

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**A COMPARISON OF POPULATION ECOLOGY OF BEISA
ORYX IN AWASH NATIONAL PARK AND ALLEDEGHI
WILDLIFE RESERVE, ETHIOPIA**

BY

G/EGZIABHER TEFAY

*A thesis Submitted to the School of Graduate Studies of Addis Ababa
University in Partial Fulfillment of the Requirements for the degree of
Masters of Science in Dry land Biodiversity.*

JULY, 2005





A herd of Beisa oryx

ACKNOWLEDGEMENTS

I am very grateful to my advisor Dr. Solomon Yirga for his consistent and stimulating advice, valuable suggestions, constructive criticism and critical reading of the manuscript. He taught me basic ecological methods in the field and provided me materials for reading and fieldwork. Without specifically his professional support and sincere collaborations, the work would not have been completed within relatively short period of time.

My deep gratitude is extended to the staff of ANP especially the park warden, Ato Arega Mekonen who provided me with the necessary informations during my fieldwork.

My sincere thanks also goes to my wife, W/ro Alganesh Wagaw who encouraged me throughout my study. I would like to thank my classmates and all friends, Vendeline Emmanuel Tairo, Francis Moyo, John Bukombe, Daniel Macharia, Clara Makenya, Martina Hagwet, Samuel Mamo, Abdi Itana and Dereje Mekonen. I would like to highly appreciate Vendeline Emmanuel Tairo, John Bukombe and Daniel Macharia for sacrificing their time in assisting me in data analysis.

I would like to express my appreciation and sincere thanks to members of Metehara sugar plantation and Melka werer agricultural center who provided me with climatic data.

I am grateful to RPSUD (Research Program on the Sustainable Utilization of Dry land biodiversity) and Sida-SAREC for financial assistance and support.

Finally, I deeply appreciate Tigray Education Bureau for allowing me to join this program.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	i
LIST OF TABLES	iv
LIST OF FIGURES	v
LIST OF APPENDICES	vi
ABSTRACT	vii
1. INTRODUCTION AND LITERATURE REVIEW	1
1.1. Introduction.....	1
1.2. LITERATURE REVIEW	3
1.3. OBJECTIVE	6
1.3.1. General objective	6
1.3.2. Specific objectives	6
2. MATERIALS AND METHODS	7
2.1. Description of the study areas.....	7
2.1.1. Awash National Park (ANP).....	7
4.1.2. Alledoghi Wildlife Reserve (AWR)	12
2.2. Methods	15
2.2.1. Population census	15
2.2.2. Population structure	16
2.2.3. Group size	16
2.2.4. Distribution and vegetation type utilization.....	17
2.2.5. Movement and Home range.....	17
2.2.6. Diurnal activity patterns.....	18
4.3. Data analysis	18
3. RESULTS	19
3.1. Population census	19
3.2. Group size	20
3.2.1. Local Variation in group size.....	21
3.2.2. Seasonal Variation in group size	21
3.3. Group structure	22
3. 4. Age & Sex Structure	25
3. 5. Distributions and vegetation type utilization	29
3. 6. Movement and Home range.....	33
3. 7. Activity Patterns	34
4. Discussion	37
4.1. Population status.....	37
4.2. Population structure	39
4.3. Social organization and group size	40
4.4. Distribution and vegetation type utilization.....	42
4.5. Movement and home range.....	43
4.6. Diurnal activity patterns.....	44
5. CONCLUSIONS AND RECOMMENDATIONS	45
5.1. Conclusion	45
5.2. Recommendation	48
REFERENCES	49

APPENDICES..... 54

DECLARATION 58

LIST OF TABLES

Table 1: Mean group size of Beisa oryx in Awash National Park.....	19
Table 2: Mean group size of Beisa oryx in Alledoghi Wildlife Reserve.....	20
Table 3: Number of sightings of sex/age category and groups of Beisa oryx in the two study sites, Awash National Park (Illala Sala) and Alledoghi Wildlife Reserve.....	23
Table 4: Mean group size of Beisa oryx in Awash National Park (in mixed group).....	24
Table 5: Mean group size of Beisa oryx in Alledoghi Wildlife Reserve (in mixed group).....	24
Table 6: Age/Sex structure of Beisa oryx in dry and short rainy seasons in Awash National Park.....	26
Table 7: Sex/Age ratio of Beisa oryx in dry and short rainy seasons in Awash National Park.....	27
Table 8: Age/Sex structure of Beisa oryx in dry and short rainy seasons in Alledoghi Wildlife Reserve.....	27
Table 9: Sex/Age ratio of Beisa oryx in dry and short rainy seasons in Alledoghi Wildlife Reserve.....	28
Table 10: Observation of Beisa oryx in different vegetation community in Awash National Park.....	29
Table 11: Observation of Beisa oryx in different vegetation community in Alledoghi Wildlife Reserve.....	30
Table 12: Diurnal activity pattern of Beisa oryx.	35



LIST OF FIGURES

Figure 1: Climatic diagram of Awash National Park	8
Figure 2: Location Map of the Awash National Park	10
Figure 3: Map of the main study site Illal Sala and its adjacent areas in Awash National Park. ..	11
Figure 4: Climatic diagram of Alledeghi Wildlife Reserve.....	13
Figure 5: Map of the main study site in Alledeghi Wildlife Reserve	14
Figure 6: Percentage of monthly distribution of Beisa oryx in different habitats in Awash National Park	31
Figure 7: Percentage of monthly distribution of Beisa oryx in different habitats in Alledeghi Wildlife Reserve	31
Figure 8: Number of Beisa oryx observed during the present study period in different habitat types in Awash National Park.....	32
Figure 9: Number of Beisa oryx observed during the present study period in different habitat types in Alledeghi Wildlife Reserve.....	33
Figure 10: Dry and short rainy seasons home range size	34
Figure 11: The activity patterns of Beisa oryx during the hours of the day	36

LIST OF APPENDICES

Appendix 1: Beisa oryx data gathering sheet	54
Appendix 2: Data gathering sheet for diurnal activity patterns of Beisa oryx	55
Appendix 3: Vegetation classification in Awash National Park.....	56

ABSTRACT

Field study on a comparison of population ecology of Beisa oryx (*Oryx beisa*) was conducted every month from October to March, 2005 for six months in Illala Sala and adjacent areas in Awash National Park and for five months (November to March, 2005) in the selected study site in Alledeghi Wildlife Reserve. The result indicated that an average of 220 individual of Beisa oryx in Awash National Park and 335 individuals of Beisa oryx in the selected study site in Alledeghi Wildlife Reserve. The mean group sizes of 17.6 individuals were found in the selected study site in AWR, and 13.9 individuals were at Illala Sala and adjacent areas in Awash National Park. The difference in mean group sizes of Beisa oryx between the two study areas was not significant. However, they were found to be significant for mixed herds ($P=0.008$). The group structure of the animals varied with seasons in Awash National Park and the selected study site in Alledeghi Wildlife Reserve. Large herds were frequently observed during short rainy season in grassland and smaller groups during the dry season in both study sites. Variation in monthly group size did not exist in both study sites. The most cohesive herd is that of the female and her immediate young. Single males were most common at Illala Sala and its adjacent areas in Awash National Park and male-female group in the selected study site in Alledeghi Wildlife Reserve. The mean number of calves in Awash National Park and the selected study site in Alledeghi Wildlife Reserve showed significant differences between the two seasons at 0.05 level of significance ($P=0.039$ and $P=0.014$). The females during dry and wet seasons are more numerous than the males in both study sites. The animals were observed utilizing the grassland, shrub grassland and wooded grassland habitats in both seasons in both study sites, however, there was more utilization of grassland habitat (72.8% in ANP and 89.1% in Alledeghi Wildlife Reserve). Distribution of group sizes in grassland and shrub grassland habitats of the two study sites showed a high significant differences ($P=0.003$ and $P=0.025$, respectively). Grassland habitat was the best preferred habitat of Beisa oryx. The changes in the distribution of habitat preference in the two seasons showed that no significant differences. However, there was slightly significant differences in the group sizes in grassland habitat of ANP between the two seasons ($P=0.047$). Seasonal home range size varied in ANP. Wet season home range size (31km^2) was larger than that of dry season (25km^2). Minimum Convex Polygon (MCP) method was used to calculate the

home range. On the average about 52.61 % of Beisa oryx daytime were spent in feeding and 36.65%) in rest i.e. standing and lying down.

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

One of the most fascinating features of tropical Africa is the wealth and diversity of its mammalian fauna. The majority of large African herbivores belong to the order Artiodactyla (Delany and Happold, 1979). Of the five families and thirty six genera of Artiodactyla in Africa, two families and thirty two genera are endemic (Bigalke, 1972 cited in Delany and Happold, 1979).

Ethiopia is one of the few countries in the world that possess a unique and characteristic fauna with high level of endemism (WCWC, 1991). Some of these are protected within National Parks, Sanctuaries, Wildlife Reserves and other Conservation zones. Awash National Park (ANP), the first to be protected and gazetted together with the Simen Mountains National Park (SMNP) in 1969 (Negarit gazeta, 1969), is among the most important conservation centers of the country. The area delineated as ANP and its surroundings was known for its high population of grazers. However, the population of grazers such as Beisa oryx and Sommering's gazelle has been declining from time to time. It is difficult to find grazers in northern section of the Park that used to be grasslands, as a result of poaching, combined with limited amount of displacement and habitat fragmentation (Jacobs and Schloeder, 1993).

The Beisa oryx was seen in highest concentration in ANP and the nearby Wildlife conservation areas such as the Alledghi Wildlife Reserve (AWR) than elsewhere in Africa (Robertson, 1970; Thouless, 1995; Jacobs and Schloeder, 1993).

Beisa oryx is one of the few herbivores that have not been studied extensively in the wild. It is found in open country of Ethiopia, Somalia, Kenya and Tanzania. Its number has been much reduced by reckless hunting (Huass, 1961). In Ethiopia, it had a wide range in the arid and semiarid parts of the country. At present, however, the population is declining due to loss of

important habitats to overgrazing and other human factors. Now, it is mainly restricted to ANP and AWR.

Investigations since the early 1990s revealed a drastic decline of Beisa oryx population compared to ground survey of 1969. In 1969, 4020 individuals of Beisa oryx were estimated in ANP (Robertson, 1970). However, Jacobs and Schloeder (1993) revealed the presence of 925 individuals in the area. EWCO/CARE (2001) estimated 692 Besia Oryx in the park. Cherie Enawgaw (2004) estimated 446 Beisa oryx. This shows that the population of the species has declined by 89% compared to the 1969 population estimate.

The status of Besia Oryx (East African Oryx) is classified as low risk, conservation dependent species by the International Union for Conservation of Nature and Natural Resources (IUCN, 1996).

The distribution, population size, structure, social organization, home range and diurnal activities of the species are not well understood. This study is designed to gather data on population size, distribution, structure, social organization, home range and diurnal activities of the species in ANP and AWR, Ethiopia.

Knowledge of biology and ecology of wildlife is required for effective conservation and proper management of the conservation areas (Caughley and Sinclair, 1994). At present due to lack of research information on its population status, structure, distribution in relation to vegetation types, home range and diurnal activity patterns of Beisa oryx in ANP and AWR, the extent of human pressure on the survival of Beisa oryx is not well known. Therefore, it is crucial to study and compare these aspects in the study sites. In addition, the present study attempts to study these aspects and suggest a possible conservation strategy for its population management and ensure the future survival of this species in these conservation areas.

1.2. LITERATURE REVIEW

The ever increasing human and livestock population pressure, habitat fragmentation, introduction of exotic species and other adverse human impacts have altered the seasonal migration and movement pattern of artiodactyls (East, 1996; Kingdon, 1997). As a result of these problems, artiodactyl populations have been declining in many of their natural habitats (Caughley and Sinclair, 1994). Beisa oryx is one of the artiodactyls which is facing continued decline in their population (Jacobs and Schloeder, 1993, EWCO/CARE, 2001).

The Beisa oryx is grouped in the family Bovidae, subfamily Hippotraginae and genus *Oryx*. The word *Oryx* is from the Greek word 'Orux' meaning gazelle or antelope. The taxonomy of *Oryx* tribe is still argued. According to Ansell (1977) and Corbet (1978), the genus *Oryx* comprises *Oryx dammah* (Scimitar-horned Oryx), *Oryx leucoryx* (Arabian Oryx) and *Oryx gazella* (Gemsbok, Beisa and fringe-eared Oryx).

The genus *Oryx* is a name for several horse like antelopes, found in deserts and arid scrub lands of Africa and Arabia. They feed on grasses and scrub and go without water for long periods (Columbia Encyclopedia, 2001). They do not seek shade in the middle of the day and appear to withstand an ambient temperature of 45°C for at least 8 hours (Taylor, 1969). They congregate in areas where rainfall has brought a flush of new vegetation (Delany and Happlod, 1979).

