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Demography and dynamics of mountain nyala *Tragelaphus buxtoni* in the Bale Mountains National Park, Ethiopia

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Abstract We studied the population dynamics of endangered mountain nyala (*Tragelaphus buxtoni*) between 2003–2005 in the Bale Mountains National Park. Line-transect sampling and total count methods were used to gather data on demographics and movement patterns. The population's age-group composition was 58% adults, 25% sub-adults, 9% juveniles, 5% calves and 3% unidentified with a female-male sex ratio of 2:1. Population density was found to be significantly different between the two sub-populations (Dinsho Sanctuary and Gaysay/Adelay). A significant difference was found for age-group composition across the two sub-populations except adult females, sub-adult males and calves. The Dinsho sub-population was an isolated group. Separation and containment of the mountain nyala population could have negatively affected their ability to search for habitat requirements and mates from distant areas. The population varied between 830–908 individuals (95% CI), a reduction of 45% from earlier reports. However, the mean population density increased due to contraction of the species' habitat range. We observed a population decrease of 2–5% per year over the course of our study. Many of the assessed demographic parameters did not significantly change over the three years. This suggests that the decrease in nyala population was not due to random variations in reproduction. Anthropogenic factors such as competition with livestock for forage, habitat encroachment and poaching by the local people might have been partly responsible for the depleted population in our study areas [*Current Zoology* 56 (6): –, 2010].

Key words Density, Dynamics, Group size, Mountain nyala, Movement, Sex ratio

African forest ungulates have received less attention than their counterparts in savanna grassland (Hart, 2001). It is important to understand their ecology and population dynamics to properly manage and conserve these species (Hart, 2001; Baillie et al., 2004). Demographic information has become a vital tool in the conservation of antelopes (East, 1988), particularly for endangered species such as mountain nyala (*Tragelaphus buxtoni*). However, information is currently lacking (Bekele, 1982, Hillman, 1993) except for a few sporadic studies that estimated total population and density (Brown, 1969a, 1969b; Stephens, 1997; Stephens et al., 2001). Few researchers have described populations' sex and age characteristics (Hillman, 1986b; Gebrekidan, 1996; Refera, 2001; Refera and Bekele, 2004). Past population estimates derived by ecologists vary due to the different methods used and areas studied, but the estimates nevertheless provide useful historical data.

Mountain nyala were brought to the attention of the scientific community in 1908 by Major Ivor Buxton (Lydekker, 1911). They belong to the spiral-horned family of Bovidae (Genus *Tragelaphus*), and are endemic to Ethiopia. This species has no recognized subspecies or synonyms (Wilson and Reeder, 1993), and there are no records of animals in captivity (Hillman, 1986a). The International Union for the Conservation of Nature (IUCN) designated the conservation status of the animal as endangered in 2002. Males possess horns typical of the spiral-

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horned antelopes. An adult male may weigh over 300 kg at the age of 4–5 years, but the typical range is from 180–300 kg. Females weigh between 150–200 kg. Each individual is uniquely patterned with spots and stripes (Kingdon, 1997).

Habitat fragmentation caused by human settlement and agricultural cultivation has negatively affected the animals' potential to inhabit its suitable range. A number of individuals were observed in relatively isolated areas of Dinsho Sanctuary, Gaysay/Adelay areas, Web Valley and the highlands in the central part of the Bale Mountains National Park (BMNP). Web Valley and the highlands now support only relics of the original population due to extensive grazing and human settlement. Small populations are more vulnerable to human interference than larger groups (Pullin, 2002), so the future viability of these isolated is bleak. As Primack (2002) noted, the long term persistence of small and isolated subpopulations of a given species is limited. The limitations of a species' potential for dispersal and colonization caused by habitat fragmentation have been widely reported (Kingdon, 1989; Rochelle et al., 1999; Debinski and Holt, 2000; Trombulak and Frisell, 2000; Primack, 2002, Pullin, 2002). Habitat fragmentation may also affect population dynamics by enhancing population decline and dividing widespread populations into sub-populations within restricted areas (Rochelle et al., 1999; Primack, 2002; Pullin, 2002). The density of mountain nyala in the northern part of BMNP, particularly in Gaysay and its surrounding areas, has steadily increased over the past 30 years (Brown, 1969b; Hillman, 1986a; Refera and Bekele, 2004), although the population has decreased across the entire area of BMNP. Previous accounts show that the species was virtually absent in the study site 35 years ago (Brown, 1969a). Historic evidence suggests that most of the areas that were once inhabited by the species in the Bale Mountains are now settlements, or agricultural and grazing land (Brown, 1969 a, b; Hillman, 1986b, 1988; Stephens et al., 2001; Malcolm and Evangelista, 2002). As a result, the habitat and range of mountain nyala has decreased, leaving the animal confined to well protected areas.

