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Population ecology of the Grant's gazelle in the plains of Nechisar National Park, Ethiopia

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Abstract: A study on the population structure and abundance of the Grant's gazelle (*Gazella granti* Brooke, 1872) was carried out in the plains of Nechisar National Park, Ethiopia during November, 2008 - April, 2009. Distance sampling based on line-transect method was used to estimate the populations of the Grant's gazelles. Habitat association was assessed based on the abundance of herds or individuals observed in different habitats. The estimated population of Grant's gazelle in the study area was around 2100 heads. The population density was 10.5 ± 3.2 km^{-2}. The mean herd size was 3.65 individuals, including the territorial male, females and fawns. The age ratio of adult to fawns was 1:0.22. The age structure of Grant's gazelles was 82.5 % adult, 12.5 % juvenile and 4.8 % fawn. The sex ratio of adult male to adult female was 1:2, with a sex structure of 28.25 % male, 54.25 % female and 17.3 % immature young. The grassland habitat ranked higher in the abundance of gazelles (n = 100, 67.1 %) than shrubland (n = 49, 32.8 %), indicating higher association of them with the grassland habitats of the Nechisar plains. *Chrysopogon ucheri*, *Cenchrus ciliaris*, *Ischaemum afrum*, *Themeda triandra*, *Pennisetum mezianum*, *Brachiaria serata*, *Acacia mellifera*, *Acacia oerfota*, *Acacia brevispica* and *Dichrostachys cinerea* were the major plants consumed by gazelles.

Key words: Age and sex ratios, habitat association, Nechisar plains, population structure.

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Introduction

Gazelles (Bovidae, Mammalia) generally inhabit dry open savannah grasslands and scrub habitats (Estes *et al.* 2006; Kingdon 2004). They are both browsers and grazers feeding on a variety of plant parts including leaves, shoots, fallen flowers and fruits. They are generally drought tolerant species requiring very little water. They meet their water requirements mostly from the plant parts they consume (Grignolio *et al.* 2003; Kingdon 1997). When other sympatric herbivores migrate to other areas in search of water and fodder during dry season, gazelles remain within their original ranges or move locally within short distances, where there is enough fodder (Estes *et al.* 2006). Gazelles exhibit a high degree of spatial overlap, with other ungulates congregating to defend from predators and to satisfy their nutritional requirements in areas where resources are plenty (Berhun & Solomon 2005; Henley *et al.* 2007).

The Grant's gazelle (*Gazella granti*) is the only member of the genus *Gazella* locally extended to the central region of the Ethiopian Great Rift Valley and extended to north of Lake Ziwai at altitudinal ranges of 400 - 1600 m (Nowak 1991). Nechisar, Abijata Shala, Mago and Omo National Parks, and Yabelo Sanctuary are the conservation areas in Ethiopia holding populations of Grant's