Beisa oryx makes obligatory moves after the evening feeding peak before settling to rest (Estes, 1991). Their home range varies from 200 to 300km² for females and from 150 to 300km² for males (Frield, 1975; Kingdon, 1997). Sexes may be equal in number but usually the number of females is greater. Females give births in about nine-month interval and their gestation period is eight and half months (Walther, 1978). Calves lie up for 2-6 weeks. They join other young groups to form peer groups and may stay up to one year. Females could breed within 18-24 months and males within five years. Captive Beisa oryx is known to live for about 22 years (Kingdon, 1997).

Their herds have a definite hierarchy, with a cow leading the herd and 'alpha bull' found at the rear (Kingdon, 1997). Large herds are nearly always mixed and often do not include juveniles, but small herds under 20 may consist of females only, females with a male and females with calves (Estes, 1991). There is only slight sexual dimorphism in them. The penile sheath and scrotum are remarkably inconspicuous except for dominant males in breeding condition (Estes, 1991; Kingdon, 1997).

They are active by early morning and late afternoon hours and in moonlight. Water requirement could be satisfied with its food, which includes grasses and leaves of shrubs, by feeding during the period of maximum relative humidity between midnight and dawn (Taylor, 1969; King *et al.*, 1975). Thus, Beisa oryx is a good example of artiodactyls, which has successfully adapted to overcome harsh conditions of intense heat, little or no water and dispersed food (East, 1984; Columbia encyclopedia, 2001).

Seasonal movements in water-dependent large communities show a wet season dispersal and dry season concentration which can be related to the seasonality of rainfall and water availability, but those similar patterns do not prevail in the water-independent species (Durant *et al.*, 1986). It is suggested that seasonal migration of herbivores in grassland ecosystems of Eastern Africa is correlated to the availability of green vegetation and hence in the proportion of important nutrients.

Different species of animals make seasonal movements between habitats. In areas where food resources change with seasons, populations of mammals are known to move from one type of habitat to another depending up on the season (Began *et al.*, 1986). The availability of food resources affects the population dynamics and distribution of an animal species (Caughly and Sinclair, 1994). Knowledge of the relationship of an animal with its habitat is essential in understanding the ecological requirements of the species (Caughly, 1977). In addition knowledge in the feeding habitats of an animal are essential for making and designing strategies for management. Beisa oryx are social, living in organized herds (Estes, 1991). Habitat type often modifies the group size of ungulates increasing their population size with increase of habitat openness (Jarman, 1974 ; Hirth, 1977). One of the explanations for this is that, in an open area,

individuals in a bigger group have a greater chance of detecting predators. At the same time they have a higher probability of escaping from predation (Hirth, 1977). In closed habitats, on the other hand, a smaller group has a lower probability being victimized by predators (Jarman, 1974; Hirth, 1977). Group size may also be influenced by food conditions. For instance, Hanley (1982) explained that the increase of group size in elk and blacktailed deer was caused by a change of food selection pattern from a single plant to microhabitat patches that provided food of better quality than average.

If foraging efficiency plays an important part in determining group size, then group size should vary not only between habitats, but also between seasons. Thus, it is considered that both food conditions and avoiding victimization by predators contribute to determining group size of ungulates (Hanley, 1982).

Ungulates rarely range randomly (Duncan, 1983). A number of factors such as season, availability of food, breeding activity and population density affect home range estimates (Eberhardt *et al.*, 1984). Accurate estimation of size of home range is an important prerequisite to a better understanding of a species behavioral ecology and management (Sanderson, 1966). Home range may be defined as the area over which the animal normally travels in pursuit of its routine activities (Leuthold, 1977).

In Ethiopia, Beisa oryx is found in a wide area from sea level up to 1700m altitude in eastern and southern part of the country (Yalden *et al.*, 1996). Significant populations of them can be seen in conservation areas including Mago and Omo National Parks (Lamprey, 1994). They are also common through out the Awash Valley (Robertson, 1970; Jacobs and Schroeder, 1993; Thoules, 1995; EWCO/CARE, 2001). The estimated total population of Beisa oryx in Ethiopia is believed to be between 4000-5000 with steadily declining herds (East, 1997). Robertson (1970) estimated 4020 individuals in the whole areas of the ANP. Jacobs and Schloeder (1993) estimated only 925 individuals in ANP, which is 23% of the 1969 estimate. Cherie Enawgaw (2004) estimated 446 Beisa oryx which is 89% of the 1969 estimate. This shows that the population of the species is declining in ANP. Therefore it is important to have reliable current information regarding this low risk but conservation dependent mammal in ANP and AWR (IUCN, 1996).

1.3. OBJECTIVE

1.3.1. General objective

To study and compare the population ecology of Beisa oryx in ANP and AWR, Ethiopia

1.3.2. Specific objectives

- To determine and compare population size, herd sizes, population structure and distribution of Beisa oryx in the two study sites.
- To determine their movement and home ranges size of Beisa oryx in ANP
- To describe the diurnal activity patterns of Beisa oryx in ANP.

2. MATERIALS AND METHODS

2.1. Description of the study areas

2.1.1. Awash National Park (ANP)

ANP is located in the Great Rift Valley, 195km east of Addis Ababa on the road to the Red Sea. It covers an area of 756 km². The park lies between latitude 8^o45' N and 9^o15'N and longitude 39^o 45'E and 40^o05'E. The altitude varies from 750m ASL at Awash River Gorge to 2007m ASL at a mount Fantalle. The Park is bordered to the west by the edge of the Sabober plain, to the south and east by the Awash River and to the north by Kesseme and Filwoha Springs. The Assab and Djibouti-Addis Ababa highway passes through it. The main entrance gate and the headquarters are 195 and 207km from Addis Ababa, respectively (Figure 2). The study was conducted at Awash National Park and 174km² of the Illa Sala grassland plain and adjacent areas (Figure 3).

Climate of ANP may be characterized as semi arid. The annual rainfall ranges between 400 and 700mm (Daniel Gemechu, 1977). Rainfall is bimodal with two distinct rainy seasons: the short rains which usually begin in February and extend to the end of April, and the long rains which extend from July to September. Since the area is located within the inter tropical convergence Zone, there is temporal and spatial variability in rainfall, humidity and temperatures (Daniel Gemechu, 1977). Data collected at Metahara sugar plantation between 1995 and 2004 show that the mean annual rainfall was 503.6 mm. The least rainfall occurs during October, November, December and February and maximum rain fall was during the months of July and August. There is only one really distinct dry season in which there is usually no or low rain fall recordings. This extends from late October to January.

The lowest monthly day time and night time temperatures occur during October to January and the highest of these temperatures occur in May and June. The maximum and minimum

temperatures vary from 36.9°C in June to 30.6°C in December and from 21.3°C in June to 16.9°C in December, respectively.

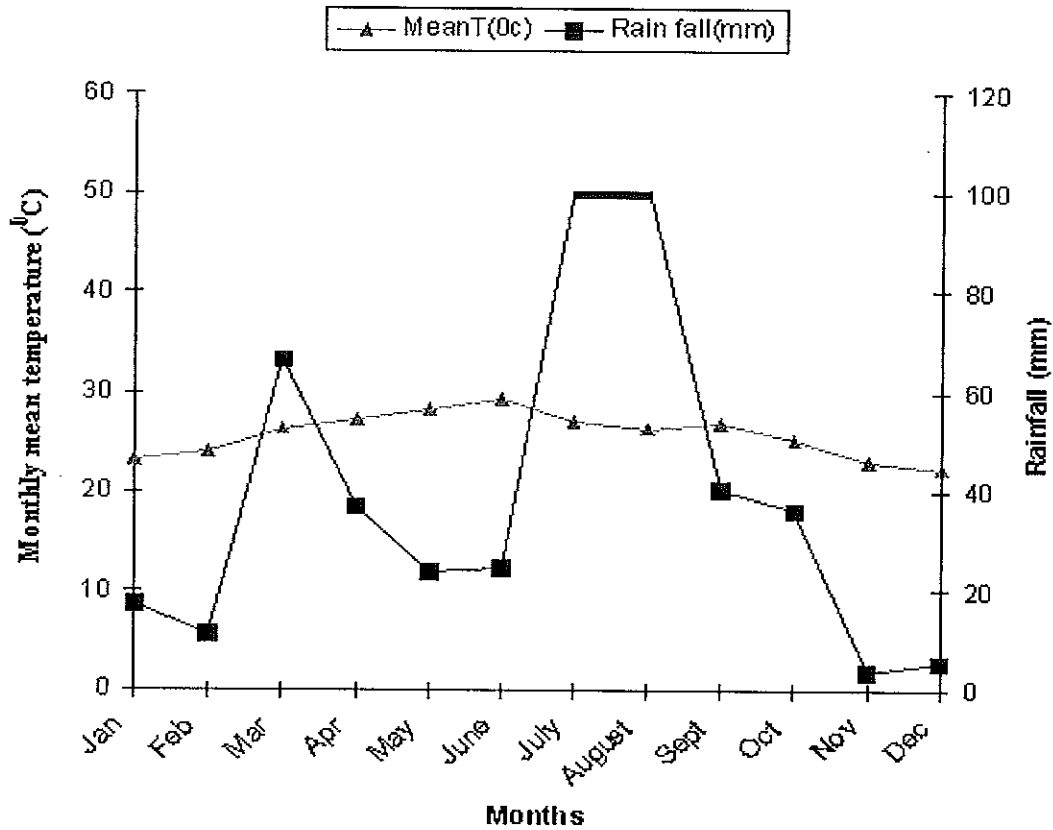


Figure 1: Climatic diagram of Awash National Park

The terrain in ANP is mainly Acacia woodland and grassland. Riverine forest occurs in the hot spring and along the bank of the Awash River. Jacobs and Schloeder (1993) identified eight types of vegetation (Appendix 3). These vegetation types are grassland, open grassland, low vegetation cover, shrub grassland, shrubland, bushland/woodland, dense tree canopy and wooded grassland.

The grasslands are dominated by *Chrysopogon plumulosus*, *Bothriochola radicans* and *Ischaemum afrum* in the lower elevations (Illala Sala) and *Hypharrhenia hirta* and *Themeda triandla* at higher elevations (on the slopes of Fantale Mountain). The shrubland type occurs in

areas where there are moderate to heavy grazing pressure. It is dominated by *Acacia nubica* and *A. senegal*. The bush land and woodland types are also dominated by *Acacia tortilis* and *A. senegal*. However, in some places *Balanites aegyptiaca* becomes dominant in the woodland vegetation type. The dense tree canopy is dominated by *Ficus* and *Acacia trees* (Jacobs and Schloeder, 1993; Almaze Tadesse and Masresha Fetene, 1999).

The wildlife of Awash reflects its dry nature. It supports 81 species of mammals and 453 species of Birds (Hillman, 1993). The most common mammals include Beisa oryx, Soemmerring's Gazelle, Warthogs and Anubis and Hamadryas baboons. The tiny salt's Dikdik and both greater and lesser Kudus are present. Cheetah, serval and leopard are also present but it is not easy to spot them. The Giant Tortoise, Reedbuck, Aardvark, Caracal, Rock hyrax are also represent. In the bottom of the gorge, the black and white colobus monkey can be seen (Hillman, 1993). At filwoha, waterbuck is present.

There are 453 species of birds recorded in Awash Park. They range from the great Ostrich, the less common secretary Bird and Abyssinian Ground Horn bill, to the flashes of brilliant pink, which are the Carmine Bee-eaters, and the Abyssinian Roller with turquoise and purple, wings. And between these two extremes, birds of the riverine forest, Caucal, Turacu, Go away birds; birds of prey, and birds of the savanna are represented.

