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Social organization in the mountain nyala (*Tragelaphus buxtoni*) population in the Bale Mountains National Park, Ethiopia

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This study was conducted in 2009 and 2011 in the Bale Mountains National Park in Ethiopia to assess social organization of endemic and endangered mountain nyala. The main objectives of this study were to identify social group types of the mountain nyala in the park, and to determine the frequency of occurrences, group sizes and number of age/sex categories in social group types. Based on age/sex composition, five social group types were distinguished: all-male, all-female, male-female, female-juvenile and male-female-juvenile group types. A total of 572 groups and 5187 individuals of mountain nyalas were recorded during the study period. Overall mean and typical group sizes for the species were 9.1 ± 0.5 (range: 1–107) and 24 animals, respectively. Male-female-juvenile social group type was the most frequently observed group type (31% of the total records), contained the highest proportion of animals recorded (64%) and had the largest mean group size (18.5 ± 0.8) and typical group size (31.9) than the other social group types. Lone animals constituted 16.3 and ~2% of the total groups and animals recorded, respectively, in which over two-thirds of them were adult males. Both mean number and proportion of individuals of each age/sex category across social group types significantly increased when they were associated with one or two other age/sex categories than when not associated. In general, data presented here represents the first detailed information available on the species’ social organization behaviour and provides important base-line information.

Key words: Group size, mountain nyala, park, social group, social organization.

INTRODUCTION

The mountain nyala (*Tragelaphus buxtoni*) Lydekker (1911) is a spiral-horned antelope endemic to Ethiopia (Brown, 1969; Yalden et al., 1984). This species has been declining considerably both in number and distribution (Stephens et al., 2001; Befekadu and Afework, 2004; OARDB, 2007; Evangelista et al., 2008; Malcolm and Evangelista, 2011; Yosef et al., 2010). It inhabits three discrete mountain ranges in Ethiopia’s south-eastern highlands (the Ahmar, Arsi and Bale Mountains); with the majority of the population (80% of the total) being persisting...
in the Bale Mountains, it has an estimated global total population of 3,500-4,000 animals (Evangelista et al., 2008; Manor and Saltz, 2003; Malcolm and Evangelista, 2011; Yosef et al., 2012). These recent reports show the substantial population decline that mountain nyala has been experiencing as Yosef (2007) estimated the total population of mountain nyala ranging between 1720 and 2035 individuals; when compared with earlier report of 7000-8000 animals by Brown (1969). It is currently listed as an endangered species by IUCN which has been primarily attributed to uncontrolled hunting and habitat loss and degradation (IUCN, 2013). Thus, given its national and global conservation significances and the ever increasing threats facing it through direct and indirect human-induced activities (Malcolm and Evangelista, 2011; IUCN, 2013), having detailed information regarding the biological and ecological aspects of the species has been identified as one of the top management-oriented priority research topics by the Bale Mountains National Park (BMNP) management (OBARD, 2007).

Previous studies on mountain nyala have been primarily focusing on its distribution, activity patterns, population status and structure (Brown, 1969; Hillman, 1986; Woldegebriel, 1997; Stephens et al., 2001; Befekadu and Afework, 2002, 2004; Malcolm and Evangelista, 2011; Anagaw et al., 2011, 2013 Yosef and Afework 2013). Detailed information on aspects of their social grouping is lacking and as such, the aim of this study was directed at filling this gap and providing baseline information against which future works can be compared.

Social organization in ungulates is considered to be the adaptive outcome of selective pressures arising from predation and intra- and/or inter-specific competitions (Leuthold and Leuthold, 1975; Gerard and Loisel, 1995; Desbiez et al., 2010). Several studies have suggested that such social organization is affected, separately or interactively, by a number of factors such as predation and human-induced disturbances (Leuthold and Leuthold, 1975; Hillman, 1986, 1987; Gerard and Loisel, 1995; Befekadu and Afework, 2004; Loee et al., 2006; Stankowich, 2008). For instance, a study of kob antelope (Kobus kob kob) population in Comoé National Park, Côte d’Ivoire, which was suffering from heavy over-hunting by both natural predators and humans, found that population decline resulted in changes to the social organization of the species (Fischer and Linsenmair, 2007).