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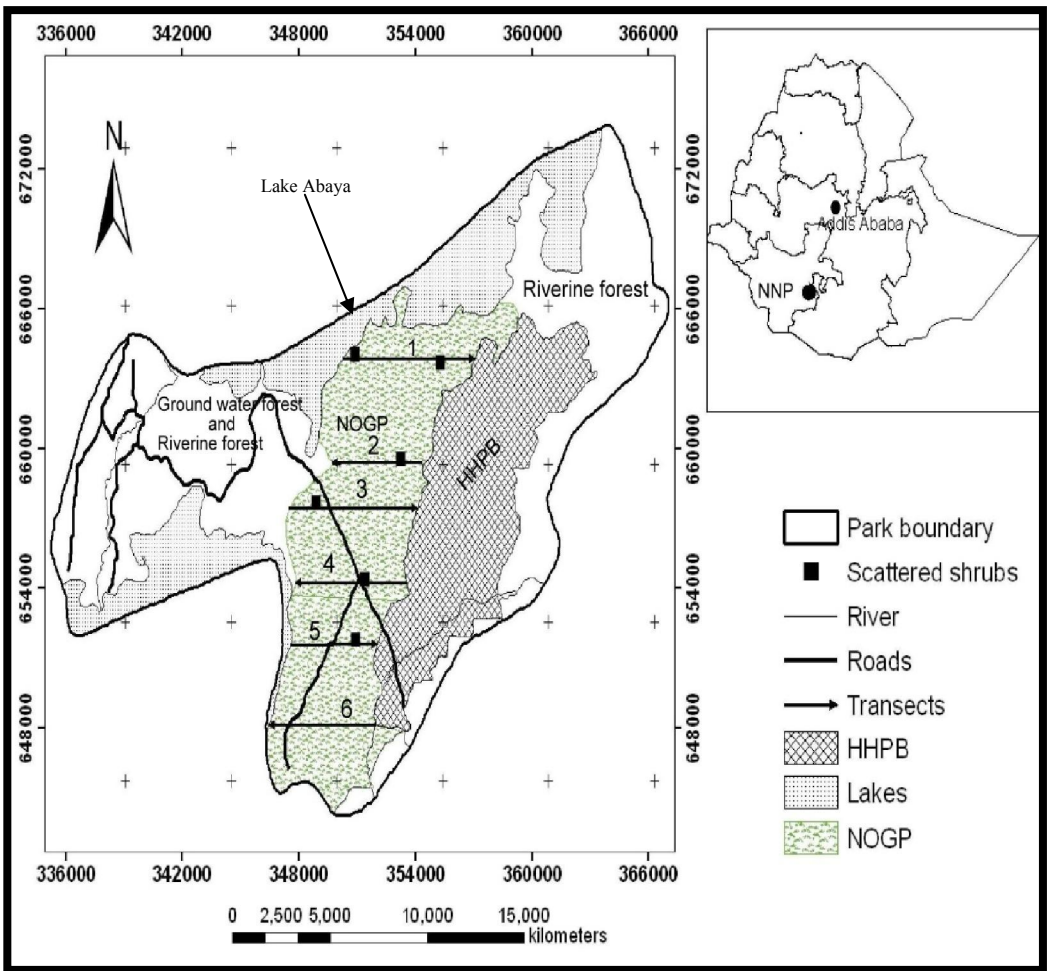

Fig. 1. Map of Nechisar National Park showing transects (1 - 6). Inset: the map of Ethiopia showing the location of the study area (NNP = Nechisar National Park, NOGP = Nechisar Open Grassy Plains, HHPB = Hare Hill Plateau Bushland).

gazelle (Duckworth *et al*. 1992; Hillman 1993; Yalden *et al*. 1984).

Nechisar National Park (NNP), especially the Nechisar plains represent a preferred habitat of the Grant's gazelle (Bolton 1970; Duckworth *et al.* 1992; Kirubel 1985; Yisehak *et al*. 2007). Although, there are large and stable populations of Grant's gazelle in the wild, in most of its ranges, gazelles have suffered due to habitat degradation, and uncontrolled hunting. These factors have reduced the formerly abundant gazelles to scattered, remnant populations and hence long-term survival of this species needs to be carefully examined (Chammem *et al*. 2008), even though this species is considered as Least Concern by IUCN (2008). In this context, the present investigation was conducted in the plains of NNP with the aim of filling the knowledge gap on the population ecology and habitat association of the Grant's gazelle.

Materials and methods

Study area

Nechisar National Park is located at about 500 km away from Addis Ababa, the capital city of Ethiopia, in the Southern Nations Nationalities and Peoples Regional State. The Park is situated between 5° 51′ - 6° 10′ N and 37° 32′ - 37° 48′ E (Fig. 1) with altitude ranges from 1108 m asl at Lake Chamo and 1650 m asl at the peak of Geda hill (Bolton 1969). The Park covers an area of 541 km^2 of which 436 km^2 is covered by land. The remaining 78 km^2 is aquatic, as the Park is located in the very scenic part of the Great Rift Valley floor between the two lakes, Lakes Abaya and

Chamo (Amha & Wood 1982). The rugged mountainous parts of the Park have a brown calcareous loamy soil derived from volcanic rocks. The plains of the NNP have black cotton soil with high proportion of clay (Bolton 1970; Kirubel 1985). The annual rainfall is bimodal with a long rainy season during March - June and a short rainy season during September - November. The mean annual rainfall for the period 1998 - 2008 was 822.28 mm. The peak mean monthly rainfall was in April (159.7 mm). The hottest time of the year in NNP was during January - March, while the cooler months were November and December. The mean annual maximum temperature in the area was 31.05 °C and the mean annual minimum temperature was 16.22 °C.