There is evidence that small and isolated wild populations are at risk of inbreeding depression, *and* this severely affects the viability of endangered species (Hedrick and Kalinowski, 2000; Keller and Waller, 2002; Primack, 2002; Pullin, 2002). Garner et al. (2005) noted that substantial losses in genetic diversity are most likely to occur at the herd and/or population level before conservation action is taken at the species level. A fragmented habitat may have different resources than the original habitat., such as food, cover and breeding sites These can result in an entirely different population structure, even for small populations (Caughley and Gunn, 1996).

A fence encircling the Dinsho Sanctuary physically separates the inhabiting mountain nyala sub-population from the relatively larger sub-population in the Gaysay/Adelay sites. The Sanctuary is also surrounded by human settlements and cultivated land. These physical barriers and the separation they cause might influence the population dynamics and other life history parameters of the isolated sub-population.

The general objective of this study was to characterize and describe the demographic parameters of mountain nyala in the northern region of the BMNP, Ethiopia. The study's aims were to: 1) estimate the population density of the species; 2) determine and compare age group composition, sex-ratio, calving rate, and group size between the sub-populations of Dinsho Sanctuary and the Adelay/Gaysay areas, and 3) measure changes in the population numbers and movement patterns of the animal in relation to the available habitats, including crop lands, especially between the Sanctuary and outside habitat.

1 Materials and Methods

1.1 Study area

The study area is located within 6°20'–7°40'N, 39°30'–39°58'E along the southeastern highlands of Ethiopia (Fig. 1).