This implies that data collected on patterns of ungulate social grouping is of paramount importance for conservationists as this information, if gathered on regular time intervals, could help detect changes in the patterns, which in turn aids to assess the underlying causes; and develop appropriate management actions required to abate the causes (Jarman, 1974; Fischer and Linsenmair, 2007; Bagchi et al., 2008). Although acquiring detailed information on wild ungulates’ social behaviour is acknowledged for effective conservation management, such data is lacking for several of Ethiopian’s endemic species, including the endangered mountain nyala (T. buxtoni). This study was, therefore, undertaken to: (1) identify the social group types of the mountain nyala population in the BMNP; (2) determine the frequencies, group sizes and group compositions (numbers of age/sex categories) of the social group types; and (3) investigate the effects of habitat type on these variables.

MATERIALS AND METHODS

Study area

BMNP was established in 1971. It is situated between 6° 29’ and 7° 10’ North, and 39° 28’-39° 58’ East. The current area of the Park is 2200 km² and covers a landscape that ranges in altitude from 1500 to 4377 m asl (Hillman, 1986; OBARD, 2007). The park encompasses five vegetation zones: the northern grasslands, northern woodlands, Ericaceous forest, the Afro-alpine moorlands and grasslands, and southern Harenna forest (OBARD, 2007). Seventy-eight mammals and 278 bird species have been recorded from the BMNP: of which 20 mammals and six bird species are endemic to Ethiopia (Addisu, 2007, 2011). The area usually receives eight months (March to October) rainfall a year (Hillman, 1986).

The present study (Figure 1) was carried out in the northern section of BMNP, encompassing two (i.e. the northern grasslands and northern woodlands) of the five vegetation zones in the park. These habitats harbour over 75% of BMNP’s mountain nyala population (Hillman, 1986; Befekadu and Afework, 2004; Malcolm and Evangelista, 2011). The landscape is characterized by mountainous ranges with a central broad flat valley and varies in elevation from 3000 to 3550m asl. The mountainous areas are covered by three isolated forest patches (namely: Adellay forest (location, 6°50’ N and 39°33’ E), Boditti (6°57’ N and 39°33’) and Dinsho hill (6°50’ N and 39°36’ E)), which is dominant by Hagenia abyssinica and Juniperus procera tree species (OBARD, 2007). The central flat valley (also known as Gaysay valley; 6°53’ N and 39°33’ E) is generally classified as a montane grassland ecosystem and is dominated by swamp grasses and sedges of Cyperus and Scirpus genera and low bushes of Artemesia afra and Helichrysum splendidum (Befekadu and Afework, 2004; Bezawork et al., 2009; OBARD, 2007; Yosef et al., 2012).

Data collection

The three forest patches and Gaysay valley were delineated as four separate blocks and data collection in these blocks was done during August to October both in 2009 and 2011. Observations in each block were made on different days, but under similar weather conditions and within similar time of the day (early in the morning from 07:30 to 10:30 h and late in the afternoon from 14:30 to 17:30 h), when the animals are more active (Befekadu and Afework, 2004). Each block was visited four times in each year by same two people and observations were aided by 8 x 40 Nikon Binoculars. Data recorded whenever a group of mountain nyala was observed were: block name, date, time, group size, group composition and habitat type. Operational definition of a ‘group’ used in this study was: any number of animals of the species found together at any point in space and time, within a distance of less than 50 m between them, and apparently in sensory contact with one another (Leuthold and Leuthold, 1975; Hillman, 1987).

Previous reports indicate that young males of mountain nyala leave nursery groups and associate with adult males when they become sub-adults and sub-adult females usually remain in the nursery groups until they give birth (Hillman, 1986; Befekadu and
Afework, 2004). Thus, the composition of all mountain nyala groups seen over the study period was recorded using three age/sex categories: adult male (old and young/sub-adult males), adult female (old and young/sub-adult females) and juveniles of both sexes (immature and calves of both sexes). This distinction was made based on body size and other morphological features like presence/absence and size of horns. As (sub)adult of mountain nyala show sexual dimorphism (only males' bear horns) and juvenile males bear smaller horns and juvenile females are smaller in body size than (sub)adult females, it was possible to accurately assign individuals of the species to age/sex categories. For each group observation, habitat type within which it was observed was also recorded as either forest woodland or open grassland.