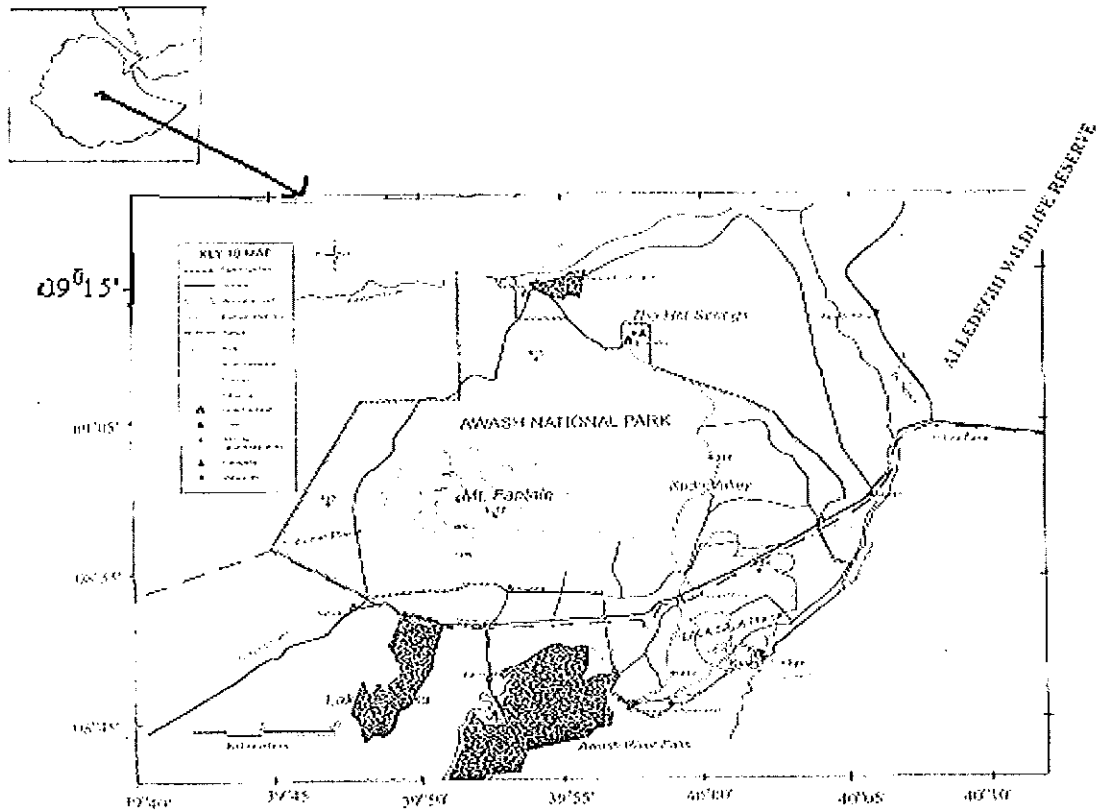


Figure 2: Location Map of the Awash National Park

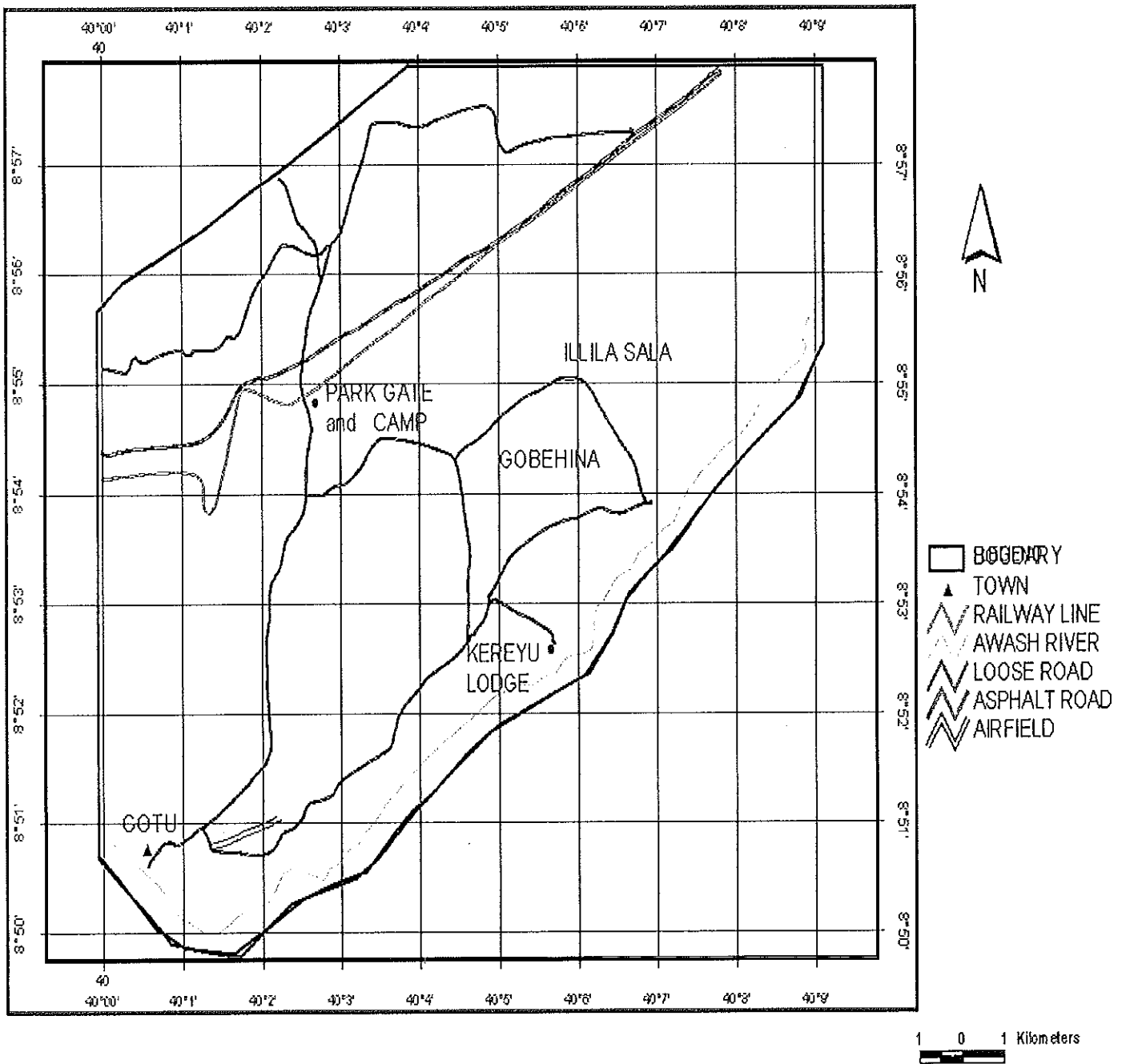


Figure 3: Map of the main study site Illal Sala and its adjacent areas in Awash National Park.

4.1.2. Alledeghi Wildlife Reserve (AWR)

AWR is located approximately 50km to the north east of Awash National Park, on the way to Djibouti and Asab. It is estimated to be about 1832km² and its altitude is ranging from 650-950m. In AWR, which is located between 09 10' N and 09 25'N and, 40 15'E and 40 26'E, was selected as the 2nd study area because of its high Oryx population and accessibility. The plain nature of its habitats is easily accessible with vehicle, despite the gullies and undulating surface of the area. The AWR plains begin from the Arba River, near the Rail Way Bridge that crosses the Awash River. It stretches from this point in a broadening manner to the North east, skirting the Western foot hills of Assebot and Afdem mountains on the Eastern side and having the Awash River as their Western boundary. Much of the area is exposed to intensive human activity, which places the wildlife resources under considerable stress in their competition with livestock.

Data collected from Melkawerer Agricultural Research Center show that mean monthly temperature ranges from 23.8^oC in November to 31.3^oC in June. There is striking similarity in the distribution of rainfall to that of ANP. The bulk of the rainfall is between July and September, with short rains being in February, March and April. Mean annual rainfall is 551.2mm (Figure 4)

The vegetation is broadly classified as grassland, in which various heights of grasses grow which are of few cm height to long grasses. Wooded grassland, shrubland and bushland habitats are also common. The grasses are of various types, the dominant being *Chrysopogon plumulosus* and *Bothriochloa radicans*, which are palatable to both wild animals and domestic livestock. Most of the palatable grasses are distributed all over the plain.

The wildlife faunal diversity is dominated by Beisa oryx and Soemmerring's Gazelle that contribute the highest of the ungulate biomass in the wild. Grevy's zebra, Warthogs, Gerenuk and Ostrich are also present.

The Afar and Issa people currently utilize the wildlife Reserve as a whole as 2grazing land. About 25km² of the area is also used as a modern sheep ranch. Over utilization has resulted in

soil erosion and bare ground. In addition, bush encroachment such as *Prosopis juliflora* is prevalent.

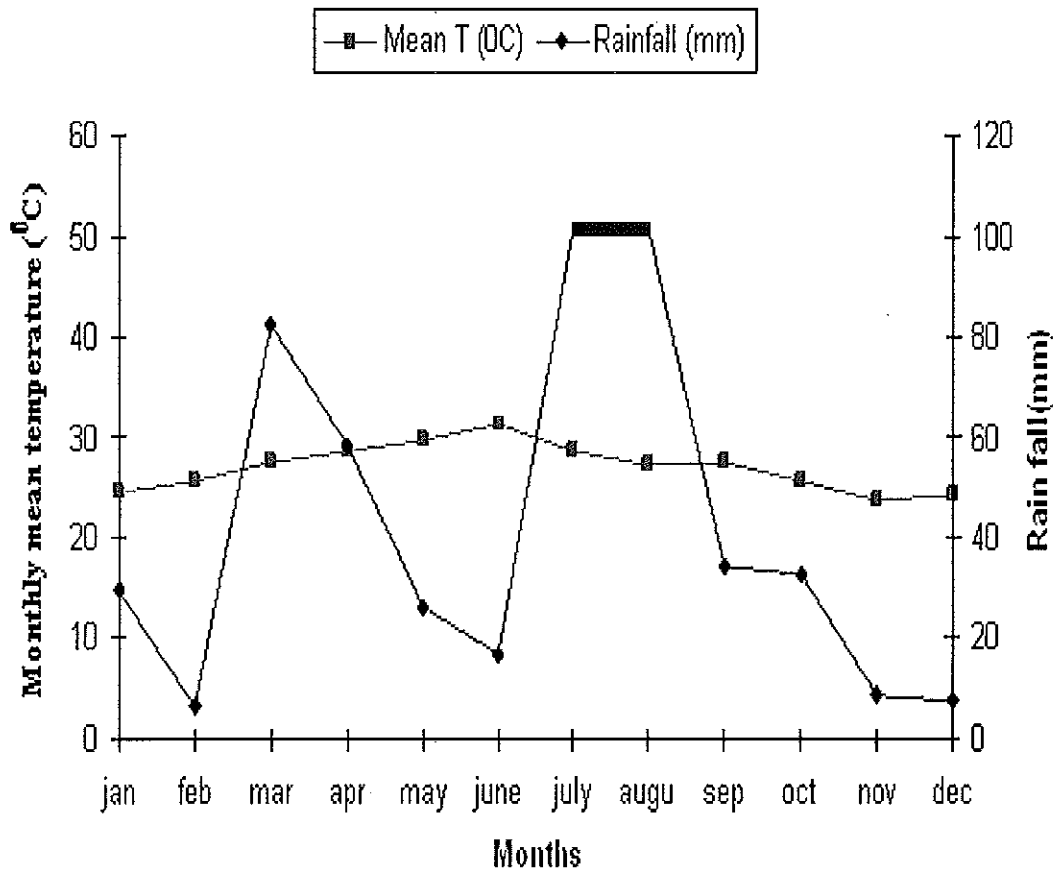


Figure 4: Climatic diagram of Alledoghi Wildlife Reserve

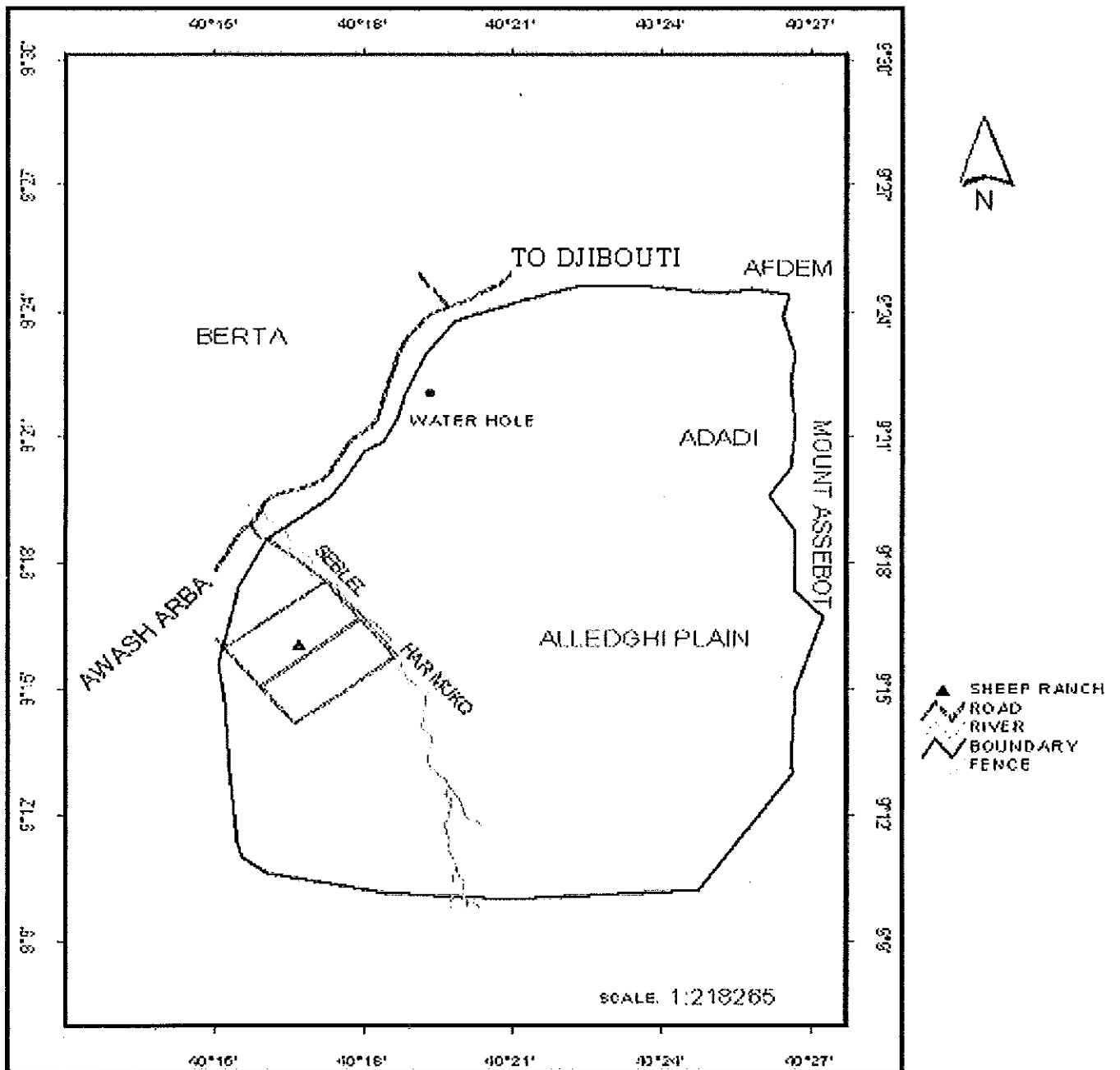


Figure 5: Map of the main study site in Alledoghi Wildlife Reserve

2.2. Methods

Preliminary surveys of the two study areas (ANP and AWR) were conducted during the 1st month of the study (*i.e.* October) in order to assess the overall vegetation type classification previously carried out by other workers and the general distribution of Beisa oryx. After the survey, study sites were selected in both ANP and AWR. In AWR, Only an area of about 470 km² close to the southern end of the Wildlife Reserve was selected. In ANP, an area 174 km², including Illala Sala and adjacent areas, was selected.