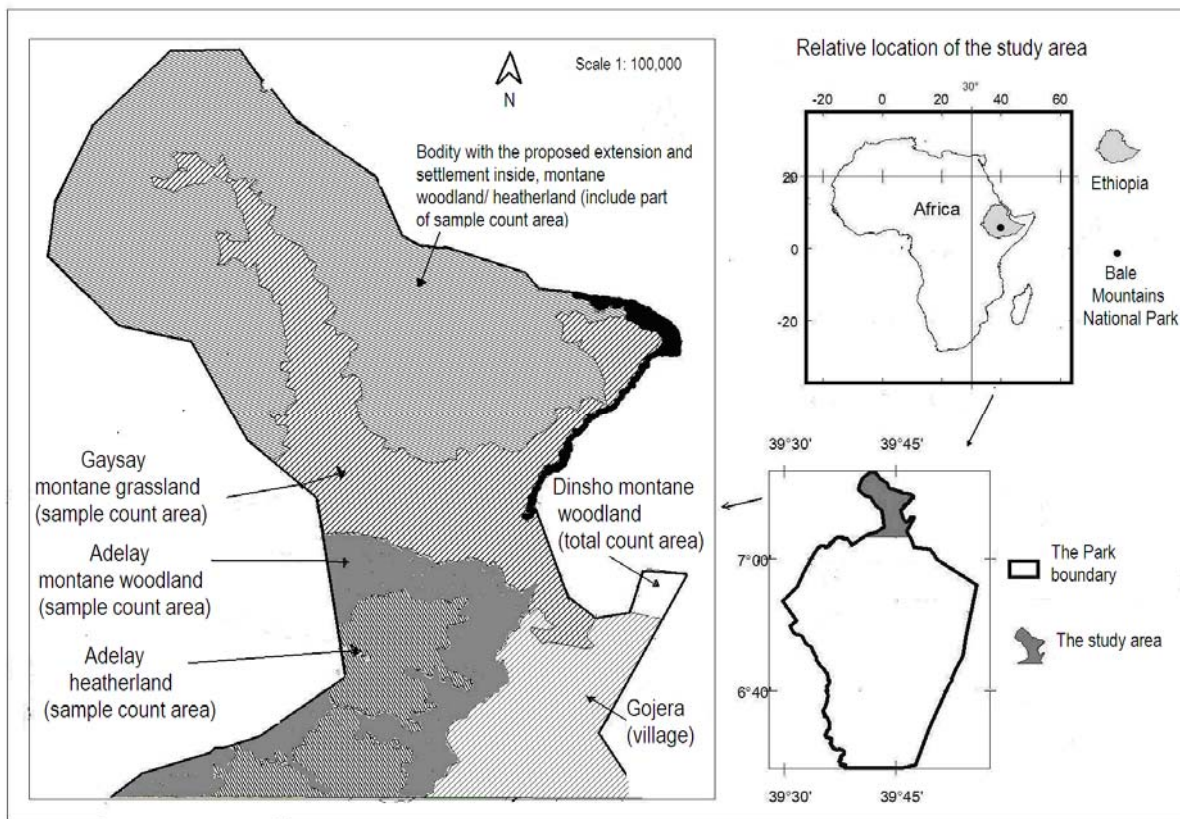


Fig. 1 Location map of the study area with the proposed extension

The study area is within the montane grassland and woodland eco-region, along the northern part of the Park, and contains different elevation and vegetation types. Montane grassland (3000–3100 m asl) occurs on flat terrain, located on the extreme northern part of the Park. The area is further subdivided into different vegetation communities of open grassland, swampy grassland, *Artemesia/Helichrysum* bush and *Hypericum bush* (Hillman, 1986b). Montane woodland (3100–3400 m asl) is subdivided into four zones based on the major vegetation structure and/or plant communities (Hillman, 1986b). These include *Hagenia/Juniperus* woodland, *Hypericum* bush, montane grassland and *Hypericum* woodland. *Erica* heatherland habitat (3400–3800 m asl) occurs adjacent to the montane woodland above the tree line.

Line-transect sampling and total count methods were used to collect mountain nyala demographics in the study area from 2003–2005. Surveys were conducted every two weeks in July and August (wet season), and November and December (dry season) for the three years of the study. Two three-hour surveys were run each day, from 0800–1100 h and 1400–1700 h. All mountain nyala observed during the census were sexed, and their age was assessed according to their coat color and body size, along with horn shape for males. Individuals were assigned into age groups following Gebrekidan (1996), Kingdon (1997), and Yalden and Largen (1992).

1.2 Total count

We counted the total nyala population in the 1.2 km² Dinsho Sanctuary (Norton-Griffith, 1978; Melton, 1983; Caughley and Sinclair, 1994; Sutherland, 1996; Wilson et al., 1996). The small size of the area meant we searched

rather than sampled the Sanctuary. The area was divided into four equal sized blocks (by a parallel line in the north-south direction), 190 m wide by 1500 m long to avoid recounting animals. The borders and limits of each block were marked using white ribbons at 100 m intervals. Two observers and one recorder were assigned to each block and they searched the area by walking from the south to the north of the block. Counting was carried out simultaneously in all four blocks.

1.3 Line-transect sampling

Line-transect sampling was used to collect mountain nyala demographics (Smith, 1979, Burnham et. al., 1980; Southwell and Weaver, 1993; Plumptre, 2000). A pilot survey was carried out to determine the appropriate transect length. The desired transect length (L) was estimated using the formula:

$$L = \frac{b}{CV(D)^2} \times \frac{L_0}{n_0};$$

where: $b \approx [\text{var}(n)/n + n \cdot \text{var}\{f(0)\}/\{f(0)\}^2]$; $f(0)$ is value of the probability density function of detecting distances at zero distance; the value of b ranges from 1.5–3.0 and the most recommended value is 3.0, which we used; $CV(D)$ = coefficient of variation for population density during the pilot survey; D = population density of the animals from the pilot survey; L_0 = the total transect line length covered in the pilot survey; n_0 = number of animals encountered during the pilot survey (Buckland *et al.*, 1993).

Accordingly, the estimated transect length for the Gaysay grassland was 6.2 km ($CV = 40\%$, $n_0 = 18$ and $L_0 = 6$) and 6.8 km for the Adelay woodland ($CV = 47\%$, $n_0 = 12$ and $L_0 = 6$). During the pilot survey, animals were counted at different points along the transects. Then distances where counting were carried out (stop points) along the transects (x-axis) were plotted against sighting distances (on y-axis) where animals were observed perpendicular to the observer at each point. Then the sighting distance on the y-axis where the number of animals sharply declined (drop-off point) were taken as the sighting distance to calculate the density. Sighting distances for the Gaysay/Adelay study sites were determined from the pilot-survey data by plotting the probability of detecting $g(y)$ an animal, given that it is a distance y from the random transect lines on the y-axis and detection distance y on the x-axis. The distance at which the animal number sharply declined (drop off point) was considered as the limit of sighting distances. The sighting distances for Gaysay was 380 m and for Adelay, it was 200 m.