Data analysis

Data from the eight counting sessions over the two years were combined due to small sample sizes to analyze them separately. Social group types of the mountain nyala were identified based on each recorded group’s composition of the three different age/sex categories; thus, records with similar composition were classified as one of the possible social group types.

Differences in relative frequencies of occurrences of the whole mountain nyala groups and occurrences of each social group type between habitat types and in frequencies of occurrences of each pair of the social group types within and across habitats were tested using Chi-square tests. Chi-square tests were also used to test differences in the proportions of animals recorded across and between each pair of group types. Group size data was expressed in three ways: as mean group sizes, typical group sizes and group size frequency distributions. Mean values are more useful to compare different sets of data; whereas typical group size expresses the group size experienced by the majority of individual animals, and frequency distributions are better to illustrate the actual grouping patterns of a given species and/or group type of the species (Jarman, 1974; Hillman, 1987; Bagchi et al., 2008). Levene’s test of equality of variances of the group sizes of mountain nyala across group types was significant ($F_{4, 567} = 24.430, P < 0.005$) and log-transformation of the raw-data did not improve the fit of the data ($F_{4, 567} = 2.950, P < 0.005$). Thus, non-parametric tests (Kruskal-Wallis and Mann-Whitney tests) which do not assume homogeneity of variance were used to compare mean group size differences across social group types, of each social group type between habitat types and between each pair of the social group types within and across habitats. ‘Typical group size’ of each group type was estimated from the sum of the squares of all individuals in all groups of that group type, divided by the total number of individuals recorded for that group type (Jarman, 1974, Hillman, 1987). To see how patterns of group size distributions differ across the social group types, all groups recorded for each group type were classified into five group size categories (Bagchi et al., 2008): solitary (single animal), family unit (2–3 animals), small groups (4–6 animals), medium groups (7–10 animals) and large groups (>10 animals), and percentage relative frequencies of the number of groups recorded in each group size category for each group type were graphically illustrated. Results of ANOVA analysis of the numbers of each age/sex category across the social group types showed heterogeneity of variance in all cases. Thus, the non-parametric tests of Kruskal-Wallis and Mann-Whitney were used to see differences in mean number of each age/sex category across and between pairs of the social group types, respectively. All these analyses were conducted in SPSS version 20.
RESULTS

Social group types

Based on the composition of the three different age/sex categories, five consistently seen social group types were identified: (1) all-male group type (groups containing only sub-adult males), (2) all-female group (groups containing only sub-adult females), (3) male-female group (groups containing only sub-adults of both sexes), (4) female-juvenile groups (groups containing sub-adult females and juveniles and calves), and (5) male-female-juvenile group (groups containing sub-adults of both sexes and juveniles and/or calves).

Group type frequency and proportion of animals seen in each

The relative frequency of occurrence of each social group type of mountain nyala and the proportions of animals recorded in each of them are presented (Table 1). A total of 572 groups consisting of 5187 animals of mountain nyala were recorded during the study period. Independent of group type, the relative frequencies of occurrences of mountain nyala groups recorded was significantly different between habitat types ($\chi^2 = 139.028, df = 1, P < 0.05$ (Table 1a)), being higher in the woodlands. However, when each group type was considered separately, no significant difference between habitats was found for any of them in this regard (in all cases, $\chi^2 = 0.000–0.006, df = 1, P > 0.05$ (Table 1a)). Similarly, non-significant differences were found within each habitat type across the group types in their relative frequencies of occurrences (woodland: $\chi^2 = 0.221, df = 4, P > 0.05$; Grassland: $\chi^2 = 0.130, df = 4, P < 0.05$). Regardless of habitat type, the relative frequencies of occurrences of mountain nyala groups recorded was significantly different across group types ($\chi^2 = 196.503, df = 4, P < 0.05$ (Table 1a)). The male-juvenile group type was the most frequently observed (31% of the total group records), followed by female-juvenile group type (26%), all-male group (18%), all-female group (15%) and male-female group (11%). However, significant differences between each pair of group types in this aspect were found only between all-female vs. male-juvenile, male-female vs. female-juvenile and male-female vs. male-female-juvenile group types ($\chi^2 = 5.262–9.809, df = 1, P < 0.05$ in all cases (Table 1a).