Nechisar National Park has four major types of vegetation, the Somale-Masai *Acacia-Commiphora* deciduous bushland and thickets, the Somale-Masai edaphic grassland, the Somale-Masai riverine forest and herbaceous fresh water swamp and aquatic vegetation (Bolton 1970; Duckworth *et al.* 1992; Hillman 1993; Kirubel 1985; White 1983). Among these, only the mix of the Somale-Masai edaphic grassland (cover large proportion of the Nechisar plains and highly dominated by common grass species) and the dispersed Somale-Masai *Acacia-Commiphora* deciduous bushland and thickets (cover small proportion of the Nechisar plains, which is composed of low bushy trees and scattered shrubs set in and around the plains) are characteristic vegetation of the present study area (Yisehak *et al.* 2007). Nechisar National Park harbours a variety of mammalian, avian, amphibian, reptilian and fish fauna, and is known for its large mammalian fauna such as Burchell's Zebra (*Equus burchelli*), Grant's gazelle (*Gazella granti*), Greater Kudu (*Tragelaphus strepsiceros*), Swayne's hartebeest (*Alcelaphus buselaphus swaynei*), Guenther's dikdik (*Madaqua guentheri*) and Warthog (*Phacochoerus africanus*). Most of the vertebrate species of the present study area are under threat due to habitat loss and human induced disturbances (Yisehak *et al*. 2006).

Methods

Prior to the actual data collection, a reconnaissance survey was carried out in NNP during August 2008. During this survey, relevant information on Nechisar plains such as vegetation types and distribution of Grant's gazelle were observed and identified. Out of the 270 km^2 of the estimated extent of Nechisar plains (Bolton 1970), an extent of 200 km^2 of more or less flat area dominated by grasses, scattered shrubs and bushes were selected for the present investigation. The major consideration for site selection was the abundance of Grant's gazelle observed in different habitat types during the reconnaissance survey. Intensive field work was carried out during November 2008 - April 2009. Distance sampling based online-transect method (Focardi *et al*. 2002, 2005) was employed for estimation of the population density of Grant's gazelles in the study area. Six transects (T_1-T_6), each of 4 km length were laid and marked on a 1:250,000 topographic map of NNP. Starting points of transects were located by GPS randomly on each of the transect lines. During the transect observation, three transects (T_1, T_3 and T_5) were covered walking from east to west direction and others (T_2, T_4 and T_6) were covered walking from west to east direction. Adjacent transects were at least 1000 m apart. Transects were traversed on foot (with an average speed of 3 km h^{-1}). Radial distance (r_i), sighting angle (θ) and herd size (n) were recorded on observing a herd. Data were collected on the abundance of herds or individuals encountered in different habitat types (Owzari *et al*. 2007). The population structure (approximate age, sex, group size and composition) were recorded. Body size, shoulder height and horn size were used to determine the approximate age. Sexual characteristics such as the horn size, shape and body size were used to determine sex. Those individuals seen within a distance of < 50 m from the nearby group were recorded as members of the same group. Data collection was carried out when the Grant's gazelles were most active (06:00 - 11:30 h and 14:00 - 18:30 h) during the day time. Observations were made by unaided eyes and using a pair of binoculars (10 x 42 Bushnell). The vegetation types utilized (grazed/browsed) by gazelles were identified in the field from plant parts, shoot, leaf, stem and fruit remains in the grazed/browsed area, and recorded on the data sheet. Sample specimens of unidentified vegetation types were collected from the field for further identification.

Double counting of the same individual or herd was avoided using easily recognizable features of individual gazelles, herd size and composition. Data were collected during the dry season for three months (December, 2008; January, 2009 and February, 2009) and the wet season for three months (November, 2008; March, 2009 and April, 2009) to include both the seasons.

Table 1. Number of herds (n_i), mean herd size (s_i) and individual gazelles counted (x_i) in each of the transects during wet and dry seasons.