The Gaysay grassland was divided into five equal 1.2 km wide blocks. The first transect in the first block was laid at a distance of 950 m plus a random distance of 1–50 m from the western edge of the block. The transect line ran north-south at a 20° bearing. The other four transects were laid parallel to each other, separated by a distance of 950 m plus a random distance of 1–50 m.

The Adelay woodland was divided into three equal 1.6 km wide blocks. The first transect was selected using the same method as in the Gaysay grassland. The other two transects were laid parallel to each other separated by a distance of 1500 m plus a random distance of 1–50 m.

Data collection was carried out through direct observation of free-ranging animals using 7×35 binoculars. All sightings were made at a perpendicular angle from the transect line. Perpendicular angles were determined using Silva Compass. Sighting distances between the observer and the individual or groups of mountain nyala were determined using a Yardage Pro 500 range finder (Yardage Pro, Palm Springs, USA). When groups of mountain nyala were encountered, the distance to the center of the group was estimated following the procedures used by Burnham et al. (1980):

$$D = \frac{n}{2wLP_a}; a = 2wL;$$

where: D = density; n = number of animals detected or observed; w = truncation distance (sighting distance); L = total transect length; a = surveyed area (observed area); P_a = the probability that a randomly chosen animal is within the surveyed area.

Movement of mountain nyala in and out of the Dinsho Sanctuary was monitored to determine the ‘closedness’ or ‘openness’ of the sub-population. Regular observations were made at points along the four sides of the Sanctuary where mountain nyala commonly travel. Encountered individuals were categorized into sex and age groups. Observations were made once a week from 0530–0730 h and from 1730–1830 h for three months. To determine the temporal abundance of the species in the Gaysay area, the sub-population was monitored from 0600–1800 h six times between July–December along the five established transects.

1.4 Secondary census data sources

Secondary demographic data for the species were collated from published studies (Hillman, 1986a, 1986b; Gebrekidan, 1996; Stephens, 1997; Refera, 2001) for long-term comparisons of demographics.

1.5 Data analysis

The statistical software SPSS version 14 (SPSS Inc, Chicago, USA) was used to analyze the data. Descriptive statistics was used to calculate the mean and standard error. As there were no physical barriers or settlements between the sub-populations of mountain nyala in the Gaysay and Adelay study sites, we assumed that the individual animals in both sites would mix, so we pooled data from both sites for analysis. Selected variables were compared across years and study sites using one-way ANOVA to obtain F and P values.

2 Results

The number of mountain nyala in the study area varied between 830 and 908 individuals (Table 1). There were no significant differences in the population density of mountain nyala across years ($F_{2, 34} = 0.002$, $P = 0.998$) but the difference was significant between the study sites ($F_{1, 34} = 18.738$, $P < 0.0001$) (Fig. 2).

Table 1 Total population number and population density estimates of mountain nyala per km² in each of the study sites during 2003–2005

Year	Site	Mean population density	95% Confidence Interval		Mean population estimate	Confidence interval (CI)	
			Lower bound	Upper Bound		Lower bound	Upper bound
2003	Gaysay/Adelay	21	16	28	714	672	756
	Dinsho Sanctuary	130	123	138	157	154	160
Total					871	826	916
2004	Gaysay/Adelay	22	19	25	748	726	770
	Dinsho Sanctuary	128	117	139	154	149	159
Total					902	875	929
2005	Gaysay/Adelay	20	15	23	680	640	720
	Dinsho Sanctuary	127	117	137	153	148	158
Total					833	788	878
Mean (three years)					869	830	908

Dinsho fielded a higher population density of mountain nyala (129/km²) than the Gaysay/Adelay sites (21/km²) (Fig. 2). The age group composition was significantly different between the study sites for male adults, female sub-adults and juveniles (Table 2).