Regardless of habitat type, the proportions of animals recorded in each group type were also significantly different across the social group types ($\chi^2 = 131.821, df = 4, P < 0.001$). Over two-thirds (64%) of the total animals recorded were in the male-juvenile group type, while female-juvenile group type contained the second highest proportion (21%), both of which were significantly different from each other, as well from the other group types ($\chi^2 = 7.026–55.736, df = 1, P < 0.001$ in all cases (Table 1b)). However, no such significant difference was detected between pairs of all-male, all-female and male-female group types ($\chi^2 = 0.213–1.473, df = 1, P > 0.05$ in all cases (Table 1b)).

Group size

Habitat type had no significant effects on the mean group sizes of mountain nyala either when the social groups were treated together (Mann-Whitney $U = 29704.500, P > 0.05$) or separately (in all cases, $U = 259.00 - 2787.500, P > 0.05$). However, the effects of habitat was revealed when mean group sizes of each possible pair of the five social group types were compared within each habitat type, of the twenty (ten in each of the two habitat types) comparisons made, a non-significant result in mean group size difference was found only between male- and female-juvenile group type in the grassland habitat (Mann-Whitney $U = 205.500, P > 0.05$; (Table 1). With the exception of a non-significant result just mentioned above, in both habitat types, the differences observed were in the direction of: male < female < male-female < female-juvenile < male-female-juvenile.

Combining data from the two habitat types, a significant difference in mean group sizes of mountain nyala groups was found across the social group types (Kruskal-Wallis test: $\chi^2 = 359.908, df = 4, P < 0.05$). Regardless of the different social group types, the overall mean ($\pm$ S.E.) group size of mountain nyala was 9.1 ± 0.5 (Range = 1–107; Table 2), with typical group size of 24 animals. When group types were considered separately, male-female-juvenile group type had significantly larger mean and typical group sizes (mean $\pm$ S.E. = 18.5 ± 0.8; typical =31.9), while all-male group type had the smallest mean and typical group sizes (mean $\pm$ S.E. = 1.5 ± 1.0; typical = 2.2) as comparison to other group types (Table 2). In general, similar to the results found while treating data from the two habitat types together, mean group sizes of the group types also significantly differed from each other when data from the two habitat types were lumped (in all cases, Mann-Whitney $U = 105.000-4942.500, P > 0.05$), the differences observed being in the direction similar to what was reported above for each habitat type.

Given the non-significant effects of habitat type on the mean group sizes of mountain nyala either when the social groups were treated together or separately, the relative frequencies of group size distributions of (% of total records) and percent proportion of animals recorded in each group size category for each social group type was illustrated independent of habitat type (Figure 2).

When all the group types were considered together, percentage of mountain nyala groups recorded across the group size categories were almost uniform, but the largest proportion of animals occurred in the large group size category (> 10 animals). In the all-male group type, solitary and groups of small number of animals were common, with the majority of animals occurring in solitary...
groups; while family- and small-sized groups were the most common group sizes in all-female groups with the majority of animals occurring in the family group size. Female-juvenile and male-female-juvenile group types were characterized by small and large group sizes, respectively, with the largest proportion of animals occurring in the large group size category for both cases (Figure 2).

**Number of age/sex categories in each group type**

Kruskal-Wallis test showed that there were significant differences in mean number of animals of adult males, and of adult females, across the different group types (adult male, $\chi^2 = 33.950$, df = 2; and, adult female, $\chi^2 = 99.175$, df = 3, $P < 0.001$ in both cases). In general, mean number of individuals of each age/sex category significantly increased when they were associated with one other age/sex category than when not, and this increment was more pronounced when each of them were associated with the other two age/sex categories (in all cases, adult male, Mann-Whitney $U$: 2471.000–5570.500; adult female, $U$: 2118.500–7659.500; juveniles, $U$: 6616.500; $P < 0.05$) (Figure 3). Proportion of number of animals of each age/sex category across the social group types showed that 60–70% of animals of each of them were recorded in the male-female-juvenile group type (Figure 4).