Transects	No. of gazelles observed						Mean		
	Wet season			Dry season					
	n_i	s_i	x_i	n_i	s_i	x_i	n_i	s_i	x_i
T1	20	4.3	86	16	3.8	61	18	4.05	73
T2	19	4.4	84	22	3.6	79	20.5	4.01	82
T3	12	4.0	48	12	4.0	48	12	4.0	48
T4	8	3.3	26	5	2.8	14	6.5	3.05	20
T5	9	3.4	30	10	3.6	36	9.5	3.5	33
T6	9	2.6	23	7	2.6	18	8	2.6	21
Total	77	--	297	72	--	256	74.5	--	277

Table 2. Population structure of Grant's gazelle encountered during the study period.

Months	No. of gazelles		Sex and age category						Ratio	
			Sex			Age			Sex	Age
	n_i	x_i	Am	Af	Un	Adt	Juv	Fa	M:F	Ad:Yg
November	26	94	28	42	24	70	10	14	1:1.5	1:0.34
December	26	86	35	35	16	70	7	9	1:1	1:0.23
January	20	62	17	29	16	46	13	3	1:1.7	1:0.35
February	26	100	20	63	17	83	16	1	1:3	1:0.2
March	25	110	33	66	11	99	11	0	1:2	1:0.11
April	26	101	23	67	11	90	11	0	1:2.9	1:0.12
Total	149	553	156	302	95	458	68	27		
Mean	24.8	92.1	26	50.3	15.8	76.3	11.3	4.5	1:2	1:0.22

n_i = herds observed, x_i = individual gazelles observed, Am = adult male, Af = adult female, Un = young unknown sex (juvenile + fawn), Adt = adult total (males + females), Juv = juvenile, Fa = fawn, M = male, F = female, Ad = adult, Yg = young.

Data analysis

Density was estimated from line-transect data following the method of Buckland *et al*. (1993) using the software program DISTANCE (version 5.0, release 2) (Thomas *et al*. 2006). The programme DISTANCE was used for estimation of the effective transects width (x) and the density (D) of gazelles encountered during the investigation period. The mean herd size (S_i) was used as estimator of average herd size encountered during the investigation period as $S_i = \sum n_i)/n$, where, $\sum n_i$ = sum of total individual gazelles counted per transect and n = number of gazelle herds counted per transect (Buckland *et al*. 1993). The variations of gazelle herd size and individual number encountered during the wet and dry seasons were analyzed by independent sample test using SPSS (Version 15). The population size of Grant's gazelles was estimated by multiplying the population density with total extent of the study area (200 km^2) (Sutherland 1996). The number of gazelle herds and individuals encountered during the investigation period was summed together separately for wet and dry seasons. The variations in sex, age and herd composition within the populations during the wet and dry seasons were tested using Kruskal-Wallis test (Kruskal & Wallis 1952), using SPSS. The Mann-Whitney U test was used to test the variations in habitat use during the wet and dry seasons.

Results

Out of the total 149 herds of Grant's gazelles observed during the present investigation, 77 were during the wet season and 72 were during the dry season. The mean herd size was 3.67 $\pm$ 0.28 (SE)

Table 3. Abundance of gazelles observed feeding in different vegetation types during wet and dry seasons.

Habits	Vegetation types	% of gazelles observed on feeding		Mean %
		Wet season	Dry season	
Grassland	*Chrysopogon aucheri*	24.6	31.9	28.2
	Cenchrus ciliaris	19.4	19.4	19.4
	Ischaemum afrum	12.9	9.7	11.3
	Mixed grass species	6.4	8.3	7.3
Shrubland	*Acacia mellifera*	16.8	15.2	15.0
	Dichrostachys cinerea	10.3	9.7	10.0
	Mixed herbs and shrubs	9.0	6.9	7.9

and 3.4 $\pm$ 0.23 (SE) individuals during the wet and dry seasons, respectively. There was no significant variation between the herd size encountered during wet and dry seasons (t = 1.13, df = 147, P = 0.25). A total of 297 individual gazelles (of 77 herds) were counted during the wet season and 256 individuals (of 72 herds) during the dry season (Table 1). There was no significant variation in the number of individuals observed during the wet and dry seasons (t = 1.91, df = 551, P = 0.058). Thus, the average number of 276.5 (≈ 277) individual gazelles were counted (≈75 herds) in the Nechisar plains with an average herd size of 3.65 individuals.

