POTENTIAL FOR SUSTAINABLE TROPHY SPORT HUNTING ON MOUNTAIN NYALA (*TRAGELAPHUS BUXTONI*) IN THE BALE MOUNTAINS OF ETHIOPIA

Field research progress report submitted to BERSMP

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General introduction

The charismatic mountain nyala (*Tragelaphus buxtoni*) is an endemic flagship species for the Ethiopian highlands that is now limited in its distribution to the Bale and Aarsi massif. As a result of its restricted population and steady decline in numbers, it is listed as Endangered by the IUCN Red List. Since its discovery in 1908, mountain nyala have declined substantially in number and range of its distribution. The population of mountain nyala was estimated to be 7000 to 8000 in the 1960's while less than 3000 individuals remain today. A number of factors have contributed to the mountain nyala's population decline, including habitat loss and habitat fragmentation as a result of the occupation of suitable areas by humans and livestock, direct disturbance by humans and livestock in areas where they overlap with mountain nyala, and illegal hunting for bush meat. It is estimated that the Bale Mountains harbour 74% of the remaining mountain nyala population.

Wildlife conservation in developing countries with high number of people living in poverty is a challenging task and increasingly necessitates community involvement and economic benefits from conservation activities. Community-based approaches that allow communities to derive economic benefits from their wildlife resources in the management of wildlife are increasingly being implemented in many African countries. Community-based conservation, which attempts to devolve responsibility for the sustainable use of wildlife resources to the local level, can include consumptive activities, such as trophy hunting, as well as non consumptive activities, such as tourism. Trophy sport hunting can be a successful conservation tool as it has the potential to generate substantial amounts of money that can be directed to the local community and further conservation efforts. Since its discovery in 1908, the mountain nyala has become an important trophy species for sport hunting in Ethiopia. When sustainably implemented, mountain nyala trophy hunting has the potential to provide economic incentives for conservation, including economic benefits to local communities for community-based conservation. Sustainable trophy hunting however needs detailed study of the ecology and genetic aspects of the species to assure the long term sustainability of the species survival.

2. Objective of the study

The General objective of the research is to provide a scientific back ground for sustainable practice of trophy sport hunting on mountain nyala in such a way that, both the local people and Mountain Nyala conservation practices are benefited. Sustainable trophy hunting can never be adequately addressed with out full understanding of the species ecology, genetics and threats presented to its survival. This study provides adequate information from basic ecology and distribution pattern of the species to genetic aspects of the different nyala population across the Bale massif.

Sustainability of the mountain Nyala for trophy hunting will be studied from a number of different perspective including population distribution and population estimate, sex age composition, mating system, threats presented to the species including habitat loss and habitat fragmentation, the extent of contribution of the trophy hunting to the conservation of the species and genetic differentiation and inbreeding level which are explained in consecutive chapters in this report.

Chapter 1

Distribution pattern and population estimates of Mountain nyala in the Bale Mountains of Ethiopia

Status of the field work: 65% completed

Introduction

After hundred years of its discovery in 1908, the range and population estimate of the endemic mountain nyala remains unclear. The only reliable population estimates of mountain nyala was carried out on the Gasay area, Northern end of the park, and Head quarter since 1970 by different researchers. Wildlife conservation management cannot be adequately developed without reliable population estimates of the species. This research is conducted to determine the spatial distribution and population estimate of the mountain nyala.

Study area

The Bale massif above 2000m asl was identified from Digital elevation model and considered for the mountain Nyala distribution study (Fig 1). There is limited information for the presence of mountain Nyala below 2000m asl.

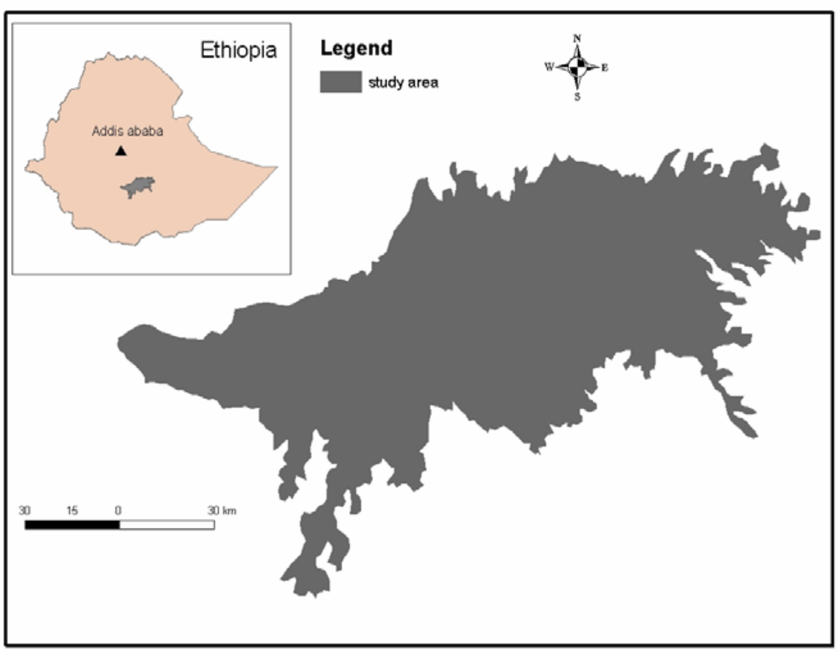

Fig 1. Study Fig 1. The Bale massif which is above 2000m asl.

Method

Mountain Nyala population distribution survey was started from the already known nyala populations. Latter, intensive field and questionnaire survey was carried out in the potential suitable habitats of mountain nyala which is described in the second chapter of this report. The map of the core areas of mountain nyala in the range of Bale massif was carried out by a number of different methods depending up on the landscape and habitat type of the area (Fig 2).

Gasay area; The core area of the mountain nyala was limited to the park boundary which is partially protected from livestock grazing and human interference.

Hora and Hanto area; These areas were dominated by human settlement and livestock grazing. A boundary of the Erica area which is surrounded by the human settlement was considered as core area for the human settlement.

Sodotta and Senatee area; It is an open plane area with some Erica on the mountains. Questionnaire survey with the local people was carried out to determine the availability of Nyalas. Further field work was carried out in identifying groups and number of animals from intensive field survey. There are very few groups in this area.