The study was undertaken between October 2004 and March 2005. Data were obtained on the population size, structure, distribution, social organization, home range and activity patterns on the dry and short rainy seasons.

Seasonal differences in population size, distribution, social organization, home range and diurnal activities of Beisa oryx in the study areas were compared. Separation of dry and wet seasons was based on the change of rainfall pattern. Population size, distribution and social organization of Beisa oryx in ANP and AWR were compared.

Almost all surveys were conducted from vehicle using existing roads in ANP and through transects in AWR. When the animal was sighted, the vehicle was stopped and group size, sex/age, location and date were recorded.

2.2.1. Population census

Total population census was done using direct count method following silent detection and estimation of population size (Wilson *et al.*, 1996; Caughley and Sinclair, 1994; Norton-Griffith, 1978). Twelve routes (length ranging from 13 to 13.2 km), each route being 3 km away from the other, were established in AWR for vehicle moving. In ANP, the existing roads were used to estimate the population size. Counting was carried out using naked eyes and/or binoculars four times during the dry season (October, November, December and January, 2004), and two times

during short rainy season (February and March, 2005) in both the study sites. The censuses were conducted when Beisa oryx is most active in the morning (6:00-11:00am) and in the late afternoon (16:00-18:00pm) following the method of Lewis and Wilson (1979). Each count was completed in one day. Data were collected as per the animal census form (Appendix 1). From monthly data, the number of groups in each class sizes (lone animal, pair, 3-10, 11-20, 21-50, 51-100, >1000) were recorded.

2.2.2. Population structure

During total counting, detailed observations of the entire herd were made, which enabled to categorize them into their respective age groups. The categories used were calf, subadult and adult. Sex was distinguished for adults whenever possible.

Clues to age were provided by body size and horn sizes. The primary sexual characteristics such as the presence of penis sheath, scrotum or udder were used to determine the sex as described by Wilson *et al.* (1996).

2.2.3. Group size

During each total count, the location of every group of Beisa oryx was plotted on the map of the study areas (Lewis and Wilson, 1979; Hillman, 1987). Individuals were considered as members of the same group if the distance between them was less than 50m as used in Borkowski and Furubayashi (1998). Groups were defined as individuals being within 50m of their nearest neighbour.

Group size data from all observations were collected and tabulated for each month, and means for monthly group size and standard errors were calculated.

2.2.4. Distribution and vegetation type utilization

To assess the distribution pattern and the diurnal utilization of each vegetation type, data from the break down of the total counts were used. The location of each herd and the vegetation type at each location were recorded. This could give seasonal distribution and vegetation utilization of each herd (Norton-Griffiths, 1978). Taking group sightings as scores with respect to habitat types and comparing their frequencies to the relative availability of vegetation types. Besides this, footprints, dropping and feeding sign were observed to find out their distribution in ANP and AWR.

2.2.5. Movement and Home range

Data on movement and home range size were obtained from the group observation of the groups of Beisa oryx in ANP only. All the groups were located two times in 24 hours for the observational seasons following the method of Wilson *et al.* (1996). A number of naturally recognizable individuals (broken legs, broken horns, etc), group size, and composition of animals permitted identification of a group of Beisa oryx as was adopted by Leuthold (1972) for buffalo. The technique used in mapping home range was by checking the movement and location of animals. The location of an animal on the ground was approximated on the map and then transferred to a working map of the same scale (1:50,000) with 1km grid as was adopted by Murray (1982).

The size of home range for the animal was calculated by Minimum Convex Polygon (MCP) method. The boundary of home range was obtained by connecting the most peripheral locations where the members of a group have been seen, following the method of Massei *et al.* (1997). Movement and home range study was performed only in ANP.

2.2.6. Diurnal activity patterns

Santiapillai *et al.* (1999) and Irby (1982) used a 5-min. recording interval when studying activity of wild ass in SriLanka and Chanler's mountain reedbuck in Kenya, respectively. This interval had also been used by Berihun Gebremedhin (2002) when recording the activity of Sommering's gazelle. The proportion formed by the records of each activity within a period (generally 12h) has been converted to a length of time in hour (*i.e.* activity was summed by hour to obtain frequency data).

For the present study, Beisa oryx activity was divided into feeding (noting whether the animal was browsing or grazing); standing and lying (resting); walking; and "other", which included all other activities such as fighting, drinking, etc. A recording sheet was prepared with a column for each activity and a remarks column for detailed behaviour notes (Appendix 2). At every five-minute interval the appropriate activity was ticked off on the sheet.

Selected animals were observed continuously from 0600h to 1800h for each of four consecutive days. All observations were carried out from 100-200m from a vehicle, using binoculars. Data were collected using the "focal sampling" technique (Altman, 1973). The study of activity patterns of Beisa oryx was done only in ANP. ANP was selected due to the ease to observe the Oryx.

4.3. Data analysis

Statistical package (soft ware) used to analyze the data was SPSS (SPSS INC. Version 10, 2000). Descriptive graphs, Levine's statistic (test of homogeneity of variance, comparison of means using Analysis of Variance (ANOVA), t-test for independent samples, paired samples t-test, Pearson's/ spearman's correlation co-efficient were used.

3. RESULTS

3.1. Population census

During the study it was observed an Average of 335 individuals in the selected study site at AWR and 220 individuals at Illala Sala in ANP (Table 3). A mean group size of 17.6 individuals in the selected study site at AWR and 13.9 individuals at Illala Sala in ANP (without including single individuals) (Table 1 and 2). Mean group size of 11.2 and 18.3 (without including single individuals) were counted during dry and short rainy season's censuses respectively, in ANP (Table 3). There was marked difference in the mean group size of Beisa oryx counted in the dry and short rainy season ($P=0.04$). Similarly mean group size of 13.2 and 20.9 of Oryx individuals were recorded in AWR during the dry and short rainy season (Table 3). At AWR there was no significant difference between the two seasons ($P=0.106$). The total count in the selected study site at the AWR cannot be used to estimate the total population of Beisa oryx in the reserve, since the survey did not include the total area and since there is no uniform distribution of the animal in AWR. However, the total count at ANP can be taken as the total estimate for the whole park, because virtually no Oryx population is left in the previous ranges of the species, as determined from the repeated survey of the areas.

Table 1: Mean group size of Beisa oryx in Awash National Park

Sex/Age	Mean \pm S.E
Male	1.4 \pm 0.3
Female	7.8 \pm 0.9
Subadult	1.5 \pm 0.3
Calf	1.2 \pm 0.3
Unidentified	2.0 \pm 0.8
Mean group size of Beisa oryx	13.9 \pm 2.6

3.2. Group size

The differences in mean group sizes of Beisa oryx between the two study sites show that the differences are not significant. However, they were found to be significant for mixed herds ($P=0.008$) (Table 4 and 5). Comparison of the frequency of group sizes of Beisa oryx in different habitats is based on the encounter of Oryx during the total count, not on samples of equal area sizes from each habitat types.

Adult male Beisa oryx were territorial for the study months. Many of the adult males in the study were individually recognizable.

Table 2: Mean group size of Beisa oryx in Alledoghi Wildlife Reserve.

Sex/Age	Mean \pm S.E
Male	1.5 \pm 0.3
Female	7.1 \pm 0.9
Subadult	2.3 \pm 0.5
Calf	0.9 \pm 0.2
Unidentified	5.8 \pm 2.0
Mean group size of Beisa oryx	17.6 \pm 3.9

3.2.1. Local Variation in group size

Group size data recorded from the two study areas were treated separately. From the records, it was found that mean group size for ANP was 13.9 ± 2.6 . The mean group size for AWR was slightly higher, reflecting the high population of Beisa oryx in the area and the wide range of group size (Table 2).

The data for ANP and AWR showed that real difference in monthly mean group size did not exist. The difference in mean group size between the two localities was not significant (Table 1 and 2).

3.2.2. Seasonal Variation in group size

Due to the difference in the duration of seasons, records include unequal proportions of short wet season and longer dry season data. In grassland in ANP between the two seasons showed slightly significant difference ($P=0.047$). The differences between the group sizes observed in shrub grassland and wooded grassland in ANP were not significant. Similar comparison of change in group size for habitats in AWR between the two seasons showed no marked difference for all habitats.

3.3. Group structure

From the recorded data, six group types were distinguished

- 1) Single male
- 2) Male-Female group
- 3) Female group
- 4) Male-Female-calf
- 5) One adult male & females, with or with out calves/sub adults.
- 6) Mixed groups consisting of adult males, adult females, sub adults and calves

A total of 1352 sightings of Beisa oryx were made in 158 observations in ANP, in which 1174 animals were classified (Table 3). Of the 158 observations, 60 (or 38%) were solitary animals, predominantly adult males. The next category comprising female group individuals accounted for 19.6% of the observations. The biggest family group observed was of 104 individuals. Female groups were observed every month, and their size range from 2 to 12. The number of adult males per group ranged from 0 to 15.

Similarly, a total of 1673 sightings of the species were made in 141 observations in AWR, in which 1138 animals were classified (Table 3). Of the 141 observations in AWR, 38 (27%) were paired animals, mainly male-female pair. The next category comprising solitary males accounted for 26% of the observations. The biggest family group observed consisted of 100 individuals. Like in ANP, female groups were observed every month, and their size ranged from 3 to 18. The number of adult males per group ranged from 0 to 18.

The main social bond observed was that between the female and her calf. There can also be a positive link between a dominant male and the remainder of his harem.

Table 3: Number of sightings of sex/age category and groups of Beisa oryx in the two study sites, Awash National Park (Illala Sala) and Alledoghi Wildlife Reserve

Age/sex wise sightings of Beisa oryx during the study period													
Illala Sala								Alledoghi Wildlife Reserve					
Age/Sex	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Nov	Dec	Jan	Feb	Mar	Mean
M	30	30	29	16	40	38	31	39	33	30	40	33	35
F	147	118	98	120	108	125	119	152	127	118	153	110	132
SA	23	23	20	21	21	24	22	17	68	42	44	47	47
C	8	20	15	15	24	30	19	13	17	13	28	14	17
Un	45	35	38	30	30	0	30	65	165	70	140	95	107
T	253	226	200	202	223	217	220	286	410	273	405	299	335
X	10.1	7.5	8.3	5.3	8.9	13.6	9.0	8.7	14.1	8.5	15	15	12.3
G	25	30	24	38	25	16	26	33	29	32	27	20	28

(M-male, F-female, SA-sub adult, C-calf, Un-un identified, T-total, X-mean group size and G-number of groups)

Table 4: Mean group size of Beisa oryx in Awash National Park (in mixed group)

Sex/Age	Mean \pm S.E
Male	3.4 \pm 0.7
Female	13.1 \pm 2.3
Subadult	4.2 \pm 0.8
Calf	2.6 \pm 0.6
Unidentified	6.1 \pm 2.5
Mean group size of Beisa oryx	29.4 \pm 6.9

Table 5: Mean group size of Beisa oryx in Alledoghi Wildlife Reserve (in mixed group)

Sex/Age	Mean \pm S.E
Male	3.4 \pm 0.9
Female	17.7 \pm 2.2
Subadult	8.1 \pm 1.5
Calf	2.7 \pm 0.6
Un identified	17.4 \pm 6.5
Mean group size of Beisa oryx	49.3 \pm 9.7

3. 4. Age & Sex Structure

In ANP, the mean number of adult males, adult females and subadults did not show significant difference between the two seasons. However, the mean number of calves showed slightly significant difference between two seasons at 0.05 level of significance ($P=0.039$) (Table 6). On average adults made up about 80.2% of the population. The proportion of the subadult and calves in the classified total were 10.6% and 9% respectively. The observed sex ratio among males and females range from 1:2.7 in February to 1:7.5 in January with an over all mean number of 1:3.9 (Table 3). This indicates unequal mean longevity among males and females.