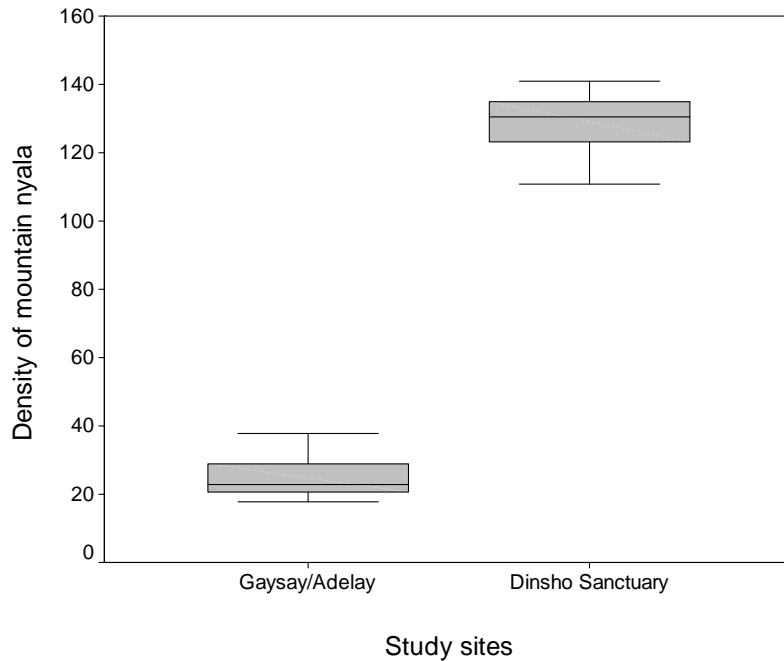


Fig. 2 Population density of mountain nyala in Dinsho and Gaysay/Adelay sites

The box-plots show error bars at 95% CI.

Table 2 Age group compositions from Dinsho Sanctuary and Gaysay/Adelay sites, and comparison between sub-populations

Age group and sex category	Study sites	Mean (%) \pm SE	<i>F</i>	<i>P</i>
Male adult	Gaysay/Adelay	12 \pm 0.7	0.335	<0.0001
	Dinsho Sanctuary	25 \pm 0.8		
	Total	19 \pm 1.3		
Female adult	Gaysay/Adelay	39 \pm 1.3	0.007	0.772
	Dinsho Sanctuary	40 \pm 1.4		
	Total	39 \pm 1.0		
Male sub-adult	Gaysay/Adelay	10 \pm 0.7	1.282	0.063
	Dinsho Sanctuary	9 \pm 0.5		
	Total	9 \pm 0.5		
Female sub-adult	Gaysay/Adelay	20 \pm 0.9	0.655	<0.0001
	Dinsho Sanctuary	11 \pm 0.8		
	Total	16 \pm 1.0		
Juvenile	Gaysay/Adelay	10 \pm 0.7	0.067	0.017
	Dinsho Sanctuary	8 \pm 0.6		
	Total	9 \pm 0.5		
Calf	Gaysay/Adelay	5 \pm 0.4	0.042	0.594
	Dinsho Sanctuary	5 \pm 0.3		
	Total	5 \pm 0.3		

The female to male sex ratio of the species was 2:1 (range 1.7–2.3:1 at 95% CI). There were a higher proportion of females in Gaysay/Adelay than in Dinsho.

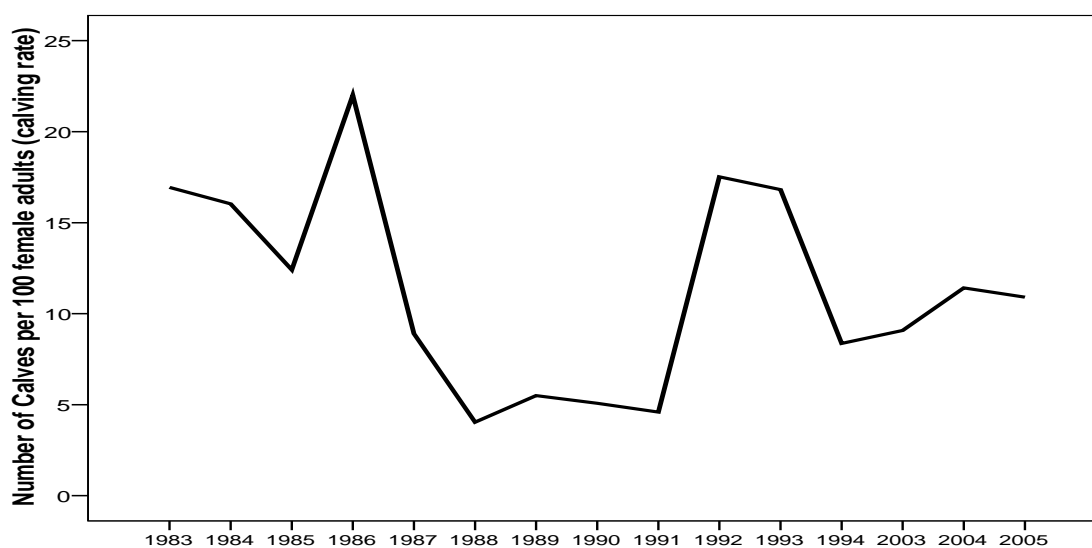
The proportion of nyala in each age-group was not significantly different across the three years of our study (Table 3). Adult males made up 19% of the total population, and adult females made up 39%. Sub-adult males comprised 9% and sub-adult females 16% of the population.