Odobullu, Abasheba Demero and Shedom: Identifying the core areas of mountain nyala in these dense and extended forests was the most challengeable work. Demarcated the study area was started from Questionnaire with the local people who are living in the vicinity. Because Nyalas avoid human settlement in these areas, some sides of the core areas were demarcated on the side of the human settlements. In the extended forest, once a preliminary core area is established from pellet abundance and interview local people, transects were established in the direction of the extended forest and core areas of the mountain Nyala. However, some localities between Odobullu and Abasheba areas were not assessed due to the difficulties of the tertian. A total of 5054 GPS locations (1312 in Odoobullu, 1384 in Abasheba-Demero, 499 in Hanto and 659 in Horra, 1000 in gasay and 200 in headquarter) were used in mapping the core areas of the mountain nyala by using Arc Gis.

Different methods used to estimate the mountain nyala population. In small and confined areas such as Gasay area and Head quarter, total population estimate was carried out by dividing the area in to blocks using natural marking that enables us to cover the whole area. Population composition was assessed by distinguishing sex and age classes for individuals in each social group during the total count. Adult males are easily distinguished by their large twisted horns, large size and dark brown/grey color. Sub-adult males have straight spike horns (not twisted), are medium sized and are brownish in color. Adult females on the other hand don't have horns, are smaller in size and have a red brown color. Sub-adult females are differentiated from adult females by their small size and reddish color. Juvenile are differntiated by their small size. The population in Sodotta and Sennate were very small and groups were recognized by their individual members.

In dense forests (Odobullu, Abasheba and Shedom) and Erica dominated land escapes (Hanto and Hora), pellet count was carried out to estimate the population size. Pellet count was also carried out in Gasay area where reliable population estimate was possible by total count. Population estimate for animals living in dense habitat is one of the challenges for ecologist in the lat decades. Where bush or woods are too thick to allow good visibility, pellet group counts may be the only feasible ecological survey technique. The method has a number of assumptions including that, the pellet groups are correctly identified and none are lost from the sampling plots. The other challengeable assumption in pellet count estimate is steady-state assumption. The steady-state assumption states that the number of dung piles being deposited each day equals the number disappearing each day, i.e. the number of dung piles per unit area remains constant from day to day. Further, seasonal changes in defecation rates and dung decay rates can violate the steady-state assumption.

Effective population estimates from pellet count needs three important variables; (i) the amount or 'standing crop' of faecal pellets (ii) the rate at which those faecal pellets were deposited and (iii) the rate at which those faecal pellets have decayed. To quantify precision of the estimate of animal density, it is important to estimate the precision of each of the three components. The other difficulties in population estimate from pellet count are associated with the challenge in determining the rate at which wild animals deposit faecal pellets in a forest.

As part of developing the technique, transects of 250m difference were developed by GIS and random points were allocated on each transects in proportion to the area of each core areas of the mountain nyala which was mapped during this study. Random points were allocated on each transects in proportion to the area of each localities (122 quadrants for 31 km^2 gasay area). In each random point, quadrate of 4*5 m^2 size was established and the numbers of pellets were counted in each quadrate. The pellet of Nyala was distinguishable from other herbivores in the vicinity, Bohor reedbuck (*redunca redunca*), Meneliks bushbuck (*tragelaphus scriptus meneliki Neumann*) and

Grey duiker (*sylvicapra grimmia*) by its size and shape. From the pellet count studies, density of animals will be calculated as Da= Ds/Pi*I, where Da= Density of the animal, Ds= Total number of faecal pellets, Pi= Mean time to decay of the pellets and I= Rate of production of pellets. Even though population estimate from pellet count is crucial strategy in estimating population size in animals living in dense habitat, getting reliable data on defecation rate needs long intensive field work. During this study, the degradation rate of feacals was studied from 98 samples. However, the other important variable, the study on rate at which those faecal pellets were deposited, progressing. As an alternative method of estimating population size, the relative abundance of the nyala populations in the forest area was estimated by a relative index from known population size of Gasay. The index will relate the true abundance as in the equation E(n)=*p*N, with E(n) the expected value of the index, N the true population size, and *p* the constant proportion of the population size which is represented by the index.

Result

The full result of this work is not yet completed. From the preliminary analysis, the core area of mountain nyala in Odobullu, Abasheba, Hanto, Hora was 71 km^2, 34 km^2, 23 km^2 and 21 km^2 respectively. Gasay area is 31 km^2 where as the head quarter is 1.07 km^2 (Fig, 1). Mountain nyala are distributed in 14 localities across the Bale massif (Fig 2).

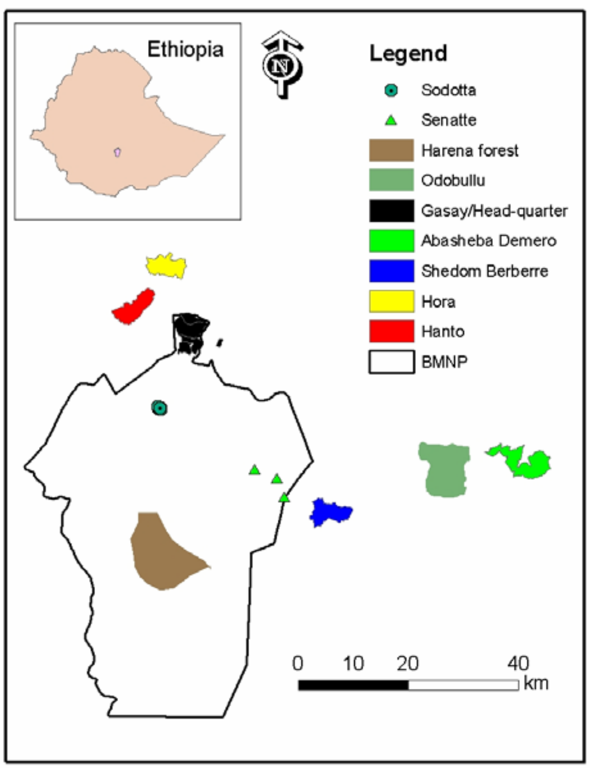

Fig 2. Core mountain Nyala population in the Bale Massif (Six more areas on field progress).

In the already completed sites (Fig 2) there are at around 2227 individuals of mountain nyala at six sites estimated from relative index method of pellet count (based on the total count in Gasay area). The estimate from pellet defecation and degradation rate is not yet established due to difficulties of following a given group for whole day. In May 2008, however 19 mountain nyala are collared (see chapter two) that enable us to collect the data easily.

