts need to be combined with detailed ecological data collection and effective law enforcement in the region.

Species distribution of kobs (*Kobus kob*) in the Shai Hills Resource Reserve: an exploratory analysis. R.A. Antwi, E.H. Owusu, D.K. Attuquayefio (2018).
Environmental Monitoring and Assessment 190(3):1 07. doi: 10.1007/s10661-018-6475-z.

Abstract

The well-being of a species fundamentally rests on understanding its biology, home range, and distribution. The highly seasonal distribution of kobs poses conservation and management difficulties, particularly because of the capricious nature of the ever-changing ecological and vegetation dynamics of the ecosystem. Assessing the distribution of kobs and their associated vegetation provides insight into the vulnerability and conservation status of the species. Species distribution and habitat suitability maps were developed and created respectively for the management of kobs in the Shai Hills Resource Reserve. Kob presence data collected was analyzed using the spatial analyst and Hawth's tool in the ArcGIS software where the gradients of kob distribution within the protected area landscape were plotted and mapped. Seven environmental variables including location, land cover/use, slope/elevation, nearness to dams and rivers, temperature, and rainfall were considered to have effect on kob distribution pattern and as such used in the development of species distribution and habitat suitability maps. The results indicated that kobs in the Shai Hills Resource Reserve (SHRR) assume a clumped or contagious distribution pattern where individual kobs are aggregated in patches. Rainfall, temperature, nearness to dams and rivers, slope/elevation, and land cover/use had influence in kob distribution. Of all the cataloged habitats, 86, 13, and 1% were moderately suitable, suitable, and unsuitable, respectively. Long-term survival of species depends on adequately large areas of suitable habitats and opportunities for home range activities between such areas. As such, it is recommended that suitable habitats for kobs be dedicated and designated as conservation areas, especially areas along the western boundary.

Buffon's kob (*Kobus k. kob*) (©ASG)

Survey of husbandry practices for Bovidae in zoos: the importance of parasite management for reintroduction programmes

Eulalia Moreno Mañas, Moisés Gonzálvez Juan, María del Rocío Ruiz de Ybáñez Carnero, Tania Gilbert, Juana Ortiz, Gerardo Espeso, Jesús Benzal, Belén Ibáñez, Francisco Valera Hernández (2019).

Veterinary Record doi: 10.1136/vr.104985

Abstract

Animals from zoological institutions may be used for reintroductions. These individuals are considered healthy, but they are not necessarily free of parasites, despite the minimum husbandry standards required of zoological institutions as described in the European Association of Zoos and Aquaria guidelines. In this sense, parasitism has been identified as the cause of failure, or has added difficulties, in some reintroduction programmes. Here the authors attempt to summarise the risk of parasitism to animals originating from zoological institutions by analysing a questionnaire about parasite prevalence, sampling methods, treatment and control in three ungulates in European zoos. Completed questionnaires were received from 38 institutions (58.5 per cent response rate). Most of the responding institutions (97 per cent) detected the eggs of endoparasites in faeces, but only one reported ectoparasites. Most institutions followed a similar preventive schedule, with ivermectin as the preferred prophylactic treatment for parasites, commonly administered in food every six months. The frequent use of concentrating flotation techniques as the sole method to evaluate the presence of parasite eggs in faecal samples is not recommended because it fails to detect trematode and lung nematode infections, so it would be better to use flotation techniques together with sedimentation procedures or serological and molecular tests. The results suggest that parasite control in zoological institutions can be complicated, indicating the need to implement a specific management schedule for institutions involved in reintroduction projects.

Instructions to Gnusletter Contributors

Antelope Specialist Group
Groupe de Spécialistes des Antilopes

Gnusletter welcomes articles on all aspects of antelopes, of interest to those involved in conservation, management, and research on antelopes and the general public. Articles may include but are not limited to research findings, notes from the field, reviews of topics relevant to antelope conservation, anecdotal accounts, opinions, commentaries, and book reviews. Readers are encouraged to submit comments, opinions, and criticisms of articles published in *Gnusletter*. Such correspondence should be a maximum of 300 words. All submissions will be edited and published at the discretion of the editorial board. Original articles will be subject to a peer-review process. The editorial board currently consists of the ASG Co-Chairs and the *Gnusletter* editor.

Submission: Articles should be submitted to the editor, Steve Shurter (sshurter@white-oak.org),

Manuscripts: should be in English and double-spaced with 1" margins and in Times New Roman 12 pt font Research articles may have a maximum of 5000 words.

Opinions expressed should be based on adequate evidence. Titles should be concise and accurate and include any relevant scientific (taxonomic) name. A full-length paper must include a proper summary. We welcome word-for-word translations of summaries where appropriate.

Localities with well-known other spellings or older names should have these placed in parentheses after first mention, while localities too small to be in the *Times atlas* should be given their precise geographical co-ordinates (preferably with some evidence of source). Authors are encouraged to follow ASG's taxonomy (as used in the IUCN Red List www.iucnredlist.org) and to provide explanations for any deviation. On first mention of a species, both English and scientific name should be given, but only one after that, preferably the English.

Metric units and their international symbols should be used (other systems of measurement can be added in parentheses), with temperatures in Centigrade (Celsius).
Dates should be written 1 January 1985, times of day as 08:30, 17:55, using the 24- hour clock.

Tables and figures: These should be numbered in the text consecutively as they appear (Table 1, Figure 1 etc.) and the Tables and figures placed on separate pages along with the caption at the end of the ms.

Photos: are welcome and should be submitted separately (NOT embedded in the manuscript) preferably in jpeg format and with the appropriate photo credit.

References: In the text should not use & or a comma before the date and should be listed chronologically. Publications by the same authors in the same year may be distinguished by a, b, etc., after the date. With more than 2 authors use et al.

e.g East (199) said……
… according to Kingdon and Hoffman (2013)
..(Smith 1979, Jones 2010)…….. Smith et al. (2014)
Smith (2000a,b)

A full list of references should be provided at the end, listed alphabetically. Book titles and journal names should be in italics. Do not abbreviate journal titles. The following are shown as a guide:

Stanley-Price, M.R. 1989. *Animal Reintroductions: the Arabian Oryx in Oman*. Cambridge University Press, Cambridge, UK.

Grimshaw, J.M., Cordeiro, N.J. and Foley, C.A.H. 1995. The mammals of Kilimanjaro. *Journal of the East Africa Natural History Society* 84: 105-139.

Hillman, J. C. 1979. The biology of the Eland (*Taurotragus oryx* Pallas) in the wild. PhD thesis, University of Nairobi, Kenya.

IUCN. 2016. The IUCN Red List of Threatened Species. Version 2016-3. Available at: www.iucnredlist.org. (Accessed: 07 December 2016).

Kingdon, J. 2013. Genus *Tragelaphus*. In: J. Kingdon and M. Hoffmann (eds). *Mammals of Africa*, *Pigs, Hippopotamuses, Chevrotain, Giraffes, Deer and Bovids,* pp. 138-141. Bloomsbury, London, UK.

Spalton, J.A., Lawrence, M.W. and Brend, S.A. 1999. Arabian oryx reintroduction in Oman: successes and setbacks. *Oryx* 33: 168-175.