Table 3 Age groups of mountain nyala across years (2003–2005)

Age groups	Year of census	Mean (%) ± SE	$F_{2,51}$	P
Male adult	2003	22 ± 2.4	0.177	0.838
	2004	18 ± 2.5		
	2005	16 ± 2.4		
Female adult	2003	41 ± 1.8	0.066	0.936
	2004	38 ± 2.2		
	2005	37 ± 1.0		
Male sub-adult	2003	8 ± 1.0	0.790	0.459
	2004	9 ± 1.3		
	2005	11 ± 1.0		
Female sub-adult	2003	16 ± 1.3	0.325	0.724
	2004	15 ± 1.3		
	2005	18 ± 2.6		
Juvenile	2003	9 ± 1.6	0.158	0.854
	2004	8 ± 2.5		
	2005	10 ± 1.8		
Calf	2003	5 ± 1.1	0.154	0.858
	2004	5 ± 0.7		
	2005	6 ± 1.3		

The annual mean calving rate was nine calves per 100 adult and sub-adult females (range 8–10 at 95% CI). The calving rates between Dinsho (range 8–12), and Gaysay/Adelay (range 7–10) were not significantly different ($F_{1,34} = 0.029$, $P = 0.091$). The recruitment, which is the proportion of immature (juvenile) age groups to female (adult & sub-adult females) to the population, was also not significantly different ($F_{1,34} = 0.670$, $P = 0.419$) although a relatively higher rate (0.19) was recorded in Gaysay/Adelay sites than in Dinsho (0.17). The historical mean calving rate based on data recorded between 1983–1994 and 2003–2005 was 12 calves per 100 adult females, and the calving rates were significantly different across years ($F_{14,123} = 1.802$, $P = 0.040$).

The proportion of calves observed per 100 female adults and sub-adults was significantly different across years ($F_{14,123} = 1.048$, $P = 0.041$) (Fig. 3), but not between seasons ($F_{2,123} = 2.123$, $P = 0.051$). The proportion of calves was not significantly different between the study sites ($F_{1,34} = 0.042$, $P = 0.594$) (see Table 2) or across the years of the study ($F_{2,34} = 0.154$, $P = 0.858$) (see Table 3).

**Fig. 3 Proportion of calves per 100 adult females mountain nyala across years**

Source: Hillman, 1985, 1986a, 1986b; Gebrekidan, 1996; Stephens, 1997; Refera, 2001; Refera and Bekele, 2004; the present study from 2003–2005.

The population trend shows an increase between 1983–1986; a sharp decline between 1986–1991; increase during 1991–2004 and decline between 2004–2005. Between 1991 and 1994, the population dropped below 150 individuals, the lowest reported number mountain nyala during the Park’s history (Table 4). The rate of change in the population size (log-transformed) is shown below (Fig. 4). The population declined by an average of 2% per year.

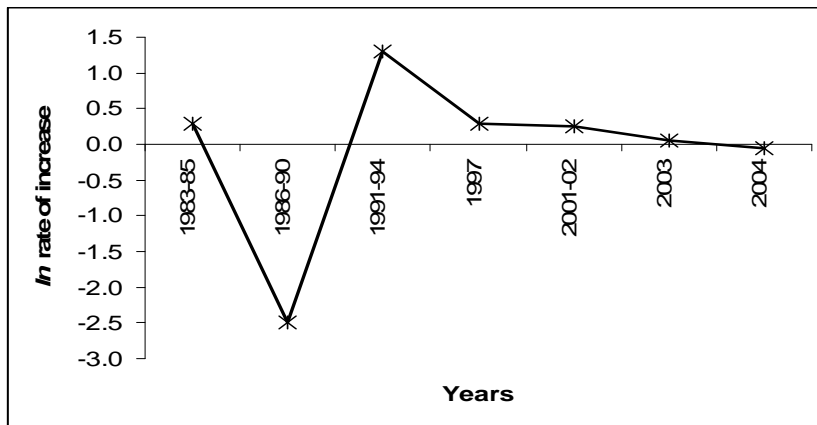


Fig. 4 Population rate of change (log-transformed) of the mountain nyala population from 1983–2005

Source: Hillman, 1986a, 1986b; Gebrekidan, 1996; Stephens, 1997; Refera, 2001; Refera and Bekele, 2004; the present study, 2003–2005.

The preferred habitat of the species in the Park contracted considerably, while population density decreased from mid-1980 to early 2000 (Table 4).