Chapter 2

Habitat use and feeding ecology of mountain nyala

Status: 70% of the field work is completed

Introduction

Mountain nyala is endangered endemic antelope to Ethiopia found in the fragmented patches in the south east of the country. Since its discovery in 1908, mountain nyala has declined substantially in numbers and distribution. Though no study is carried out in detail for the cause of the decline, reduction in range of habitat due to human encroachment involving the occupation of suitable areas by humans and hunting are likely to be the major threat.

In most Eastern Africa countries, large areas of wild life conservation areas have been displaced by pastoral rangelands that cause serious wildlife conservation problem due to habitat loss. In the current study area as well, there is growing interest in using the park and surrounding area for livestock grazing and agriculture due to the ever-increasing human population in the country. As a management solution, understanding the habitat use and feeding ecology of the mountain nyala is vital for the conservation of the species. This research is conducted to examine the habitat preference and feeding ecology of mountain nyala.

Study area

The research was conducted in eleven localities of the Bale Mountains that harbour mountain nyala (Fig 1).

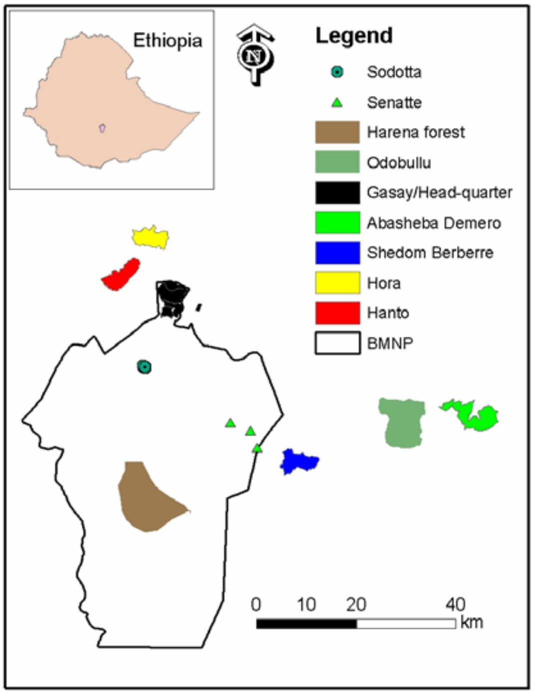

Fig 1. Core study area for the Mountain nyala habitat preference in the Bale Mountains, Ethiopia (Field progress in six more areas)

Method

Nine females and ten male individuals of mountain nyala (*Tragelaphus buxtoni*) were darted from May 24 to June 1, 2008 by a remote injection system from the ground at a distance of 30 to 40m by Dan-Inject JM Special with 3ml. Female were collared with GPS collars and males were collared with VHF collars. The GPS units were programmed to provide fixes every 2 h and data were downloaded remotely by reviver once per month. The position of the males was recorded by GPS in 2 hrs interval by intensive focal watch. The GPS data were projected into UTM coordinates in ArcInfo (v8.0) and then imported to ArcView (v3.2) and ArcGis for spatial analysis. Home range was calculated by minimum convex polygon and kernel estimate methods. A home range has been defined as the area traversed by an individual or socially cohesive group of animals in the normal activities of foraging, mating, and caring for young. The home ranges of male and females were compared by Mann–Whitney Matrix. Seasonal variation and variation in consecutive months was compared by Wilcoxon signed-ranks test. A critical value of 0.05 was used for rejection of the null hypothesis (Zar, 1999). The type of habitat in the home range of each collared individuals was studied from ground survey.

Habitat preference was further studied by focal watch on the radio collared individuals though scan sampling. The habitat of study area was initially divided in to three major vegetation zones; woodland, Erica and Gasay opened land by using GIS from data collected from the boundaries of such habitats by visual inspection. The Gasay opened land was then further divided in to 6 recognized habitat types; wet land, drainage, swampy area; Carex dominated grassland, Artemesia bush land and Helichrysum grassland by visual inspection. The range out side the park is divided to pasture, human settlement and agriculture by using 10m resolution satellite image and ground survey. Geographic Information System software and Erdass imaging were used to map habitat types from ten meter resolution satellite image to assure the mapping from the ground with information from Ground-truthing.

The habitat used by the groups in each class of vegetation types was recorded by a scan sampling technique in every 15 minutes interval from collared and recognized group members. Group members were recognized by photo ID which is prepared based on the number and pattern of white spot on their side which is unique for individuals. Availability of each habitat was then expressed as a percentage of total habitats. Habitat use expressed as a percentage of the total number of sightings for each habitat type. The habitat preference is then calculated as the ratio of the habitat use to the availability of habitat type.

For the collared and recognized individual group members, the food type observed to be eaten was recorded in ten minutes interval if they are browsing. A food type was defined as distinct kind of item eaten by Nyalas. If the animal were grazing, it was simply recorded as grazing as it is difficult to observe what particular grass or other species was eaten. Simpsoni ndex (D) was used to describe dietary diversity.

$$D = \frac{1}{\sum_i p_i^2},$$

Where p• is the proportion of food type i in the total of food types consumed during the period of interest. Morisita index was used to assess dietary overlap between sexes or between months.

$$C_H = \frac{2\sum_i p_{ij}p_{ik}}{\sum_i p_{ij}^2 + \sum_i p_{ik}^2},$$

Where p, and p• k represent the proportion of food type i in the diet of the two sexes of Nyalas species.

The above mentioned methods as part of examining the habitat preference of the nyala were carried out in the Gasay area, northern end of the park. The largest mountain nyala population is however found out side the park, the majority of them in the dense forest east side of the BMNP. In these localities studies on habitat use from focal watch was difficult for two reasons. First, the area is too dense forest to observe animals. Second, animals in such area hunted legally and illegally for many decades and appear to be very shy. Habitat use in such areas was studied from pellet abundance with vegetation cover. Quadrates of 4*5 m^2 of laid on random points on stratified transects by using Excell. Stratified sampling is suggested because it provides better overall comparative accuracy than either random or systematic sampling. The number of pellets and the ground cover of such community and grassland areas were sampled with 1 x 1 m^2 plots. Plants in the quadrant were identified to species or generous level. The abundance of pellet and vegetation used as indication of the suitable habitat for the mountain nyala. Because, the mountain nyala distribution in the Bale massif is proofed to be concentrated between 2000-3250m asl, a random locations was generated out side the already studied localities that harbour mountain nyala in the attitudinal range to examine the habitat type and its correlation with the mountain nyala abundance. To determine if there was a relationship between the forest types and the number of pellet groups, an ANOVA was performed to find any significant relationships.