Similarly, in AWR, the mean number of males, females and subadults did not show significant differences between the two seasons. However, the mean number of calves showed significant difference between two seasons at 0.05 level of significance ($p=0.014$). On average, adults made up about 73.4% of the population. The proportion of subadults and calves in the classified total were 19.2% and 7.5% respectively. The observed sex ratio among adult male and females range from 1:3.3 in March to 1:3.9 in January (Table 3). In dry season, the mean number of males, females, subadults and calves did not show any significant difference between the two sites. However, in wet season the mean number of subadults showed significant difference at 0.05 level of significance ($P=0.008$) between them.

Table 6: Age/Sex structure of Beisa oryx in dry and short rainy seasons in Awash National Park.

Age/Sex structure	Number of animals (Mean± S.E)	
	Dry season	Short rainy season
Adult male	26.3 ± 3.4	39.0 ± 1.0
Adult female	120.8 ± 10.1	116.5 ± 8.5
Subadult of both sex	21.8 ± 0.8	22.5 ± 1.5
Calf	14.5 ± 2.5	27.0 ± 3.0
Total	183.4 ± 16.8	205 ± 14

The age and sex of individuals counted during the census of six months in ANP and five months in AWR, is given in table 6 and 8 respectively. Mean number of adults, subadults and calves varied in the seasons. Adults, subadults and calves had greater mean number in the short rainy season than the dry season (Table 6 and 8)

Sex Ratio

The Adult sex ratio calculated is shown in Table 7 and 9. These show that there is an unequal sex ratio in the population; the females during dry and short rainy season are more numerous than the males in both study areas.

Table 7: Sex/Age ratio of Beisa oryx in dry and short rainy seasons in Awash National Park.

Sex/Age category	Sex/age ratio	
	Dry season	Short rainy season
Male: Female	01:4.6	01:3.0
Subadult: Adult	01:6.8	01:6.9
Calf: Adult	01:10.1	01:5.8
Calf: Others	01:14.2	01:7.1

Table 8: Age/Sex structure of Beisa oryx in dry and short rainy seasons in Alledeghi Wildlife Reserve.

Age/Sex structure	Number of animals (Mean± S.E)	
	Dry season	Short rainy season
Adult male	34.0 ± 0.7	36.5 ± 3.5
Adult female	132.3 ± 10.2	131.5 ± 21.5
Sub adult of both sex	42.3 ± 14.7	45.5 ± 1.5
Calf	14.3 ± 1.3	26.0 ± 2.0
Total	222.9 ± 26.9	239.5 ± 28.5

Table 9: Sex/Age ratio of Beisa oryx in dry and short rainy seasons in Alledoghi Wildlife Reserve.

Sex/age	Sex/age ratio	
	Dry season	Short rainy season
Male: Female	01:3.9	01:3.6
Subadult: Adult	01:3.9	01:3.7
Calf: Adult	01:11.6	01:6.5
Calf: Others	01:21.6	01:12.7

3. 5. Distributions and vegetation type utilization

The relative use of different vegetation communities by Beisa oryx is indicated by the number of animals observed in each vegetation communities during the monthly observation periods (Table 10 and 11). Use of the habitat types available to Beisa oryx varied with seasons.

Table 10: Observation of Beisa oryx in different vegetation community in Awash National Park.

Month	Total count	% of observations of Beisa oryx						
		GL		SGL		WGL		
		No	%	No	%	No	%	
October	253	139	54.9	31	12.3	61	32.8	
November	226	160	70.8	28	12.4	38	16.8	
December	200	57	28.5	72	36	71	35.5	
January	202	49	24.3	31	15.4	122	60.4	
February	223	129	57.9	21	9.4	73	32.7	
March	217	190	87.6	8	3.7	19	8.8	
Average	Dry	220.3	101.3	44.6	40.5	46.7	73	36.4
	Wet	220	159.5	72.8	14.5	6.6	46	20.8

A comparison of the percentage on monthly observation of Beisa oryx to different habitat types shows that they have high preferences for grassland than other habitat types (Figure 6 and 7). During February and March most sightings were at grassland. The vegetation at AWR generally is similar to that of the ANP. The main vegetation types that are frequented by Beisa oryx were grassland, shrub grassland and wooded grassland. Comparing the distribution of the Beisa oryx in

grassland (GL), shrub grassland (SGL) and wooded grassland (WGL) habitats showed that there were no significant differences in the frequency of group sizes between the two sites.

Table 11: Observation of Beisa oryx in different vegetation community in Alledeghi Wildlife Reserve.

Month		Total count	% of observations of Beisa oryx					
			GL		SGL		WGL	
			NO	%	NO	%	NO	%
November		286	83	29.0	15	5.2	188	65.7
December		410	332	80.98	15	3.7	63	15.4
January		273	193	70.7	42	15.4	38	13.9
February		405	386	95.3	15	3.7	4	0.99
March		299	248	82.9	15	5.0	36	12.0
Average	Dry	323	202.7	60.2	24	8.1	96.3	31.7
	Wet	352	317	89.1	15	4.4	20	6.5

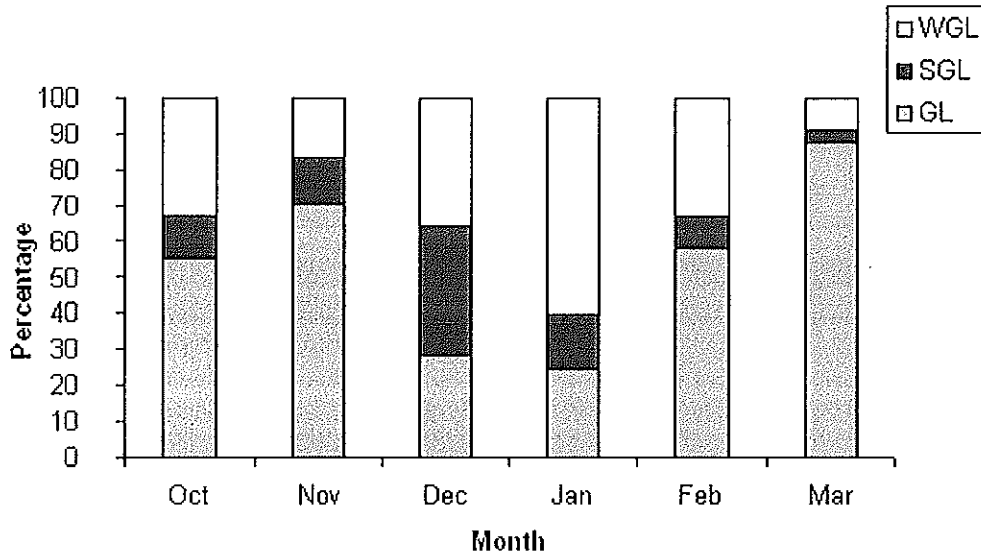


Figure 6: Percentage of monthly distribution of Beisa oryx in different habitats in Awash National Park

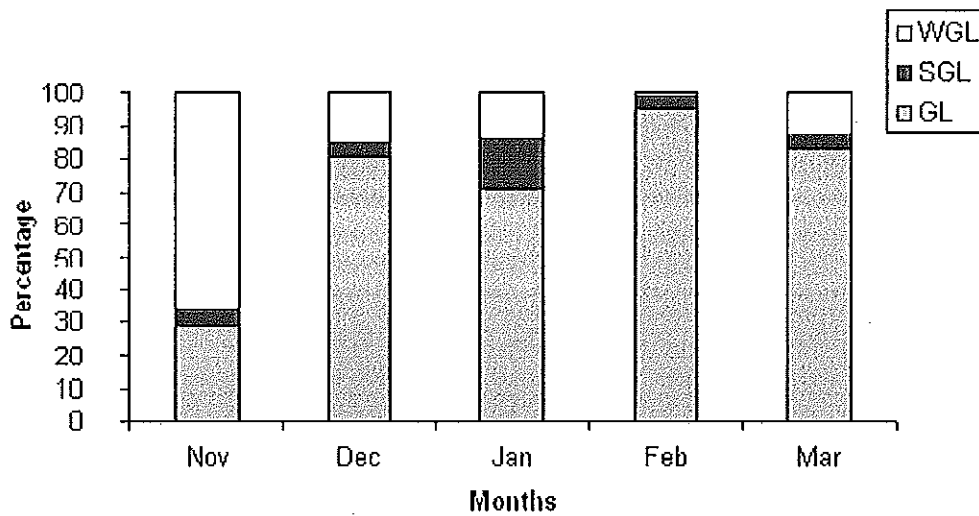


Figure 7: Percentage of monthly distribution of Beisa oryx in different habitats in Alledoghi Wildlife Reserve

Differences existed between habitats in the distribution of group sizes or in the distribution of number of Beisa oryx. The result of analysis for the distribution of Beisa oryx at GL and SGL

was found to be significant ($p= 0.003$ and 0.025 , respectively). However, there was no marked difference between the two sites for wooded grassland.

The changes in the distribution of habitat preference in the two seasons of AWR showed no significant difference. However, there was slightly significant difference in the group sizes in GL habitat of ANP in the two seasons ($P=0.047$).

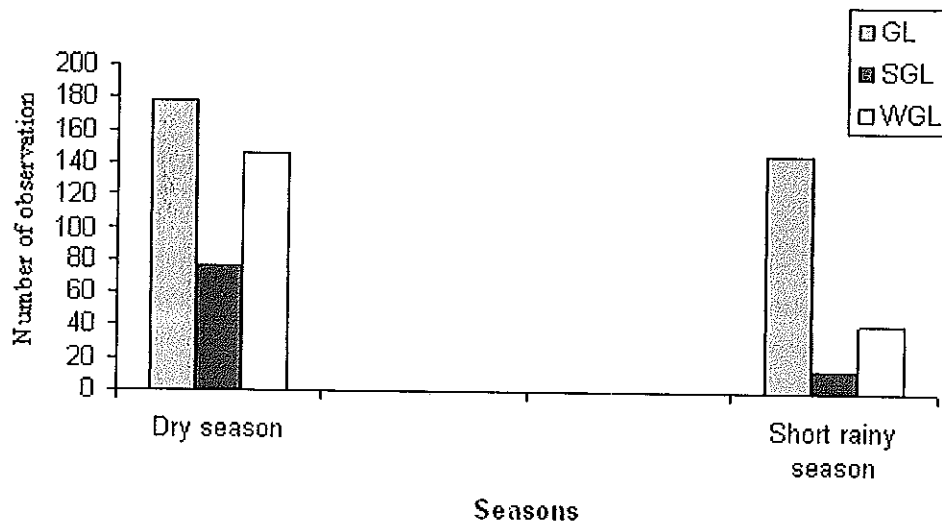


Figure 8: Number of Beisa oryx observed during the present study period in different habitat types in Awash National Park.

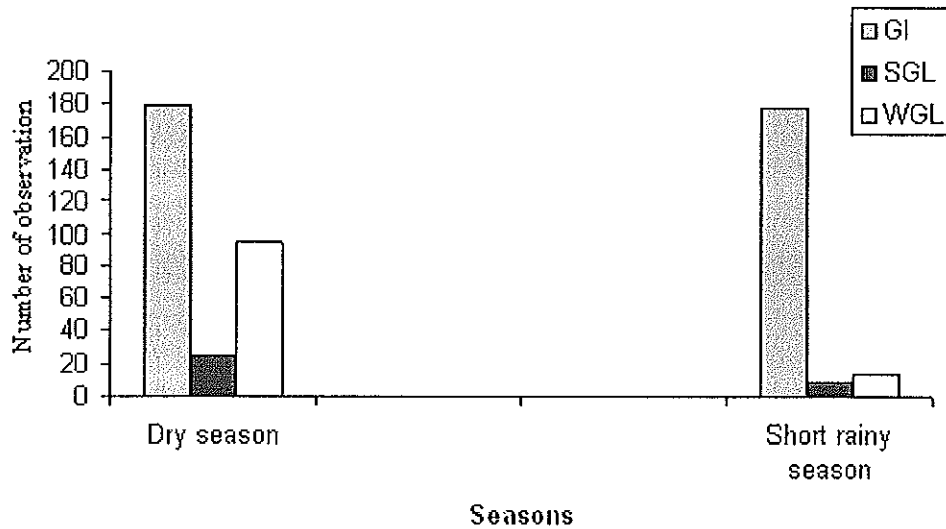


Figure 9: Number of Beisa oryx observed during the present study period in different habitat types in Alledoghi Wildlife Reserve.

3. 6. Movement and Home range

The home range size estimated by MCP method varied between the seasons. The proportion of home range is considerably greater during the dry season (31km²). In the wet season, when the plain grasses sprout, the Beisa oryx tends to aggregate (*i.e.* form bigger groups of up to 104 individuals) instead of moving and occupying wider areas. The estimated home range for the species in the short rainy season was about 25km²

The Beisa oryx were observed to move considerable distances in the direction of the adult female. They were observed to walk after evening feeding peak. It was also observed that Beisa oryx nod their heads when walking fast. The solitary males often remained in the same general area for long time, spacing 0.5 to 1km among them.