Table 4 Estimates of mountain nyala population density and habitat ranges in the species stronghold area (1983–2005)

Years	The species stronghold area (km ²)	Sampled area (km ²)	Density	Estimated population	Source
1983–1985	51	17.2	21.3	1320	Hillman, 1985, 1986a, 1986b
1986–1990	106	22.6	16.6	1760	Gebrekidan, 1996
1991–1994	48	14.6	3.0	145	Gebrekidan, 1996
1997	51		10.4	530	Stephens, 1997
2001–2002	13	13.0	54.0	704	Refera and Bekele, 2002
2003	34	15.1	21(130)*	909	the present study
2004	34	15.1	22(128)*	964	the present study
2005	34	15.1	20(127)*	915	the present study

*values outside the bracket indicate Gaysay/Adelay’s mountain nyala density while those in brackets show Dinsho Sanctuary’s mountain nyala density

On average 94% of surveyed mountain nyala moved from Dinsho to the villages at dusk, and a similar proportion returned at dawn the following day. The number of animals moving into and out of Dinsho were not significantly different across the four routes monitored (Table 5). However, a few solitary individuals were observed moving along routes or tracks that were not commonly used by the species.

Table 5 Movement of mountain nyala between Dinsho Sanctuary and the surrounding villages through four major routes

Exit and entry routes of the mountain nyala between Dinsho Sanctuary and the villages	Direction of movement with reference to the Sanctuary	Average no. of animals traveled	95% confidence Intervals		$F_{1,22}$	P
			Lower bound	Upper bound		
Dinsho Vs north-west of Gojera	Out at dusk	68	62	74	1.028	0.322
	In at dawn	71	67	75		
Dinsho Vs Zaloabeba	Out at dusk	18	16	20	0.190	0.667
	In at dawn	18	16	21		
Dinsho Vs Karare	Out at dusk	39	33	44	0.035	0.853
	In at dawn	39	36	42		
Dinsho Vs south-west of Gojera	Out at dusk	13	11	15	0.612	0.442
	In at dawn	14	13	15		
Average animals moved outwards from Dinsho		138				
Average animals moved inwards to Dinsho		143				
Total mean number of animals moved		141				

The overall activity of the nyala did not differ between the wet and dry seasons. A bimodal-peak temporal abundance pattern was observed during daylight hours (Fig. 5). The first peak occurred at 1000 h and the second at 1500 h. The mean number of animals observed was not significantly different for each hour of the day ($F_{11,184} = 1.228$, $P = 0.267$), although higher variations in abundance were observed in the afternoon period than in the morning.

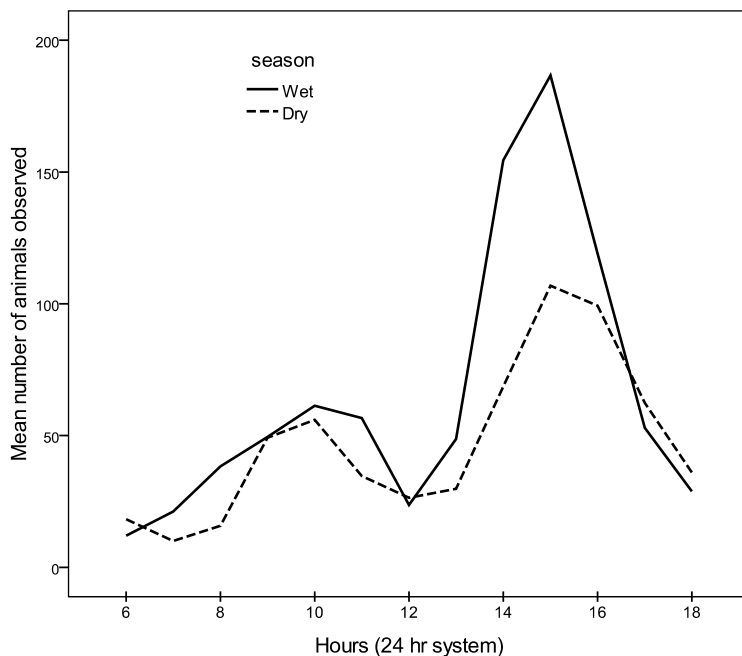


Fig. 5 Temporal changes in the abundance of mountain nyala population during daylight (0600–1800 h) in Gaysay grassland area

Nyala group sizes were significantly different between the study sites ($F_{1,34} = 12.657$, $P < 0.001$), but not across years ($F_{2,34} = 0.083$, $P = 0.774$). The mean group size in Gaysay/Adelay was 7, and 12 for Dinsho. The maximum group size observed in Gaysay/Adelay was 38, and in Dinsho it was 24.