In each localities of mountain nyala habitat, Shannon-Weiner Index was used to Measure species richness and evenness within a community. Richness indicates number of species and evenness indicates distribution of individuals among species. Shannon-Weiner Diversity was calculated as -Σ (pi)(ln pi) where pi is proportion of individuals belonging to the ith species. Evenness is calculated as Σ pi ln pi/ln S where S stands of number of species. Relative frequency of species is calculated by dividing the number of occurrences for a single species by the total number of occurrences for all species.

Community similarity among the sites was quantified with Jaccard's index. Similarity index between different localities that harbor the mountain nyala was calculated as 2 sum nc/sum n1 + sum n2 where *nc* = the common species between sites; *n1*= the species of site 1 and *n2* = species of site 2. Multi-Response Permutation Procedures (MRPP) was used to examine the difference in species composition in between different sites of the core areas of the mountain nyala. MRPP is a non-parametric procedure used to test the hypothesis that no difference exists in composition between two or more groups of plots. To test for differences in the number of species per site, a two-factor ANOVA was used. Tukey's HSD test was used for multiple comparisons.

Result

The Gasay area which is a total of 31 km^2 areas classified in to seven vegetation zone from 12,000 GPS locations. The vegetation classification from the ground survey was further confirmed by 10m resolution satellite image. The forest, Erica, artiemsia, and wet land are clearly identified in the image analysis (Fig 1).

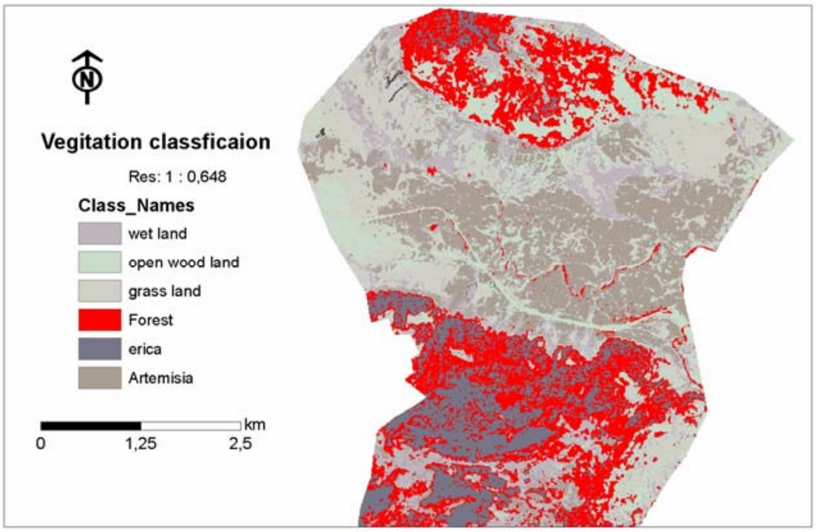

Fig 2. Gasay area major vegetation zone from satellite image analysis (Preliminary analysis)

In terms of altitudinal zones digital elevation model was used to identify the preferred attitudinal range of the species. From the already finalized study sites, about 92% of the populations of nyala are found in the altitudinal range between 2000asl and 3250 asl (Fig 1). The remaining 7% of the population is found in the range of 3250 to 3750. The only population which is found above 3750 is the population in senate which represents less than 1% of the population (Fig 3)

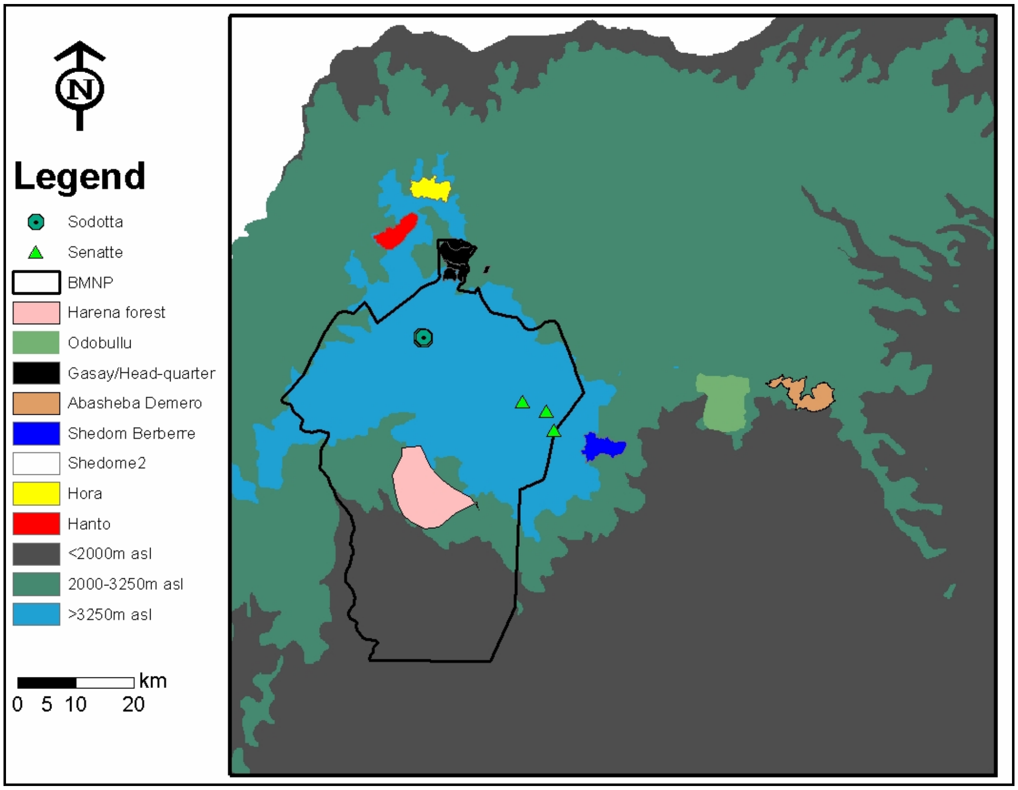

Fig 3. Altitudinal range of mountain nyala distribution.