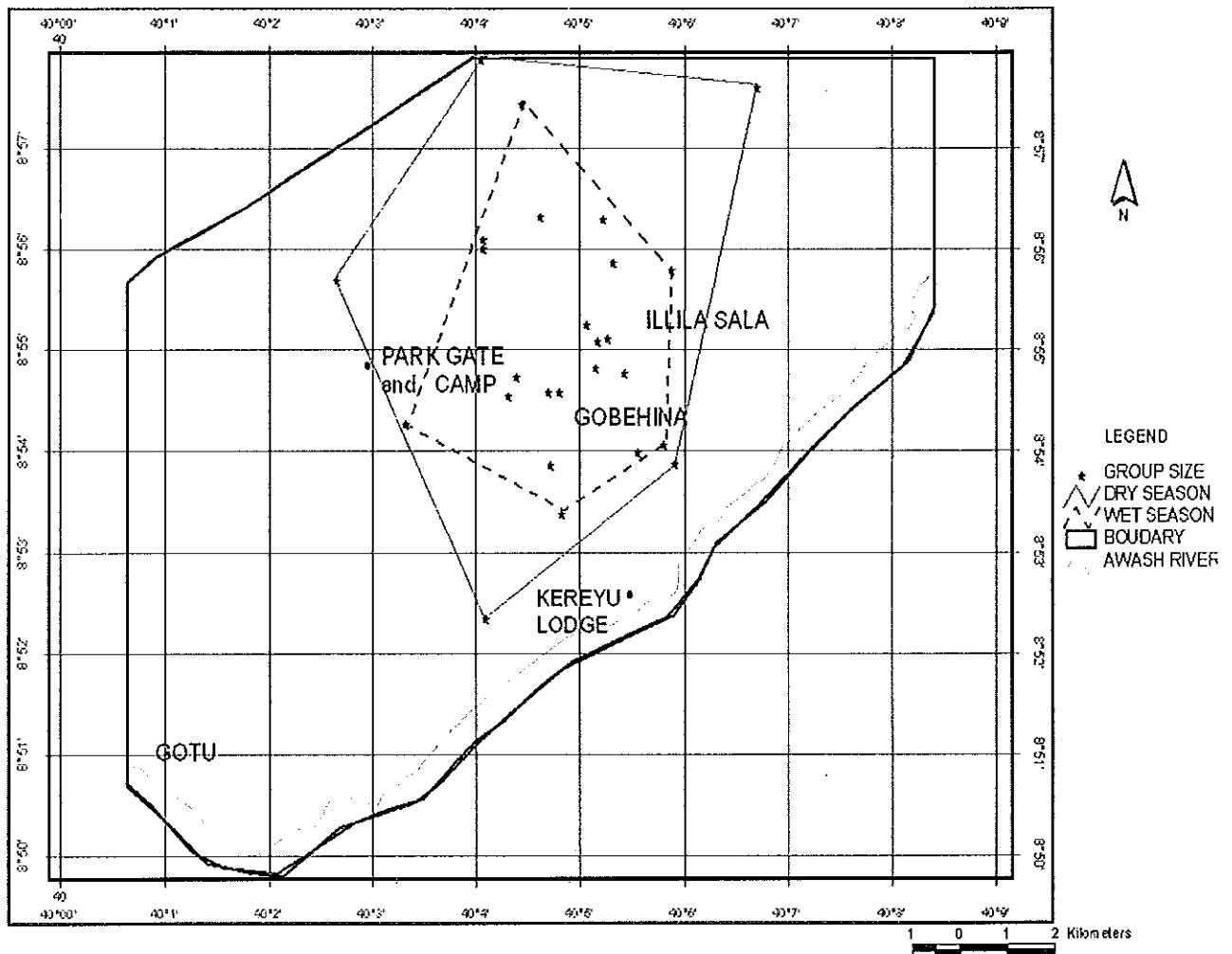


Figure 10: Dry and short rainy seasons home range size

3. 7. Activity Patterns

During the study of the activity pattern, a total of 2304 frequency of occurrences were taken between 6:00 and 18:00 hours. Groups consisting of a male, Females and calves were observed for the whole day for four days every month since December.

The data from table 12 are used to show the percentage of frequency of occurrences of activities of Beisa oryx observed at different times of the day. Feeding peaks in the early morning and late

afternoon (evening), Resting (standing or lying) increases in the middle of the day. On the average about 52.61 % of Beisa oryx daytime were spent in feeding. Figure 16 shows the feeding, standing, lying, walking and others activities according to the time of the day. The feeding may take place at all hours but there is a drastic reduction in feeding activity between 10:00 and 15:00 hours.

Table 12: Diurnal activity pattern of Beisa oryx.

Time	Frequency of occurrences of activities observed (%)				
	Feeding	Standing	Lying	Walking	Others
6:00-7:00	88.82	2.94	0	5.88	2.35
7:00-8:00	82.24	5.14	0	7.01	5.61
8:00-9:00	58.36	15.99	8.18	9.29	8.18
9:00-10:00	48.73	33.47	1.69	12.71	3.39
10:00-11:00	31.52	47.47	1.17	11.67	8.17
11:00-12:00	27.04	49.69	9.12	7.86	6.29
12:00-13:00	27.25	47.83	21.74	1.74	1.45
13:00-14:00	40.63	32.03	15.23	3.52	8.59
14:00-15:00	39.04	31.87	23.9	4.38	0.796
15:00-16:00	46.15	31.14	10.99	7.33	4.395
16:00-17:00	57.98	26.459	13.62	1.17	0.78
17:00-18:00	83.57	10.14	0	2.42	3.86
Average	52.61	27.85	8.80	6.25	4.49

There were two distinct peaks in feeding, one in the early hours of the day between 6:00 and 8:00 hours, and another in the late afternoon between 17:00 and 18:00 hours. The feeding activity drops to a slow rate before the Beisa oryx stand or lie down.

Around the middle of the day, Beisa oryx pass some hours (36.65%) in rest i.e. standing and lying down. During resting, Beisa oryx tend to stand and/or lie down more during the dry season

during than the wet season. The morning and the late afternoon activity peaks were most obvious during the dry season, with most animals remaining inactive during the noon hours, which are the hottest hours of the day.

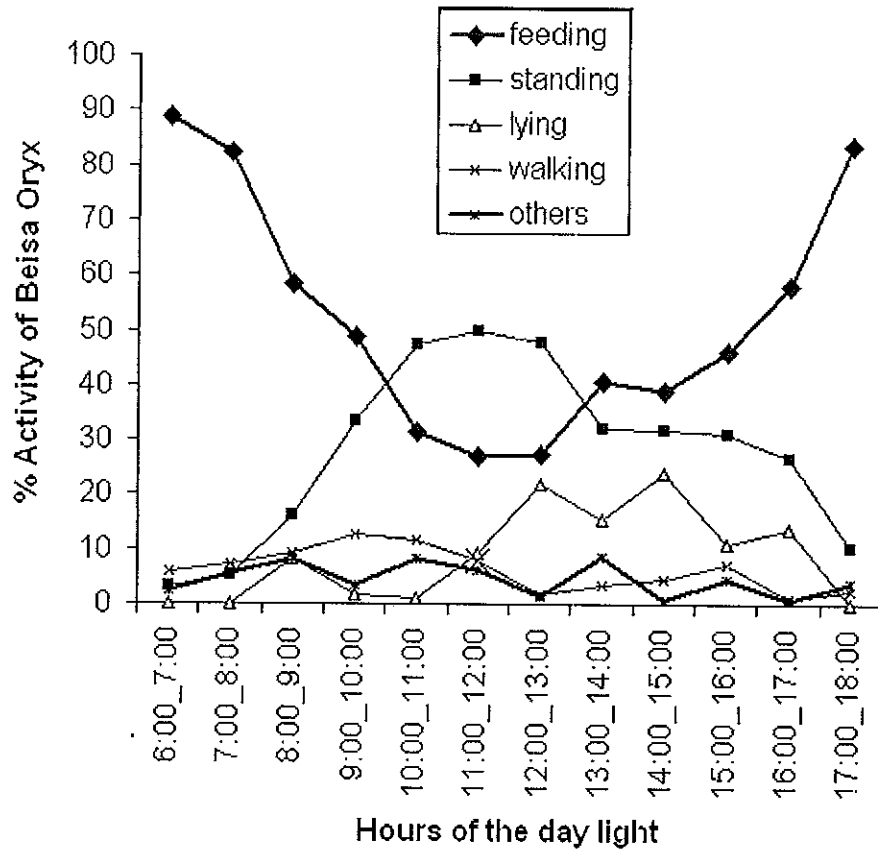


Figure 11: The activity patterns of Beisa oryx during the hours of the day

4. Discussion

4.1. Population status

Direct total count method was applied during the census of the population of Beisa oryx in ANP and AWR. This method was the most appropriate in the view of small size of the study area and the large size of the animal resulting in a reasonable degree of accuracy.

Number of Beisa oryx counted each month both in the park and the wildlife reserve range from 200 to 273 and 273 to 410, respectively, in the monthly total count. From the total count it can be deduced that some groups of Beisa oryx leave and join the study area at AWR as indicated by the number of females and subadults changing each month (Table 3). The population of this species at ANP did not show exaggerated seasonal or monthly fluctuation, as the suitable habitat is limited. There is a possibility for the population of Beisa oryx of the selected study area in AWR to move to other localities in AWR. However, local migration between the two study sites (ANP and AWR) does not seem possible due to the presence of Awash River gorge which is difficult to cross from each side.

Beisa oryx were abundant in ANP in various localities (Robertson, 1970; Schloder and Jacobs, 1993). Current assessment of these previous localities of the Beisa oryx showed that they are absent in most of their previous range. Habitat change as well as indiscriminate hunting by local people could account for this.

Water is not a limiting factor for the distribution of group sizes of Beisa oryx as they can survive the dry season with out water. The availability of green vegetation or its patchy distribution as well as over-stocking of domestic stock affect the abundance of available vegetation and hence the distribution and group size of Beisa oryx (Western, 1975).

Compared to previous surveys conducted in ANP by other workers (Robertson, 1970; Schloeder and Jacobs, 1993), the population is declining alarmingly as a result of the heavy human interference as well as road accidents.

According to local informants, illegal hunting is common in the reserve and the distribution is fragmented and uneven. Currently, the species were mainly concentrated in an area which is relatively free from the Afar and Issa pastoralists. Judging from the number of groups seen and the number of individuals in the study sites showed increase when compared to the report of Thouless (1995).

The range of distribution of Beisa oryx showed that the species at ANP is confined to the area around Illala Sala in about 174km² (Figure 2). From the repeated surveys of Beisa oryx, they have been eliminated from the previous habitats and localities in the western and northern (sabober, metehara and north of filwoha) portions of the park. The currently available habitat for Beisa oryx, Illala Sala and adjacent areas, is the relatively more protected area in the Park. Human interferences such as grazing domestic animals and hunting are relatively less pronounced than they are in the other portions of the Park. Unlike the ANP, AWR possesses large population of the species (Table 3). However, the population has declined very seriously as judging from the heavy human interference even though there is an increase compared with the figures of earlier years (Thouless, 1995). Human interference in this area is even heavier than in ANP. Part of the Beisa oryx population is found in the southern part of the plain, which is relatively free from grazing from both pastoralists.

The population of the Beisa oryx reported in the present study at Illala Sala showed a decrease from that estimated by Robertson (1970), Schloeder and Jacobs (1993) and Thouless (1995). Currently, there are only few non-domestic ungulates in both ANP and AWR, the dominant being Beisa oryx and Sommerring's gazelle. Livestock are the most numerous animals as the result of the free access that the pastoralists have to the areas, resulting in a year round grazing and trampling and thus affecting the vegetation structures of the areas.

Ungulates have the strategy of utilizing their habitats developed through their evolutionary adaptation that are not observed in domestic livestock. Cattle have lost such evolutionarily developed adaptive strategies for grazing, *i.e.* they don't have knowledge as to where to graze and when to graze. Such evolutionarily developed strategies could have enabled the Beisa oryx to use the wide areas. However, the rapid increase in domestic animals in the areas disrupts their adaptation.

4.2. Population structure

In both ANP and AWR, the mean number of calves showed significant difference in the two study sites. This may be because of peak birth of animals during the wet season. Or it may be because of failure of counting the calves in the scattered groups during dry season.

In ANP, the present sex ratio of male to female and calves to others is 1:3.6 and 1:9.6 respectively, which is not consistent with what has been reported by Robertson (1970) for the same species in Illala Sala in that male to female and calves to others was 2:3 and 1:8.3, respectively.

There was no significant difference between the two study sites in dry season in the mean number of male, female, subadult and calves. However, there was significant difference between the two study sites in the short rainy season in the mean number of subadults at 0.05 level of significance ($P=0.008$).