The density of Grant's gazelles in the study area was estimated as 12.0 ± 3.4 km^{-2} and 9.0 ± 3.1 km^{-2} during the wet and dry seasons, respectively. The overall density was estimated to be 10.5 ± 3.2 individuals km^{-2} during the study period. The population size of gazelles was estimated to be 2400 (1720 - 3080) and 1800 (1180 - 2420) individuals during the wet and dry seasons, respectively, with 95 % confidence interval and at 5 degree of freedom. Out of the total 553 individual gazelles observed, 156 were adult males, 302 adult females and 95 young of unknown sex (68 juveniles and 27 fawns) (Table 2). The sex structure of Grant's gazelles was biased towards females.

The following eight types of herd organization of the gazelles were recorded: single male, paired male-female herds, all male herds, mixed herds consisting adult females, adult males, juvenile and fawn, herds consisting of only two females, herds consisting of 3 - 5 females, herds consisting of 6 - 10 females and herds consisting of 11 - 14 females. Mixed herds were more, and the least was of herds of 11 - 14 females. In all these herds, there were more adult females compared to the number of males and young. There was no significant variation in the distribution of herd composition during the wet and dry seasons (χ^2 = 3.786, df = 2, P = 0.052).

Abundance of gazelles seen in the grassland habitat was more during the wet season than during the dry season (Fig. 2). Grant's gazelles were observed to feed on different species of Poaceae and Fabaceae families. Abundance of gazelles observed feeding on different vegetation types is given in Table 3. The major species of plants consumed by gazelles during the study

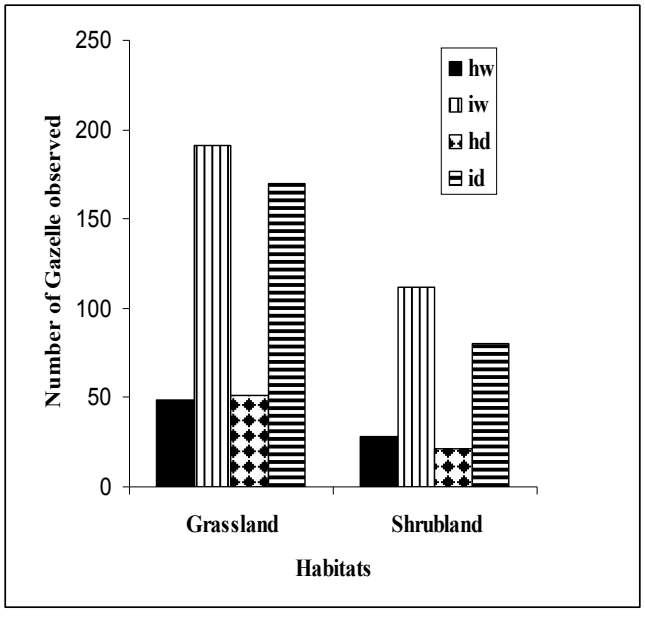

Fig. 2. Grants gazelle distribution in different habitats during wet and dry seasons (hw = herds in the wet season, iw = individuals in wet season, hd = herd in the dry season, id = individuals in the dry season).

period were *Chrysopogon aucheri* (28.2 %), *Cenchrus ciliaris* (19.4 %), *Ischaemum afrum* (11.3 %), mixed grass species (*Themeda triandra*, *Pennisetum mezianum* and *Brachiaria serata*) (7.3 %), *Acacia mellifera* (15.0 %), *Dichrostachys cinerea* (10.0 %) and mixed herbs (*Acacia oerfota* and *Acacia brevispica*) (7.9 %).

Discussion

Populations of Grant's gazelle during wet and dry seasons in NNP were 2400 (1720 - 3080) and 1800 (1180 - 2420), respectively. However, as the populations did not vary significantly among seasons, it can be inferred that NNP can satisfactorily provide the eco-requirements of the gazelles throughout the year. During the dry season, grasses in the flood plains dry up and productivity drops. This causes some of the gazelles to spend the dry season in the shrublands and surrounding bushlands. They also become less active during the dry season, which reduces the probability of observation of gazelles during the census time, thereby affecting the population estimates.