Food item of mountain nyala

Nyalas main food items in Gasay area include grass spp., Artemesia afra, Gallium semensis, Hypericum revolutum, Hagenia abyssinica, Solanum sessilisellatum, Helichrysum splendidum, Discopodium spp. and Carduus spp. Female mountain nyalas have high preference for carex dominated grassland followed by helicrism grass land in the wet season in their diurnal habitat use.

2.2.3 Home range and movement pattern of mountain nyala

The average home range of females home range in July, 2008 was 2.01 km^2 (0.85 to 4.76, sd= 1.23) (Table 1; Fig 2). Because the collars are fixed at the end of may 2008, No much data on this aspect.

Table 1. Female home range in June, 2008

Female ID	Home range (km^2)
Female 1	2.65
Female 2	1.35
Female 4	1.85
Female 5	1.31
Female 6	0.85
Female 7	4.76
Female 8	1.67
Female 9	1.65

Females spend much of the day time in the open place and forests or human settlement in the night and intensively use constant localities (Fig 1. and Fig 2).

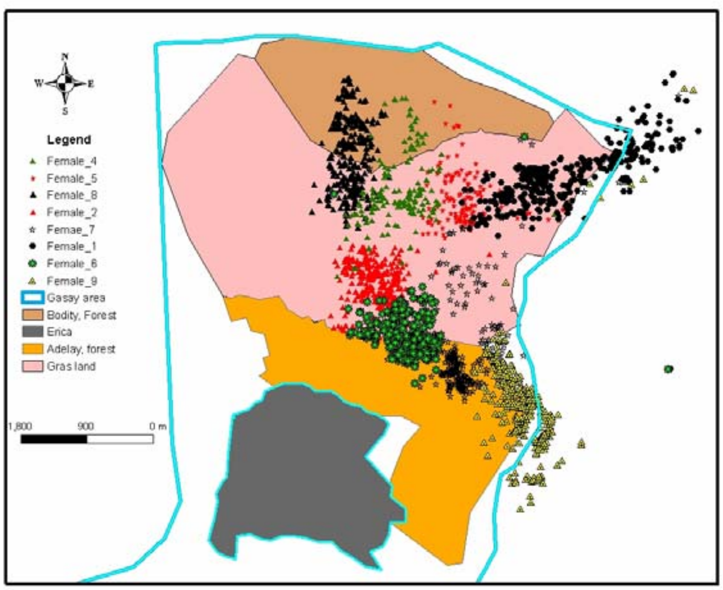

Fig 4. GPS coordinates recorded in 2 hrs interval for each collared females in July.

Females use quite specific home range during the two consecutive wet seasons, June and July (Fig 4&5). Details of the statistical measures on seasonal differences in the home range will be continued as data collection proceeds.

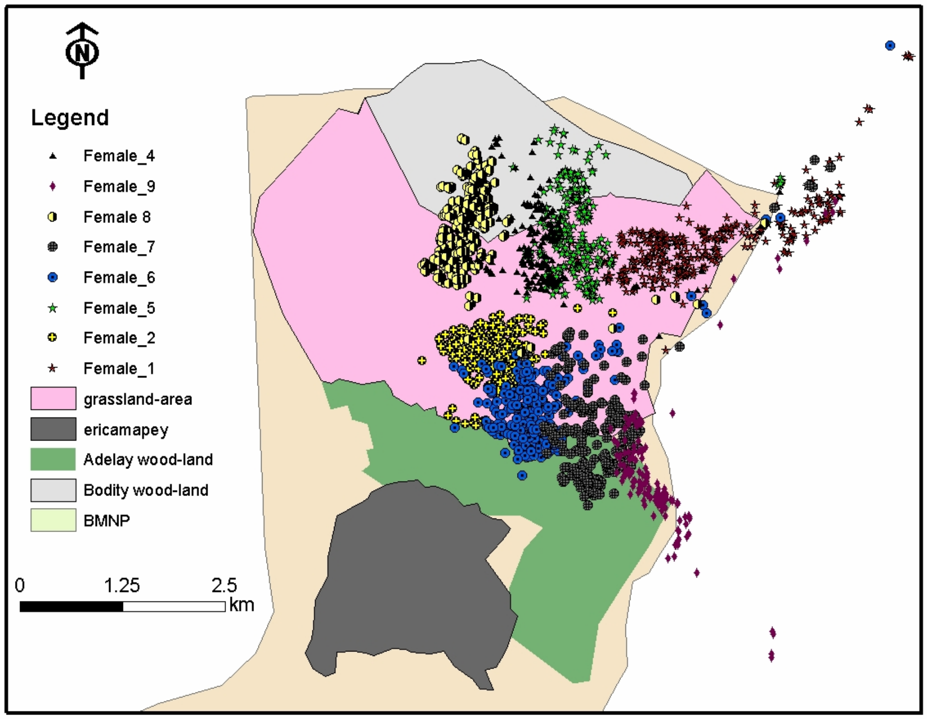

Fig 5. GPS coordinates recorded in 2 hrs interval for each collared females in July,

Chapter 3

Mating system and social organizaion of mountain nyala

Field work progress status: 95% completed

Introduciton

Social organization is defined as the way in which members of a species interact with each other. Descriptions of a species' social structure or social organization typically arise from studies of interactions or associations between individuals. A general hypothesis linking social organization with feeding ecology in African ungulates with body size; small species need high-quality food to maintain a relatively high metabolism and therefore selectively browse on shoots and fruits in the forest. The resource distribution of high-quality food selects for territoriality and a rather solitary way of life. Very large species, on the other hand, live in more open habitat, eat poor-quality food in bulk and graze less selectively on grassland. Such ecological conditions favour living in groups or in herds to counteract predation pressure. Male social organization is however, affected by the mating system strategy. Social organization can vary depending up on resource availability. When resources are available in the wet season, females probably may aggregate in large group and when resources were limited in dry season, the group may be split in two or more groups, coherent with the groups merge (fusion) or split (fission) principle.

In mammals, species with high sexual size dimorphism tend to have highly polygynous mating systems associated with high variance in male lifetime reproductive success (LRS), leading to a high opportunity for sexual selection. Female group size, movement pattern, how synchronize their oestrus is, the difficulties of males in locating females decide which strategy males have to follow in their mating system. If female group size varies, or females within groups synchronize their oestrus, or males can anticipate female receptivity, then males should remain with groups where there is a high immediate probability of successful mating. Otherwise roving **(**i.e. moving between female groups in search of estrous females between groups) is favoured.