**Lone mountain nyals**

Ninety-three (16.3%) of the total groups recorded were
Figure 2. Group size frequencies (in % of all groups recorded for that group type) of each social group type of mountain nyala and number of animals seen (in % of all individuals recorded for that group type) in each group size category of each social group type. Group size categories were defined as: solitary = single animal; family unit = 2–3 animals; small groups = 4–6 animals; medium groups = 7–10 animals; and large groups >10 animals.
lone animals, representing 1.8% of the total animals observed for mountain nyala. Over two-third (70 records or 75.3%) of the loners were males and juveniles were not seen alone, implying that adult male nyala relatively shows higher tendency to exhibit solitary behavior. These figures represent 20.5 and 4.9% of all group records, and 7.7 and 0.8% of all individuals seen for male and female mountain nyalas, respectively.

**DISCUSSION**

This study relatively presented detailed data, as compared to others studies (Befekadu and Afework, 2004; Yosef et al., 2010, 2012), on the species concerning patterns of social organization mainly, focusing on frequencies of occurrences, group sizes and compositions of the different social group types, as well as the influence of habitat type on these attributes. Although habitat type had a significant effect on the frequency of occurrence of overall mountain nyala groups in the study area, this effect was non-significant when each social group type was separately considered. Furthermore, no significant effects of habitat type on mean group sizes of overall groups and each group type were revealed. These results, particularly, in the case of mean group sizes, contrast with the general presumption that ungulates form larger group sizes in open habitats than in dense habitats, which is mainly attributed to a defensive mechanism against higher predation pressure in open habitats (Leuthold and Leuthold, 1975; Hillman, 1987; Gerard and Loisel, 1995; Tadesse and Kotler 2014; Loe et al., 2006). Thus, this lack of differences between open grassland and woodland habitats in the present study may be due to the similarities existing between the two habitats in the stimuli (e.g. resource availability, competition, predation and/or disturbances) in response to which the formation of social organization of the species was necessitated.

Previous reports indicate that young (juveniles and calves) of both sexes of mountain nyala usually associate with adult females until they become sexually mature (Hillman, 1986; Befekadu and Afework, 2004). Similarly, juveniles were not encountered in the absence of females during the present study, indicating the presence of strong bond between mothers and juveniles/calves. Thus, as suggested by Hillman (1986), the basic social unit of mountain nyala consists of an adult female with her offspring from the past one or two births and these family units often aggregate, forming large groups. This is easily seen (Figure 2) where family (2–3 animals) and small (4–6 animals) group sizes of mountain nyalas were the most common of any group type where females were present, except when all age/sex categories were considered together which formed larger group sizes due to aggregations of different family units.

Overall group size, the low incidence of lone animals and preponderance of lone adult male of mountain nyala reported here are also consistent with the previous
reports (Hillman, 1986; Befekadu and Afework, 2004). Coupled with the occurrences of several adult males together within a male-female and male-female-juvenile group types (as observed in the present study), such low incidence of lone animals (particularly, of adult males) in antelopes is an indication of the non-territorial behavior exhibited by adult males of such species (Leuthold and Leuthold, 1975; Hillman, 1987), which is in accordance with the suggestions of Hillman (1986) and Befekadu and Afework (2004) for mountain nyala. Although males of mountain nyala are presumed to be non-territorial, they usually leave groups and become solitary when they get older (Hillman, 1986; Befekadu and Afework, 2004). The tendency for adult males to become solitary when they get older has also been reported for other ungulate species, such as common eland (Tragelaphus oryx) and African buffalo (Syncerus caffer) (Hillman, 1987). However, it is noted that such solitary adult males of the common eland, a species known to exhibit a non-territorial behaviour, often return to nursery groups periodically and continue to contribute to reproduction, while those of the African buffalo, a territorial species, do not rejoin groups and do not contribute to reproduction thereafter (Hillman, 1987). In the case of mountain nyala, whether these solitary males remain in a solitary state or rejoin the male-female and/or nursery groups and continue to contribute to reproduction is yet to be demonstrated and requires further study based on long-term observations of individually known animals and/or on the age effects of testes activity of such old males (Hillman, 1987).