3 Discussion

Estimates of the number of mountain nyala in the northern part of BMNP prior to 2003 have been relatively inconsistent. The differences may be due to the use of different sampling methods, and the estimates of nyala numbers from Gaysay area traditionally being used to project the total population size for the entire northern part of the Park. Hillman (1986a) noted that the density of mountain nyala observed in Gaysay only cannot be taken as a representative of the northern part of the Park.

Brown (1969b) reported a female to male ratio of 4.5:1, which is a higher proportion of females than our study. However, Refera (2001)¹ and Refera and Bekele (2004) reported sex ratios relatively similar to our results, with 1.24:1 during the wet season and 1.25:1 during the dry season. A higher proportion of females than males in a given population is beneficial because recruited offsprings increase the population size (Wedekind, 2002), although the role of males in the dynamics of ungulate population is crucially important (Myserud et al., 2002).

The calving rate we found is lower than the 17.3% reported by Brown (1969b). Mountain nyala are known to produce calves year-round, with the main calving season over the wet season between June–September, and a peak in August–September (Brown, 1969b; Hillman, 1986a, 1986b; Hillman and Hillman, 1987; Kingdon, 1997). Mothers hide the calves for first few weeks postpartum in dense vegetation, while they feed and then return to suckle at regular intervals.

Although the average group size of the species remained relatively constant over the course of our study, large groups were less common. Brown (1969a) also reported that mountain nyalas generally do not form large herds, but are commonly found in small family units or bachelor groups.

The Dinsho and Gaysay/Adelay subpopulations had distinct population structures. The movement survey data from the Dinsho Sanctuary clearly indicated that the same number of animals moved into and out of the Sanctuary. Moreover, the sex ratio and age composition of the population that moved into and out of the Sanctuary was not significantly different. These observations indicate that the Dinsho group of mountain nyala is a ‘closed’ population, disconnected from the Gaysay/Adelay sub-populations, probably due to human settlement and agricultural barriers. A high density population in a confined area is likely to experience enhanced inbreeding, loss of genetic variability and diminished survival. Similar scenarios concerning small populations of wild animals have been raised in other studies (Hedrick and Kalinowski, 2000). Evidence shows that inbreeding occurs commonly in nature and can be severe enough to affect the viability of small and isolated populations (Keller and Waller, 2002, Garner et al., 2005).

Male-biased hunting practices as well as poaching of the species by the local communities in the northern part of the Park and its surroundings might have contributed to the observed lower number of adult males in Gaysay/Adelay than in Dinsho Sanctuary. Brown (1969a) supported this assumption, and stated that the population decline was caused by hunting. Adult male mountain nyala horns are cultural significant and used in local community rituals. This may have encouraged local communities to kill more adult males than females

¹ Refera B, 2001. Population status, structure and diurnal activity pattern of mountain nyala *Tragelaphus buxtoni* in the Bale Mountains National Park, Ethiopia. M.Sc. thesis.

(Mamo, 2007²). Some studies suggest that male-biased hunting pressure limits population size because female fecundity may be reduced when males are selectively removed (Fairall, 1985; Ginsberg and Milner-Gulland, 1994). Milner-Gulland et al. (2001) reported that reproductive collapse in a Saiga antelope population occurred because of sex-biased harvest.

The mountain nyala population has steadily decreased in the study area, although the cause of decline is not fully understood. Existing evidence shows that the BMNP population of mountain nyala has been reduced considerably over the past three decades. Many of the demographic parameters of mountain nyala did not change significantly over time, suggesting the observed decline is not due to an innate demographic characteristic of the species. Therefore, anthropogenic factors may have affected the population dynamics. Similar assumption was noted by East & IUCN (1999) that Africa will lose a substantial portion of its remaining antelope populations during the 21st century due to anthropogenic pressures. Mountain nyala are typically not a forest dwelling animal, so the high number of nyala found in the forested Dinsho Sanctuary could suggest that the species was forced to occupy a less preferred habitat. The observed high density of nyala in the Dinsho Sanctuary is not favorable for the existence of a viable population in the future. Creation of a migration corridor that would connect the Dinsho sub-population to the rest of the study area should be considered. Further study is needed to assess inbreeding and loss of genetic variability in the population due to the high density of animals in Dinsho. It is also important to establish a genealogical relationship for the sub-populations in other areas, for conservation of the meta-population of the species in a wider geographic range.

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