Males in the majority of ungulate species compete with each other to have exclusive access of a female. However, strategies used by males in the competition vary greatly among taxa. In some ungulates, a males exclusively monopolize relatively stable groups of females in the form of unimale harems or two or more males may share mating by defending the group against other males; multimale harems. Males may try to mate with females in mixed-sex groups containing more than one adult male (female-following: e.g., African buffalo *Syncerus caffer*; fallow deer *Dama dama*; this may variously include the temporary defence of estrus females from other males in the group and the establishment of stable dominance hierarchies. In another form of female-defence, males move over large areas searching for, briefly associating with, and trying to mate with oestrous females (roving: e.g., alpine ibex *Capra ibex*).

The second common type of male mating tactic is to defend territories containing resources, such as forage, that predictably attract females (resource based territories: e.g., blackbuck *Antilope cervicapra*, puku *Kobus vardoni*). Territorial males attempt to mate with oestrous females as they move through these territories in search of resources. Their is also small mating territories (Leks) which is small fraction of the range of females. These territories are devoid of resources such as food or water, and females are thought to visit leks for the sole purpose of mating. Except for some field reports, no study was carried out in the mating and social organization of the mountain nyala. This research is carried out to fill the gap.

Method

Five female groups and 150 males were recognized by the number and pattern of their white spots with 19 collared animals (9 females and 10 males) were observed as focal animals since June 2008.

A strong and long-term association between the focal groups in the wet and dry season was studied from focal watch on radio collared animals and individually recognized individuals. When conducting focal group observations in examining social organization, it is important to explicitly define the rules for inclusion of individuals in the group. In this study, a group were defined by spatial proximity according to the "10-m chain rule" under this definition; mountain nyala were considered part of a group so long as they were within 10m of a nearest neighbour. Latter however, individual animals were recognized by the number and pattern of the white spots which are unique for individuals.

To examine the social organization, the number of groups, core area used, and interaction with other members were studied for three consecutive years. The group size for a particular day was estimated using the identification data. Each day's identifications were divided into two sets, before and after midday and group size for that day was then estimated using a Petersen mark–recapture estimator.

$$g = (n_1 + 1)(n_2 + 1)/n_{12} - 1$$

Where g is the estimated the group size, $n1$ is the number of individuals identified in the first set of identifications, $n2$ is the number identified in the second set, and $n12$ is the number identified in both sets. We estimated the coefficient of variance (CV) of each day's group-size estimate (Seber, 1982):

$$CV = [(n_1 + 1)(n_2 + 1)(n_1 - n_{12})(n_2 - n_{12})/(n_{12} + 1)^2(n_{12} + 2)]^{1/2}/g$$

We used two levels of precision because the precision of these group-size estimates decreases as group size increases. Therefore, including only the most precise estimates may lead to group sizes that are biased low. The group sizes experienced by members of groups are called "typical group sizes" and their mean is estimated as

$$g_t = \Sigma g(i)^2 / \Sigma g(i)$$

Result

The mating system of mountain nyala is in preparation for submission for publication

Chapter 4

Potential suitable habitat assessment

Field progress status: 70% completed

Introduction

Understanding the potential suitable habitats for the mountain nyala is extremely important to maintain, restore, or expand the necessary habitat components required by the species. Even though, many species are adversely affected by human activities at large spatial scales, it is difficult to detect in such a large scale. Application of remote sensing and Geographic Information System (GIS) tools becomes increasingly important in solving the limitation in understanding the habitat availability in a large scale which is difficult to detect by ground surveys.

A habitat model is a descriptive or mathematical representation of the relationship between a wildlife population and its habitat. Habitat Suitability Index (HSI) models indicate habitat suitability as the geometric mean of several habitat components, the resulting index ranges from 0–1, representing habitat quality as a function of species presence, abundance, or distribution. A number of methods are developed in habitat modelling including multiple linear regression, discriminate analysis, and logistic regression.

Method

Habitat suitability is measured by means of a suitability index, which is a unit less variable describing habitat priority with respect to the needs of the species under consideration. Habitat suitability model for mountain nyala was developed by using the logistic regression of presence/absence of mountain nyala on habitat variables. A suitable habitat was then identified by using Geographic Information System (GIS), by applying the regression coefficients which was developed by logistic regression. Delineation of the best potential sites for mountain nyala is then developed from such back ground.

Habitat suitability model

The logistic regression model was based on the function

$$\text{logit}(P) = ß0 + ß1x1 + ß2x2 + ... + ßnxn, \text{ Equation 1}$$

$$\text{logit}(P) = \log[P/(1-P)] \text{ Equation 2}$$

Equation 1 and Equation 2 results

$$P = 1/[1+ \exp(ß0 + ß1x1 + ß2x2 + ... + ßnxn)].$$

where ß0 is a constant, xn are habitat variables selected to enter the model, ßn are regression coefficients adjusted to each variable and *P* is the probability of occurrence of an event (in the case of nyala presence).

The model is based on 18 spatial data layers (i.e., maps of geographically referenced data within a GIS database) for the presence or absence of mountain nyala; Tree dominated forest, bamboo forest, Erica, Human settlement, pasture, cultivated land each in three altitudinal zones.

The variables describing the composition of the landscape were produced by pixel-based processing GIS tool. In order to calculate the relative proportions of the different landscape elements in a certain area, the study area was first reclassified according to the classes used in the model. In the second phase, the focal statistical functions were used to calculate the needed sum or mean values for each pixel as a function of the input pixels in the specified neighbour hood of each location. In the next phase, raw data were standardized to score maps to be feasible for use in habitat suitability models.

Satellite image analysis for mountain nyala suitable habitats

The GIS layer was derived from supervised classification of ten meter resolution spot image, 5000 GPS locations were collected with their cover type. This information was used to help train the computer to recognize features with in the study area. Training is the process of defining criteria by which patterns in image data are recognized of the purpose of classification by using signature file that contains the mean and standard deviation of each sample (ERDAS, 1994). The supervised classification was preformed using Classification/Supervised Classification tool in Imagine. Mean data values of each circle for each of the five environmental variables were extracted from their respective GIS layers with the GIS utilities function of the ERDAS Imagine image processing software program (ERDAS 1997) (Fig 1)

Result

About 11578 km^2 area which is above 2000m asl of the Bale Massif is classified in to categories, human dominated landscape, tree dominated forest, Bamboo forest, pasture, Erica and cultivated land. The GIS modelling is progressing.