Population fluctuations in ungulate species due to natural and/or unnatural factors results in changes in patterns of their social grouping (Fischer and Linsenmair, 2007; Bagchi et al., 2008), suggesting that monitoring of such behaviour could indicate the population status or the presence of some sort of threatening factors operating against them. For instance, a comparative study of Fischer and Linsenmair (2007) on the kob antelope in the Comoé National Park, Côte d’Ivoire, showed that groups with five and less animals made up 34.9% of all observed groups in 1993 when their population was at normal density, but their percentage increased to 70% in 1998 after heavy population decline. Therefore, frequency of group size distribution presented here for mountain nyala shows the pattern existing among the different group types at present and thus constitutes important base-line data for managers of the species. Future changes could be interpreted as a warning sign that necessitates investigation into the underlying causes in order to take appropriate mitigation measures.

The male-female-juvenile and the female-juvenile group types, respectively, were the first and second most frequently observed and with the highest mean group sizes than the other group types. This perhaps indicates that group types containing juveniles generally occur most frequently and with large aggregations of animals than group types without juveniles, which is consistent with the results reported for similar larger antelopes, such as the common eland (Hillman, 1987). The data also showed that all the three age/sex categories attained their first and second maximum mean numbers and proportions in these group types (Figures 3 and 4). Although the reason why such large congregations occurred in groups of mountain nyala containing juveniles is unclear, several factors such as the presence of tendencies for juveniles to associate with their peers, predation and/or human-induced disturbances could be among the major causes of such aggregations (Leuthold and Leuthold, 1975; Hillman, 1987; Loe et al., 2006; Stankowich, 2008). As observed in other ungulates (Hillman, 1987), if there is a tendency for juveniles of mountain nyala to associate with their peers, to which adult females are attracted, this would result in the formation of large groups in the female-juvenile group type. The occurrence of large number of females together in the female-juvenile group type, on the other hand, could increase the number of estrous females in the group, to which males are attracted, thus resulting in such disproportionately higher group size in the male-female-juvenile group type.

Predation is known to be another factor that shapes patterns in social grouping in ungulates (Leuthold and Leuthold, 1975; Hillman, 1987; Loe et al., 2006). Although several wild and domestic carnivores have been reported to predate upon mountain nyala (Hillman, 1986), the main diurnal predators [of juvenile mountain nyala, in particular] are semi-feral/domestic dogs (Canis familiaris) Addisu, (2008). Post-mortem data collected during 2002–2007 showed that 89% of mortality cases reported for juvenile mountain nyala were due to hunting by semi-feral/domestic dogs (Addisu, 2008). Thus, the higher aggregation in the nursery groups was perhaps in response to such predation, since large group benefits from the group’s dilution effect and improved predator detection probability (Hillman, 1987; Fischer and Linsenmair, 2007). This might hold true as there has not been reports on adult mountain nyalas being hunted by dogs (Hillman 1986; Addisu, 2008) and are therefore not often forming such large groups unlike the nursery groups that usually suffer from such dog predation. In addition to dog predation, anthropogenic disturbances due to unrestricted human and livestock movement in the area (Befekadu and Afework, 2004; OARDB, 2007; Bezawork et al., 2009; Yosef et al., 2012) could also play an important role in shaping the grouping pattern reported here (Stankowich, 2008).

In conclusion, the cumulative results obtained from the frequency of occurrences of the different social group types, as well from their group sizes and compositions, can provide important information for managers of a number of endangered wildlife species, including the mountain nyala, as changes in these patterns over time would make these managers to investigate the underlying
has been noted that social organization in ungulates is often in state of flux lasting from a few hours to several days in response to different environmental factors (Hillman, 1987; Loe et al., 2006; Fischer and Linsenmair, 2007; Bagchi et al., 2008). Therefore, long-term observations on individually known animals of mountain nyala are required to elucidate the durability/stability of the social associations reported here.