Only adults of gazelles could be differentiated into males and females through direct observation on their primary sexual characteristics. It was difficult to categorize the young (juvenile and fawn) into male and female, and hence they were recorded as unknown sex. The result of the present study showed the presence of relatively high proportion of females in the population. This indicates that the population has a potential to increase their size in NNP. Comparatively lower proportion of the young than adult (young to adult ratio = 1:2) was encountered during the present study. Young gazelles are usually hidden inside dense and tall grasses and shrubs of the plains during the wet season and in the surrounding bushes during the dry season, until they are strong enough to run fast and escape from predators. This might have influenced lower proportion of the young ones in the study area. The cause for low proportion of adult male might be related to poaching pressure, as males are chosen for their larger body size by poachers. Competition of males could also force the bachelor males to migrate to less suitable habitats that are poor in food quality, and exposing them to predators and hunters.

Ungulates living in open habitats generally form larger groups than those that live in forests. Animals in social groups can avoid predation better than the solitary ones (Harris 1996). The group size of any species can also be an indication of the quality of the habitat where they live (Mattiello *et al*. 2004). The herd size of animals is reduced seasonally when food availability drops in the grassland habitat**.** In the plains of NNP, grassland is dry during the dry season. Therefore, gazelles disperse into smaller family units and distribute themselves in the surrounding habitats to satisfy their nutritional requirements. This might help the populations to compensate food shortage during the dry season. The herd composition is influenced by a variety of environmental factors, in addition to the special features of social organizations of the species concerned (Mattiello *et al*. 2004). In general, the social organization of Grant's gazelles may be considered as a harem consisting of single territorial male with large number of females or mixed herds (herd consisting of juveniles and fawns).

A combination of ecological factors including bush fire and livestock grazing act as factors that the distribution pattern of wild animals in natural habitats (Kupika *et al*. 2014). Herbivores require a certain level of protein in their forage to sustain with the essential energy requirements. Habitat association of animals reflects strategies that enhance their survivorship and successful reproduction (Grignolio *et al*. 2003). The biomass of the grass species in NNP reaches its peak during the wet season, and decline during the dry season (Yisehak *et al*. 2007). As a result, grassland species face problems associated with food quality during the dry season. During such periods, artiodactyls from smaller family units and distribute throughout the surrounding habitats in order to obtain food. Gazelles also move to the surrounding shrubs and bushes to get enough food from dicotyledons that grow outside their original habitats (Henley *et al*. 2007). They disperse into smaller family units and distribute to the surrounding habitats to satisfy their nutritional requirements. Such conditions force gazelles to move to the surrounding bush and shrublands to find food in order to sustain themselves. The wet season is the most favourable time for Grant's gazelle population. During this time, the plains also possess high fodder quality and moderate atmospheric temperature for the gazelles to forage.

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References

Amha, B. & R. B. Wood. 1982. Limnological aspect of algal bloom on Lake Chamo in Gamo Gofa administrative region, Ethiopia. *SINET: Ethiopian Journal of Science* **5:** 1-19.

Berhun, G. & Y. Solomon. 2005. A study on abundance, group size and composition of Soemmerring's gazelle (*Gazella soemmerringi*) in Awash National Park and Alledeghi Wildlife Reserve, Ethiopia. *SINET: Ethiopian Journal of Science* **28:** 161-170.

Bolton, M. 1969. *The Nechisar Plains: Rift Valley Lakes Ecological Survey*. Report No. 2. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Bolton, M. 1970. The Nechisar Plains: Rift Valley Lakes Ecological Survey, 1970. Report No. 4. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Buckland, S. T., D. R. Anderson, K. P. Burham & J. L. Laake. 1993. *DISTANCE Sampling: Estimating Abundance of Biological Populations*. Chapman and Hall, London, U.K.

Chammem, M., S. Selmi, S. Nouira & T. Khorchani. 2008. Factors affecting the distribution of Dorca's gazelle. *Journal of Zoology, London* **275:** 146-152.

Duckworth, J. W. C., M. Evans, R. J. Safford & Z. Chemere. 1992. *A Survey of Nechisar National Park, Ethiopia: Report of the Cambridge Ethiopia Ground-Water Forest Expedition, 1990.* International Council for Birds Preservation, Cambridge, U.K.