Chapter 5

Functional connectivity and corridor analysis for the fragmented landscape of mountain nyala population

Field progress status: 80% completed

Introduction

Habitat fragmentation and its extreme relative, population fragmentation, are serious threats to species conservation. Habitat fragmentation can affect the survival of the endangered species though a number of different mechanisms including reduction of the total amount of a habitat types degrading habitat quality, genetic deterioration by minimizing gene flow Allee effect, Demographic stochastic (uneven sex ratio or age-structure) and edge effect Increased predation/disturbance by humans. In addition to loss of the amount of habitat and isolated patches, habitat fragmentation changes the properties of the remaining habitat. Habitat fragmentation can occur due to the inability of an individual to find a mate; or, in social species due to lack of critical mass of individuals to trigger an individual process such as mating.

Landscape connectivity can minimize the effects of habitat fragmentation by increasing the degree of movement or flow of organisms through the landscape. As originally defined, *landscape connectivity* is ‘the degree to which the landscape facilitates or impedes movement among resource patches. Landscape connectivity is also defined as ‘‘the functional relationship among habitat patches, owing to the spatial contagion of habitat and the movement responses of organisms to landscape structure.

We can broadly consider two kinds of landscape connectivity, structural and functional connectivity. Structural connectivity ignores the behavioural response of organisms to landscape structure and describes only physical relationships among habitat patches such as habitat corridors or inter-patch distances. The functional concept of connectivity explicitly considers the behavioural responses of an organism to the various landscape elements (patches and boundaries). For conservation of endangered wildlife, connectivity in landscape by corridors maintains a population viable even in the face of anthropogenic habitat destruction and fragmentation. Corridors, continuous strips of habitat that structurally connect two otherwise non-contiguous habitat patches, are considered as most important in land escape connectivity. The corridor concept originated from the generalized assumption that organisms do not venture into non-habitat. Under this assumption, addition of any habitat to a landscape increases the ability of organisms to move. Corridors in a landscape may therefore be a component of its connectivity if they promote movement among habitat patches, but they do not determine its connectivity. The degree to which corridors contribute to landscape connectivity depends on the nature of the corridors, the nature of the matrix and the response of the organism to both. The recently advancing GIS technology helps ecologist to understand the concepts of corridors and connectivity. GIS is a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes.

In most Eastern Africa countries, large areas of wild life conservation areas have been displaced by pastoral rangelands that cause serious wildlife conservation problem due to habitat loss and habitat fragmentation (Little, 1984). In the current study area as well, there is growing interest in using the park and surrounding area for livestock grazing due to the ever-increasing human population. To keep there livestock in closer grazing land, human settlements are intensified in the Bale Mountains including the park area with alarming rate. Although mountain nyala are physically capable of dispersing, there are potential physical and habitat barriers that may preclude immigration of a sufficient number of animals. Human activities may create barriers that slow or impede range expansion in mountain nyala.

3. Study area

The study will be carried out in Bale massif of Ethiopia in 9 populations (sub populations) of mountain nyala (Fig 1).

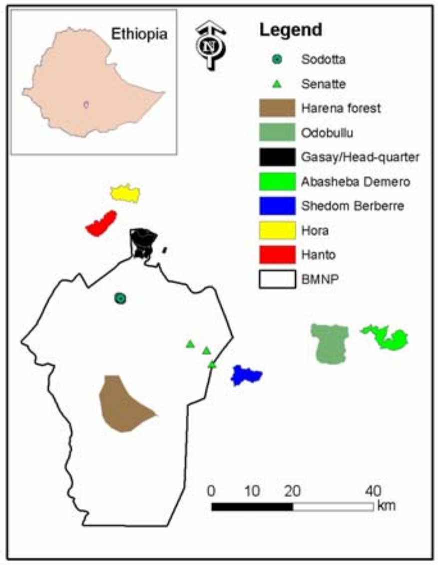

Fig 1. Genetic sampling areas; Gasay and surrounding; Odobullu, Abasheba, Shedom, Harena (three more areas which the GIS mapping is still progressing).

Table 1. Distance matrix between different populations (sub populations) of mountain Nyala

	Hanto	Hora	Gasay	HQ	Sodota	harena	shedom	Odobullu	Abasheba	senate
Hanto	0	9 km	10.8	17.26	19	44.9	50.79	63.8	77.64	38.45
Hora	9	0	12.69	17.53	26.21	52.78	53.06	63	75.44	43.62
Gasay	10.8	12.69	0	5.79	15.9	40.76	41.16	53.43	66.88	31.48
HQ	17.26	17.53	5.79	0	16	40	37	47.53	61.18	27.49
Sodota	19	26.21	15.9	16	0	26.56	36.25	53.6	68.78	25
Harena	44.9	52.78	40.76	40	26.56	0	32.25	54.89	69.1	24
Shedom	50.79	53.06	41.16	37	36.25	78	0	22.45	38.51	11.35
Odobullu	63.8	63	53.43	47.53	53.6	54.89	16.25	0	16	33
Abasheba	77.64	75.44	66.88	61.18	68.78	69.1	38.51	16	0	47.29
Senate	38.45	43.62	31.48		25	24	11.35	33	47.29	0

Corridor analysis

We used a geographic information system (GIS) (ARCINFO version 8.01 (ESRI TM) and the GRID extension) to conduct least cost path (LCP) analyses among our geographic areas of interest to examine the best possible corridors buffered by 1 km to each side. Habitat suitability scores were inverted to create cost scores allowing the most suitable habitat to be the least cost. We constructed our cost surface map by reclassifying a habitat map based on how easily a nyala can travel through each type of habitat. Higher costs were associated with human settlement and agriculture. ArcToolbox and the cost raster, we created cost weighted distance and direction rasters for source areas for each LCP. Areas adjacent to higher density urban areas or classified as high density urban were removed from the analysis creating holes in our continuous cost surface not allowing a LCP to be developed through heavily populated and surrounding disturbed areas. Pathways were then constructed by finding the easiest travel route (the least cost) between areas of interest. Map Algebra was used to calculate reciprocal pixel values of the habitat suitability model to create a cost raster that associated favorable habitat with lower pixel values, and thus, lower cost of movement through them.

Dispersal of animals depends on a number of factors including Habitat preference of target species, structure between patch (Matrix of unsuitable habitat; human settlement and agriculture), interpach connectivity; distance between patch, size of the destination patch.