4.3. Social organization and group size

Beisa oryx is a social species to the extent that animals live in groups that can number from just few to hundreds. Members of these groups, however, are not always permanent. Animals, both singly or partly could leave and join the group for hours, days or weeks. Adult males are less permanently attached to a group and are the only animals to remain solitary for any period of time. They were observed to be spaced at intervals as close as 0.5-1km radius which is almost in agreement with what Robertson (1970) identified in Illala Sala in that the male home range radius 0.75-1km. The biggest family group observed consisted of 104 and 100 individuals in ANP and AWR respectively. Female groups were observed every month, and their size range 2 to 12 and 3 to 18 in ANP and AWR, respectively..

The main social bond observed was that between the mother and her calf. There can also be a positive link between a dominant male and the remainder of his harem.

Grouping in ungulates has been interpreted as having evolved to reduce the probabilities of an individual being killed by a predator (Leuthold, 1977). A small size is also an advantage in the case of animals inhabiting marginal habitats of poor productivity. If the group size were large, then the availability of forage around each individual would be reduced by the foraging of conspecifics (Jarman, 1974).

The Beisa oryx populations of the two sites (ANP and AWR) show a number of similarities and differences in their group sizes. Relatively dense cover and open grassland areas characterized the habitat occupied by Beisa oryx in ANP. Whereas the AWR Population occupied a bushy savanna region with areas of bare, moderate and dense cover and large expanses of open grassland. Both populations existed historically in the presence of the primary predators, lion and hyena.

Based on seasonal changes in food quality and quantity in the areas, one would expect the largest group of Beisa oryx to be formed during the wet season and decline throughout the dry season as the case is in impala (Murray, 1982). Beisa oryx was observed to gather into large groups when

flush of grasses appears during the rainy season in both ANP and AWR. This is in agreement with what Jacobs and Schloeder (1993) has reported in ANP for the same species.

The pattern of group size in the different habitat types in the two study areas was entirely different. Despite the highly significant difference indicated for groups in open grassland in AWR, compared to those SGL, WGL habitats, very little difference could be detected when female, male and calf groups were examined. Group size varies in relation to different habitat conditions. Data on grouping patterns of herbivores may be indicative of the effects of a changing environment (Leuthold and Leuthold, 1975), reproductive behavior (Jarman, 1974) and environmental disturbance resulting from heavy grazing, fire and other factors. Significant difference in group sizes were found in all three habitat types, and those differences persisted when group sizes were broken down into the most important categories, female, male and mixed groups. They make little change in structure as a response to change in cover density.

Ungulate species living in open habitats generally form large groups than those in bush land or forest (Jarman, 1974). It seems that the same principle also operates within this species, *i.e.* larger groups being associated with more open grassland. This would explain most of the group size differences between ANP and AWR, as the later contains more open grassland.

The density of food resources alone may explain the occurrence of small groups of ungulates in woodland habitats because of limited vegetation at forest floor, which is too sparse for a large feeding group (Owen-Smith, 1982). In open fields or grassland, food resources are more abundant and sufficient to support large feeding groups of ungulates (Hirth, 1977).

4.4. Distribution and vegetation type utilization

The vegetation type of Illala Sala can be considered predominantly a grassland with various levels of bushland, shrubland, woodland and wooded grassland being common. In the case of AWR the vegetation type is more or less similar to that of ANP. The two sites belong to the same ecological zone, are not very far from each other, and don't have significant variation in their altitudinal range. The plains are quite extensive in AWR.

Herbivores require a certain maintenance level of protein in their forage. The study made by Almaze Tadesse and Masresha Fetene (1999) showed that during wet season the biomass of the species reached their peak and the protein content of the grasses decline during the dry season and suggested that the herbivore community of the park may face shortage of nutritionally adequate food during the dry season. The growing number of human population and livestock in and around the ANP and the corresponding reduction in pastureland is expected to increase competition between domestic animals and Beisa oryx. The monthly population counts at Illala Sala and adjacent areas showed more or less uniform trend, indicating that the Beisa oryx population is becoming resident because of the absence of other suitable areas. However, the monthly fluctuation in the number of Beisa oryx in AWR is related to the movement of Beisa oryx to other areas in the plain, although we have insufficient records in these areas to detect the magnitude of this movement. Small proportion of Beisa oryx moved into wooded grassland and shrub grassland during dry season. The reason for this could be probably most of this vegetation community is found in woody cover which probably help the grass not to be dry and thus be more palatable. Feeding on this vegetation community in the woody cover may help to overcome the heat in the dry season, which is important to conserve body water loss that can be additional reason for more utilization of SGL and WGL community.

The distribution and utilization of different habitats by large mammals can be determined by climatic conditions (Pennycuick, 1975; Kutilek, 1979). The distribution or feeding habit of Beisa oryx showed a very high utilization of short grass in each vegetation communities. The reason for the Beisa oryx utilization of short and medium grass areas might be to avoid the unpalatable tall grass (Personal observation).

Personal observations indicated that Beisa oryx didn't drink water in both seasons. However, interview made with local people indicated that Beisa oryx drank water between 11:00 am and 13:00 pm. The observation made suggested that Beisa oryx is primarily a grazer.

4.5. Movement and home range

The home range size estimated by MCP method varied between seasons. The proportion of home range, which is utilized, is considerably smaller during the wet season (about 25 km²) because of the availability of palatable grasses all over the plain, and they gather to form big groups. In dry season, they tend to occupy greater range of about 31 km² to overcome the shortage of palatable grasses which are dried. From this, it is possible to state that without humans and livestock, the Beisa oryx could occupy a wider home range area than expressed in Figure 10. The range area observed is not consistent with what has been reported for Swayene's hartebeest by Berhanu Gebre (2002) in that the Swayene's hartebeest range area was smaller during dry season. However, it is in agreement with what Murray (1982) identified for impala in Sengwa Wildlife Research Area in Zimbabwe and Katugaha *et al.* (1999) for elephant in Ruhuna National Park, Sri Lanka.

It was observed that Beisa oryx moved less far in the short rainy season than in the dry season which is in agreement with Jarman and Jarman (1973) has identified for impala. It was also observed that Beisa oryx inhabiting AWR are much less tolerant of vehicles and people than inhabiting in ANP (*i.e.* more likely to flee from the observer in AWR than ANP). This implies that there is more of human disturbance in AWR. One might expect that animals subject to disturbance would have greater flight distances than those living in protected areas (Katugaha *et al.*, 1999). This is true that Beisa oryx living in areas with heavy human disturbance like AWR have greater flight distances than those living in areas of relatively less human disturbance (ANP).

4.6. Diurnal activity patterns

Feeding and resting activity of animal fluctuates diurnally, but exceptions occur during sometimes of the year. The present observations suggest that activity fluctuations vary in responses to the environmental factors. The responsible variation could probably be food availability and temperature. Seasonal variations in daily activities were perhaps related to temperature, rainfall and ground plant biomass in reedbuck (Roberts and Dunbar, 1991). Diurnal activities pattern seem to be influenced by factors other than food availability and temperature.

Generally, the Beisa oryx were active at dawn and dusk. Similar findings were observed in the studies of other antelopes (Jarman and Jarman, 1973; Irby, 1982).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This study has been designed to see the population size, structure, social organization and distribution of Beisa oryx in the two study areas having different conservation status and examines those factors involved in the population decline of the Beisa oryx. It is apparent change in habitat quality, overgrazing, habitat degradation and competition with domestic livestock which are the main human induced factors for the decline of the species.

The ANP and AWR are under high pressure being used as grazing lands for pastoralists. Livestock are grazing in the area extensively. It was found that Beisa oryx, largely need short to medium sized grassland habitats. However, overgrazing by domestic livestock is destroying large areas of such habitats. Loss of ecologically important habitats would have a serious impact on the continuity and survival of breeding population. Maintaining this habitat by using ecologically acceptable measures and avoiding bush encroachment is essential. With the prevailing situations in both conservation areas, it is difficult to maintain the population size of Beisa oryx. A definite pattern, which is relating group size to habitat types exists commonly among ungulates. That relationship appears to have evolved as a means of avoiding predation and perhaps also as a means of optimizing feeding efficiency and forage production. In the absence of experiments designed to test the significance of those factors, it is difficult to assess which factor has been more significant in shaping ungulate social organization. However, all would have a considerable influence on the ecological behavior of animals at different magnitudes.

Different approaches are being forwarded regarding the means of conserving natural resources. Conservationists accept the principle that indigenous people have the right to use, own, and control their traditional territories (Mackinnon *et al.*, 1986). However, this idea is becoming difficult when it comes to implementation with the current human pressure (Spinage, 1998). Ecologists are arguing that all people constitute a threat to nature due to dual problems of population increase and the adoption of new technologies. These problems are prevalent in the

study areas. Effective management of Beisa oryx and other wildlife resources can be realized only if the current pressure on the conservation areas is controlled and when the pastoralists are provided with legal rights to use the resource at a limited level that are compatible with the ecology of the areas and participate them in its conservation and management.

The large ungulates of the conservation areas require substantial conservation and research attention. Reviewing past literatures (Robertson, 1970; Schloeder and Jacobs, 1993) on the population dynamics of the mammal populations of the park, and comparing them with current situations of the areas indicated that the Beisa oryx population and habitat quality are declining. Many factors could be used to account for this consequence. Overstocking of the ranges by domestic livestock and illegal hunting could be cited as the main factors.

The distribution and utilization of different vegetation communities by Beisa oryx could be explained in terms of seasonal changes. During the dry season, resources were scarce and the animals scattered all over the areas; most of them in the SGL and WGL habitats. As the short rainy season progressed, however, the animals had restricted their distribution in GL habitats is in contrary to what has been reported by Kingdon (1982) for most *Alcelaphinae*, Yakub (1999) for hunters' hartebeest and Berhanu Gebre (2002) for Swayne's hartebeest. However, it is in agreement with what has reported by Jacobs and Schloeder (1993) for the same species in ANP, and by Befekadu Refera and Afework Bekele (2004) for mountain nyala in Bale Mountains National Park. It is possible to conclude that the vegetation type for food and shelter is decisive to determine the distribution and vegetation type utilization of Beisa oryx. However, the degree of disturbance by livestock, harassment and poaching by the local people seems to contribute much in their distribution at all seasons.

Some of the observed changes in group size with seasons coincided with changes in habitat use patterns. Comparatively largest group sizes were recorded during the short rainy season when large percentage of animals was observed in grassland. The largest mean group size was recorded on grassland habitats in the short rainy season.

The diurnal activity of *Beisa oryx* seemed to depend on climatic condition. The time devoted to feeding was highest in the early morning and the late afternoon hours and it was minimum in middle of the day. On the contrary, standing and lying were highest in the mid day. The activity pattern of mammals is correlated to their daily mode of life. It may be influenced by wide range of factors such as food availability, climatic conditions, nutritive demand and protection from predation (Delany and Happlod, 1979).

The present study showed an average of only 220 and 335 individuals of *Beisa oryx* in ANP and AWR, respectively. Compared to previous estimates, for example, 4020 individuals by Robertson (1970), and the present number is alarmingly low. The reason for their low number seems to be mainly poaching and overgrazing. The situation at AWR at present is precarious from the *Beisa oryx* and other Wildlife's point of view and it is felt that there is no long-term future for the animals in their natural ranges. The small proportion of young of *Beisa oryx* indicated the decline in population and therefore the presence of problem in the areas.

Records made by Robertson (1970) and, Schloeder and Jacobs (1993) indicated that *Beisa oryx* were abundant at the park. During the surveys of this study, it was observed that there was a substantial decline in the populations of the species in and around the park and a concurrent decline in their distributions. The subpopulations of the northern, western and southwestern parts of the park have lost their quality as important habitats for *Beisa oryx*. Recent observations show that the population is totally absent from these areas, and they are confined to a very small area in the southern part of the park.

It was observed that the home range size of *Beisa oryx* is considerably greater during the dry season (31km^2) than the short rainy season (25km^2). This is partly due to the limited distribution of short grassland habitat favored by the species. They were observed to move considerable distances in the direction dictated by the Alpha female. It was also observed that the species moved less far in the wet season than in the dry season. The species in the Alledeghi wildlife reserve have greater flight distance than those living in the protected area in ANP.

5.2. Recommendation

The future of the Beisa oryx cannot be considered secure in the long term in both the National Park and Wildlife Reserve with the present wildlife management. The species survival problem has been aggravated with the increase of human need. In many cases, the root causes can be traced to habitat changes brought by man. The species is being forced to occupy unsuitable or suboptimal habitats. It is obvious that attempts to preserve these species for future generations will entail a greater commitment to habitat securement and conservation than has higher to been the case.

Based on the findings of this study, some fairly obvious and logical recommendations for the future conservation and management of these diminishing species can be made.

- Further and continuous studies of ecological problems are required to exactly pin point the causes for the population decline of the species.
- Open grassland habitat constitutes the major area of preference of the Beisa oryx. Measures of controlling the invasion of the plains by bush encroachment should be undertaken.
- Effectiveness of conservation measures that are to be taken should be monitored and assessed at every step.
- Local people should be given conservation education on sustainable utilization of natural resources and importance of conservation areas, to create awareness on the value of biodiversity.
- The park management should form strong link with the police authorities and judiciary body in order to control illegal hunting and misuse of the resource and strengthening law enforcement.
- Communities and other stakeholders should collaborate in the effective management of ANP and surrounding areas.
- The range available to wild mammals should be increased by reducing the density of livestock populations in both study areas.