Estes, R. D., J. L. Atwood & A. B. Estes. 2006. Downward trends in Ngorongoro crater ungulate populations 1986 - 2005: Conservation concerns and the need for ecological research. *Biological Conservation* **131:** 106-120.

Focardi, S., P. Montanaro, R. Isotti, F. Ronchi, M. Sacaco & R. Calmnti. 2002. The use of distance sampling a mark-resight to estimate the local density of wildlife population. *Environmetrics* **13:** 177-186.

Focardi, S., P. Montanaro, R. Isotti, F. Ronchi, M. Sacaco & R. Calmnti. 2005. Distance sampling effectively monitored a declining population of Italian roe deer, *Capreolus capreolus italicus*. *Oryx* **39:** 421-428.

Grignolio, S., F. Parrini, B. Bassano, S. Luccarini & M. Apollonio. 2003. Habitat selection in adult males of Alpine ibex, *Capra ibex*. *Folia Zoologica* **52:** 113-120.

Harris, R. B. 1996. Wild ungulate surveys in grassland habitats: satisfying methodological assumptions. *Chinese Journal of Zoology* **31:** 16-21.

Henley, S. R., D. Ward & A. I. Schmidt. 2007. Habitat selection by two desert-adapted ungulates. *Journal of Arid Environments* **70:** 39-48.

Hillman, J. C. 1993. *Ethiopia: A Compendium of Wildlife Conservation Information.* Vol.1. New York Zoological Society and Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

IUCN. 2008. *IUCN Red List of Threatened Species.* Species Survival Commission, Antelope Specialist Group, Gland, Switzerland.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, Sandiago, U.S.A.

Kingdon, J. 2004. *The Kingdon Pocket Guide to African Mammals*. Princeton University Press, Princeton and Oxford, U.K.

Kirubel, T. 1985. *Nechisar National Park: Primary Report with Particular Reference to the Distribution of Large Herbivores and Major Threats to the Park Resource.* Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Kruskal, W. & W. A. Wallis. 1952. Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association* **47:** 583-621.

Kupika, O. L., S. Kativu, E. Gandiwa & A. Gumbie. 2014. Impact of African elephant on baobab (*Adansonia digitana* L.) population structure in northern Gonarezhou National Park, Zimbabwe. *Tropical Ecology* **55**: 159-166.

Mattiello, S., C. Zanoni, H. Duplessis, E. Heinzl & M. C. Crimella. 2004. Habitat use and group size of African wild ungulates in Namibian Game Ranch. *Game and Wildlife Sci*ence **21:** 735-745.

Nowak, R. M. 1991. *Walker's Mammals of the World*. Vol. Π. 5th edn. The John Hopkins University Press, Baltimore, U.S.A.

Owzari, H. N., B. B. Rad & M. H. Emami. 2007. Habitat use by Persian Gazelle (*Gazella subgutturosa subgutturosa*) in Bamoo National Park during autumn and winter. *Acta Zoologica Mex*icana **23:** 109-121.

Sutherland, W. J. 1996. *Ecological Census Technique: Hand Book*. Cambridge University Press, Cambridge, U.K.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J. R. B. Bishop & T. A. Marques. 2006. *DISTANCE 5.0.* Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, St. Andrews, Scotland.

White, F. 1983. *The Vegetation of Africa: A Descriptive Memoir to Accompany the NESCO/AETFAT/*

UNSO Vegetation Map of Africa. United Nations Educational Science Cooperative Organization, Paris, France.

Yalden, W. D., M. J. Largen & D. Kock. 1984. Catalogue of the mammals of Ethiopia. 5 Artiodactyls. *Monitore Zoologico Italiano (NS) Supplemento* **4:** 672-721.

Yisehak, D., B. Afework & M. Balakrishnan. 2006. Human impact on plains zebra (*Equus quagga)* population in Nechisar National Park, Ethiopia. *International Journal of Ecology and Environmental Sciences* **32:** 137-142.

Yisehak, D., B. Afework & M. Balakrishnan. 2007. Population status of plains zebra (*Equus quagga*) in Nechisar National Park, Ethiopia. *Tropical Ecology* **48:** 79-86.

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