Agriculture and human settlement were assigned cost values of 15 and 20 respectively, indicating a relatively high accumulating cost for travel along or through either of these features. Wildlife crossings were given a 0 value allowing free passage under the roadways.

We modeled five pathways to connect the five high use mountain nyala habitat blocks with the five peripheral areas described above. The five connections are Gasay to Hora area, Gasay to head quarter, Gasay to Harena, Harena to shedom, , Shedome to Odobullu and Odobullu to Abasheba demero.

We made several assumptions regarding LCP modeling. Some of the assumptions are:

1. Favorable corridors were composed of primarily suitable habitat for the mountain nyala.
2. The LCP provides a greater probability of survival for a cougar while traversing the entire distance.
3. Human influences on the landscape are permanent and may hinder movement of cougars.
4. Human settlement and agriculture intensified area pose problems for successful transit

3.2 Functional connectivity

A landscape or local area with high connectivity is one in which individuals of a particular species can move freely between suitable habitats, such as favoured types of vegetation for foraging, or different habitats required for foraging and shelter. Alternatively, a landscape with low connectivity is one in which individuals are severely constrained from moving between selected habitats. Functional connectivity of the mountain nyala will be carried out by ArcGIS tools for Functional Connectivity Modeling. Although GIS software such as ArcView or ArcGIS is relatively new, it is quickly gaining popularity and has already been utilized in a wide variety of scientific studies.

Chapter 6

Genetic population differentiation of the Mountain nyala in its range from Bale to Arsi massif, Ethiopia

Lab work progress: 25% completed

Introduction

Habitat loss and fragmentation are the most serious threats to biological diversity and the Primary cause of the present day extinction. Currently, the remnant African large mammals face serious threats due to the consequence of habitat fragmentation and cut-off migration corridors. Habitat fragmentation is often defined as a process during which “a large expanse of habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original”.

Habitat fragmentation leads to loss of genetic variation though genetic drift, the stochastic loss of genetic variants, and reduction in population size, affecting mating behaviour. Population genetic theory and empirical studies indicate that long-term population viability is positively related to levels of genetic variation. The higher the Genetic variability the higher the potential of the population for fitness in the environment. Small and isolated populations can lose genetic variation over time which can be one important factor for the extinction of the small population through catastrophic natural forces and demographic, environmental, or genetic stochasticity. If the species is under trophy sport hinting, coupled with habitat fragmentation, small population of a species can be easily affected.

Method

Genetic studies will be carried out in examining the mating system, genetic population differentiation/migration rate and inbreeding level all which are used to fully understand the effects of trophy hunting. For genetic studies, feacals will be collected from identified matured males, calves and their mothers and preserved in 96% ethanol and alternative dry form as DNA source. After careful feacal preservations, Genomic DNA then will be extracted from faecal using commercial kits (E.Z.N.A. stool DNA). Primers that amplify microstelites will be used in this study. To date, no primer is known for mountain nyala and we are considering testing primers from related species. After successful amplifcations of DNA, samples from the PCR will be sequenced by automated sequencer. Digital measurements of length of polymorphism will be carried out on an ABI 373 (perkin-Elmer) using the program STR. Paternity will be assigned by CERVUS 2.0 software, a program that incorporates error rates (mistyping of alleles, mistakes in data entry, or mutation) and unsampled individuals to calculate likelihood ratios for paternity assignment among candidate males.

Traditional population genetic statistics that provide measures of genetic variation within populations (observed and expected heterozygosity, allelic diversity, and haplotype and nucleotide diversity) and the partitioning of genetic variation among populations will be tested by Wright's F-statistics (FST) based on differences in allele frequencies and R-statistics (RST) based on differences in the allele size. When examining the population genetic variations, inbreeding and relatedness, all the genetic materials from calves will not be considered as they are not randome samples. Unbiased estimates of Wright's FST and tests for significant genetic differentiation among all pairs of populations will be determined using software in GENEPOP version 3.1a. Variation in average allele sharing and relatedness scores in relation to average heterozygosity will be analysed by using one-way analysis of variance (ANOVA).

Result

Four primers that were used in cattle were tested and four of them found to amplify the nyala DNA successfully. Pellet sample colleciton is completed and the lab work is in progress.

Chapter 7

Trophy hunting in mountain nyala and its conservation value

Field work progress; 66% completed

Introduction

Wildlife conservation in developing countries with high number of people living in poverty is a challenging task and increasingly necessitates community involvement and economic benefits from conservation activities. Community-based approaches that allow communities to derive economic benefits from their wildlife resources in the management of wildlife are increasingly being implemented in many African countries. Community-based conservation, which attempts to devolve responsibility for the sustainable use of wildlife resources to the local level, can include consumptive activities, such as trophy hunting, as well as non consumptive activities, such as tourism. Trophy sport hunting can be a successful conservation tool as it has the potential to generate substantial amounts of money that can be directed to the local community and further conservation efforts. Since its discovery in 1908, the mountain nyala has become an important trophy species for sport hunting in Ethiopia. When sustainably implemented, mountain nyala trophy hunting has the potential to provide economic incentives for conservation, including economic benefits to local communities for community-based conservation.

Even though sport hunting plays an important economic and social role in many countries trophy sport hunting has to be biologically sound Legal; breeding population status, harvest levels, production, the effect of hunting and other population characteristics have to be evaluated in a population which is under any condition of hunting. Sport hunting which is not supported by detailed study of the ecology of the population may lead to dramatic decreases of wildlife populations and can lead the population to crash.

Method

All the chapters from one to six will be used to evaluate the sustanability of trophy hunting. Further the social aspects of trophy hunting including the benefits of trophy hunting for local community and contribution of the hunting consensions will be evaluated by questionnaire survey will be carried out for the local people in relation to their attitude towards the hunting concessions and benefit from the trophy hunting. The hunting tradition of the local people before and after the establishment of the trophy hunting also will be assessed by questioner survey to examine to what extent the trophy hunting company contributes in minimizing illegal hunting. Questioner survey will also be provided to the hunting company and governmental officials in relation to what share of the money earned from the trophy hunting that goes to the local people.

Result

To give a final conclusion how trophy hunting is sustainable, all the above chapters; population distribution and population estimate, sex age composition, mating system, the ecological conditions and threats presented to the species including habitat loss, the benefit of the trophy hunting to the conservation of the species, the genetic differentiation and inbreeding level must be completed.