REFERENCES

- Almaz Tadesse and Masresha Fetene (1999). Biomass production and nutrient status of three tropical range grass species in ANP. *Sinet: Ethiop. J. Sci.* **22**:89-111.
- Altman, J. (1973). Observational study of behavior: Sampling methods. In: *Foundations of Animal Behavior: Classic Papers with Commentaries* (Houck, L. D. and Drickamer, L. C. eds., 1996). The University of Chicago Press. pp: 177-217.
- Ansell, W. F. H (1977). Oryx. In: *The Mammals of Africa: An identification Manual*. (Meester, J. and Dippenaar, N. J. eds.) Smithsonian Institutional Press, Washington, D. C.
- Befekadu Refera and Afework Bekele (2004). Population status and structure of mountain nyala (*Tragelaphus buxtoni*) in the Bale Mountains National Park, Ethiopia. *Afr. J. Ecol.*, **42**:1-7
- Began, M., Harper, J. L. and Townsend, C.R (1986). *Ecology. Blackwell Science*. London. 3rd ed
- Berhanu Gebre (2002). Some patterns of population dynamics and distribution of Swayne's Hartebeest (*Alcelaphus buselaphus swaynei*) in Senkele Swayne's Hartebeest Sanctuary. Proceeding of A workshop organized by Biological Society of Ethiopia on The wildlife conservation areas of Ethiopia: Current status and future prospects. Biological Society of Ethiopia, Faculty of Science, AA, Ethiopia.
- Berihun Gebremedhin (2002). Population status and some ecological aspects of Somme ring's gazelle in ANP and AWR, Ethiopia. Unpublished MSc. Thesis. AAU, Ethiopia.
- Borkowski, J. and Furubayashi, K. (1998). Seasonal and diet variation in group size among Japanese Sika Deer in different habitats. *J. Zool. Lond.* **245**, 29-34
- Caughley, G. (1977). *Analysis of vertebrate population*. John Wiley and Sons. NY.
- Caughley, G. and Sinclair, A. R. E (1994). *Wildlife ecology and management*. Blackwell Science. London.
- Cherie Enawgaw (2004). Population status and distribution of artiodactyls in Awash National Park with special reference to Beisa oryx. Unpub. MSc. Thesis. AAU, Ethiopia.
- Columbia Encyclopedia (2001). *Six editions*. Columbia University Press.
- Corbet, G. B. (1978). *The mammal of the palaeartic region: a taxonomic review*. British museum (Natural history), London.
- Daniel Gemechu (1977). *Aspects of climate and water budget in Ethiopia*. AAU, AA, Ethiopia.

- Delany, M. J. and Happold, D. C. D. (1979). *Ecology of African mammals*. Longman, London.
- Duncan, P. (1983). Determinants of the use of habitat of horse in a Mediterranean Wetland. *J. Ani. Ecol.* **52**:93-109
- Durant, S. M., Caro, T. M., Collins, D. A. and Fitz Gibbon, C. D. (1986). Migration patterns of Thomson's gazelle and Cheetahs on the Serengeti Plains. *Afr. J. Ecol.* **26**: 17-33.
- East, R. (1984). Rainfall, soil nutrient status and biomass of larger African savanna mammals. *Afri. J. Ecol.* **22**: 245-270.
- East, R. (1996). *Antelope surveys update* Number 3. IUCN/ SSC Antelope specialist group report.
- East, R. (1997). Ethiopia. *Antelope survey update*, **6**:23-49.
- Eberhardt, L.E, Hanson, E. E and Cadwell, L. L. (1984). Movement and activity patterns of Mule deer in the Sagebrush-steppe region. *J. Mamm.*, **65**:404-409.
- Estes, R. D. (1991). *The behavior Guide to African mammals*. University of California Press. Berkley and Los Angeles, California, USA.
- Ethiopia Wildlife Conservation Organization/ Centre for American Relief Everywhere (EWCO/ CARE) (2001). *Awash National Park: Arial survey report*. EWCO, Addis Ababa
- Fried, L. R. (1975). Climate and food habits of ungulates on Galena ranch. *E. Afri. Wildl. J* **13**:203-220
- Hanley, T. A. (1982). Cervid activity patterns in relation to foraging constraints. In: Seasonal and diet variation in group size among Japanese Sika deer in different habitats. *J. Zool. Lond.* **245**:29-34
- Hillman, J. C. (1987). Group size and association patterns of the common eland (*Tragela aphas oryx*). *J. Zool.*, SOC. London. **213**:641-663
- Hillman, J. C. (1993). *Ethiopia*. Compendium of wildlife conservation information. EWCO, NYZS.
- Hirth, D. H. (1977). Social behavior of white-tailed Deer in relationship to habitat. *Wildl. Mono.* No.53. Pp 1-53.
- Huass, H. (1961). *Mammals of the world*. Methuen and Co LTD.11, New Fetter lane, E, C.4, London.
- International Union for the Conservation of Nature and Natural resources (IUCN) (1996). *IUCN category conservation dependent*, Comb ridge, U.K.

- Irby, L. R. (1982). Diurnal activity and habitat use patterns in a population of Chanler's mountain reedbeek in the Rift Valley of Kenya. *Afr. J. Ecol.* **20**:169-178
- Jacobs, M. J. and Schloeder, C. A. (1993). *The Awash National Park management plan 1993-1997*. EWCO, Addis Ababa.
- Jarman, M. V. and Jarman, P. J. (1973). Daily activity of Impala. *E. Afr. Wildl. J.* **11**:75-92.
- Jarman, P. J. (1974). The social organization of antelope in relation to their ecology. *Behavior* **48**:215-267.
- Katugaha, H. I. E.; de Silva, M. and Santiapillai, C. (1999). A long-term study on the dynamics of the elephant (*Elephas maximus*) population in Ruhuna National Park, Sri Lanka, *Biol. Cons. J.*, **89**:51-59
- King, J. M, Kingaby, G. P, Colvin, J. G and Heeth, B. R (1975). Season variation in water turn over by *Oryx* and eland on the Galana Game Ranch. *E. Afr. Wildl. J.* **13**: 287-296.
- Kingdon, J. (1982). *East Africa Mammals. An atlas of evolution in Africa*. Volume-III Part-D (Bovids). Academic Press, London.
- Kingdon, J. (1997). *The Field Guide to African Mammals*. Academic Press. London.
- Kutilek, M. J. (1979). Foraging habitat of non-migratory African ungulates in response to seasonal rainfall. *J. Wildl. Manag.*, **43**: 899-908
- Lamprey, H. F. (1994). Ecological separation of the large mammal species in the Tarangire Game Reserve, Tanganyika, *E. Afri. Wildl. J.* **1**: 63-92.
- Leuthold, W. (1972). Home range, movements and food of a buffalo herd in Tsavo National Park. *E. Afr. Wildl. J.* **10**: 233-243.
- Leuthold, W. (1977). *African ungulates: A comparative review their ecology and behavioral ecology*, Springer-Verlag, Berlin.
- Leuthold, W. and Leuthold, B. M. (1975). Patterns of social grouping in ungulates of Tsavo National Park, Kenya. *J. Zool.* **175**: 405-420
- Lewis, J. G. and Wilson, R. T. (1979). The ecology of Swayne's hartebeest. *Biol. cons.*, **15**: 1-12.
- Mackinnon, J., Mackinnon, K., Child, G. and Thorsol, J. (1986). *Managing protected Areas in the tropics*. The international union for the conservation of nature and natural resources, Gland, Switzerland.

- Massei, G.; Genove, P. V.; Stainess, B. W. and Gorman, M. L. (1997). Factors influencing home range and activity of Wild boar (*Sus scrofa*) in a Mediterranean coastal area. *J. Zoo. Soc. Lond.*, **242**:414-423
- Murray, M. G (1982). Home range, dispersal and the clan system of impala. *Afri. J. Ecol.*, **20**: 253-269.
- Negarit Gazeta (1969). *An order to provide for the establishment of Awash National Park*, No54 of 1969, order No 4 (6 January).
- Norton-Griffiths, M. (1978). *Counting animals, 2nd ed.* Africa Wildlife leadership, Nairobi, Kenya.
- Owen-Smith, N. (1982). Factors influencing the consumption of plant products by large herbivores. *In: Ecology of Tropical savanna* (Eds. B. J. Huntley and B. H. Walker). Springer-Verlag, New York.
- Pennycuik, L. (1975). Movement of the migratory wildebeest population in the Serengeti area between 1960 and 1973. *E. Afri. Wildl. J.* **13**:65-87.
- Roberts, S. C. and Dunbar, R, I. M. (1991). Climatic influences on the behavior ecology of chanler's mountain reed buck in Kenya. *Afr. J. Ecol.* **29**:316-329
- Robertson, I. J. M. (1970). *Awash National Park: A working plan.* EWCO, Addis Ababa.
- Sanderson, G. C. (1966). The study of Mammal movements-a review. *J. Wildl. Manage.* **30**:215-235.
- Santiapillai, C.; Wijeyamohan, S. and Ashby, K. R. (1999). The ecology of a free living population of the ass (*Equus africanus*) at Kalpitiya, Sri Lanka. *Biol. cons. J.* **91**:43-53
- Spinage, C. A (1998). A reply to Colchester. *Oryx.* **33**: 2-8
- SPSS institute (2000). SPSS on line help. Release version 10.0 SPSS Company, USA.
- Taylor, C. R (1969). The elad and Oryx. *Sci. Ame.* **220**:88-95.
- Thouless, C. R. (1995). *Aerial survey for wildlife in Eastern Ethiopia.* Report to EWCO. Ecosystem consultant. London.
- Walther, F. R (1978). Behavioral observations on Oryx antelope (*Oryx beisa*) invading Serengeti National Park, Tanzania. *J. Mamm.*, **59**:243-260.
- Western. (1975). Water availability and its influence on the structure and dynamics of a savanna large mammal community. *E. Afr. Wildl. J.* **13**:265-288

- Wilson, D. E.; Cole, F. R.; Nichus, J. D.; Rudran, R. and Foster, M. (1996). *Measuring and monitoring biological diversity: Standard method for mammals*. Smithsonian Institution Press, Washington.
- World Conservation Monitoring Center (WCMC) (1991). *Biodiversity guide to Ethiopia*. Cambridge, UK
- Yakub, M. D. (1999). Population size and seasonal distribution of the hirola (*Damaliscus hunteri*). Unpubl. MSc. Thesis, Addis Ababa University.
- Yalden, D. W; Largen; M. J.; Kock, D and Hillman, J. C (1996). Catalogue of the mammals of Ethiopia and Eritrea.7 revised check lists, Zoogeography and conservation. *Trop. Zoo.* 9:73-164.

Appendix 3: Vegetation classification in Awash National Park

Vegetation type	Subtypes with notes
Grassland	Occurs on alluvial soils and on the slopes of Mt. Fentale. These areas are dominated by <i>Chrysopogon plumulosus</i> and <i>Bothriochloa radicans</i> in the lower elevations, and <i>Hypharrenia hirta</i> and <i>Themeda triandra</i> at higher elevations.
Open grassland	Similar to lowland vegetation in the 'Grassland' classification.
Low vegetation cover/soil	Soils unsuitable for vegetation or areas denuded by over exploitation.
Shrub grassland	
Shrubland	<ol style="list-style-type: none"> 1. <i>Acacia nubica</i> shrubland 2. <i>Acacia Senegal</i> shrubland 3. <i>Acacia Senegal/Acacia mellifera</i> shrubland 4. <i>Acacia mellifera</i> shrubland 5. <i>Dichrostachys cinerea</i> shrubland 6. <i>Grewia spp./Acacia spp.</i> Shrubland <p>Shrubland occurs in areas of welded tuff, andosols, regosols and solonchaks, although where grassland has been heavily grazed, shrubland may form on alluvial soils. Three <i>Acacia</i> and four <i>Grewia</i> species dominate this vegetation group, which is divided as shown above.</p>

Appendix 3 continued

<p>Bushland/Woodland</p>	<p>1. Bushland 2. Woodland</p> <ul style="list-style-type: none"> a. <i>Acacia sp.</i> b. Doum Palm Oasis c. <i>Balanites aegyptica</i> <p>Typically present on shallow alluvial and colluvial soils. Dominated by <i>Acacia sp.</i> Where Bushland becomes predominantly woodland, <i>Acacia sp.</i> May be replaced by <i>Balanites aegyptica</i>. In the north of the park around Filwoha Springs, Doum palms (<i>Hyphaene atbaica</i>) take precedence.</p>
<p>Dense tree canopy</p>	<p>1. Gallery forest 2. Acacia dense canopy</p> <ul style="list-style-type: none"> a. Acient water courses b. Seasonal flooding c. Riverine woodland d. Ravines
<p>Wooded grassland</p>	

(Source: Jacobs and Schloeder, 1993)