ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

POPULATION STATUS AND SOME ECOLOGICAL ASPECTS OF SOEMMERRING'S GAZELLE (*Gazella soemmeringi*) IN AWASH NATIONAL PARK AND ALLEDEGHI WILDLIFE RESERVE, ETHIOPIA

BERIHUN GEBRE MEDHIN

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LIST OF APPENDICES

ABSTRACT

The distribution of Soemmerring's gazelle (*Gazella soemmeringi*), which had a wide range in the East Africa, is currently dwindling with the increasing human population density in the previous range. In Ethiopia, it had a wide range in the Eastern and Northeastern part of the country. However, the population is declining, because of the loss of important habitats as a result of overgrazing, indiscriminate killing and other human factors. Field study on the population status and some ecological aspects of the species was conducted every month from January to December 2000 for eleven months in Ilala Sala (Awash National Park) and for nine months (April to December) at Alledeghi Wildlife Reserve. The result indicated that mean populations of 457.8 individuals were found in the selected study site in Alledeghi Wildlife Reserve, and 41.9 individuals were counted at Ilala Sala - Awash National Park. Grouping pattern showed that cohesion was stronger. Territorial males detain females and other members of the group. The difference in mean group sizes of the gazelle between the two areas was significant. In comparing the two populations based on the main categories the difference was not significant (p=0.795). Mean group size for ANP was 4.4 while for AWR it was 16.8 individuals. A paired-sample t-test comparison of the total frequency of categories of the group sizes for the two areas showed a significant difference (p=0.026). Local variation in group size did exist in AWR (p=0.021). But this variable showed no significant difference (p= 0.414) in ANP. Herds of 6 – 10 were most common at Ilala Sala and 20 – 50 at AWR. However, herd size ranges from 3 – 250 individuals at AWR. Comparing seasonal variations in group sizes showed no significant difference. The proportions of time budgets apportioned to the five types of activities varied among seasons and months. Feeding activity comprises much of the time budgets of Soemmerring's gazelle ranging from 39.8 to 50.7% during the dry season from 38.4 to 45.7% in the wet season in male and from 51.0 to 59.6% in dry season and from 59.8 to 64.6% in wet season in female. Distribution of group sizes in grassland habitats of the two study sites showed a very high significant difference (p=0.00). High proportion of groups of Soemmerring's gazelle was observed in short-sized grass cover in Alledeghi Wildlife Reserve, where as in Awash National Park most were observed in medium-sized grass cover. Open grassland habitat was the best preferred habitat to other.

ungulate evolves behavioral and morphological adaptations that optimize the tradeoffs between these problems. Thus, within the constraints of effective strategies against predator and successful mating, one would expect strong selective pressures towards efficient use of energy and nutrients for maintenance and reproduction. Ungulates show variation in ecological behavior in response to environmental stress through time and space. Some move to higher elevations in spring and summer in search of nutritious, new growing forage (Festa-Bianchet, 1988), while others migrate to exploit temporal differences in vegetation phenology (Berger, 1991).

Forage quality, quantity and predator avoidance influence the migratory behavior of certain mammals (Festa-Bianchet, 1988). Habitat selection by an animal reflects a strategy that enhances survivorship and successful reproduction (Bowyer *et al.,* 1998). One solution offered to explain how animals deal with conflicting needs to forage efficiently and avoid predation is selection of habitats that minimize the ratio of predation risk to available forage (Pulliam and Danielson, 1991). Conversely, such animals would tend to avoid other habitats in which predation risk is higher and value of food lower. In areas where there is an inverse linear relation between risk of predation and forage, animals would be distributed mostly in the habitat with low predation and high forage. If, however, animals are displaced from this optimal habitat, because of inter-specific competition or dominance interactions with superior individuals, sub-optimal habitats could be selected until predation become too severe or forage too limiting for them to persist (Festa-Bianchet, 1988).

Many of the life history characteristics of ungulates are shaped by risk of predation (Berger, 1991; Festa-Bianchet, 1988; Hirth, 1977), and predators are capable of regulating populations of ungulates under certain conditions (Van Ballenberghe, 1987; Van Ordsol, 1984). Selection of habitat is likely to depend upon a dynamic set of conditions that include the 'state' of the individual, its environment, and perhaps its past and potential future state (Mangle and Clark, 1986 cited in Festa-Bianchet, 1988).

Behavioral information is essential to the full understanding of the ecology of a species. Different animals show different behavioral responses to the ecological changes that occur in their habitats, seasonal changes of the year, and presence or absence of predators, etc. Vigilant behavior, as one of the behaviors observed in response to various changes in the environment, may help an animal to locate food source and avoid capture by predator (Bertram, 1980). Underwood (1982) investigated vigilance behavior in several African antelopes in relation to finding food as well as in avoiding predation. Large predators prefer tall grass for successful hunting. Van Ordsol (1984) noted that hunts by lions were more successful in tall grass than in short grass. On the other hand, prey species like reedbucks of the family Rudincinae prefer long grass to avoid predators (Irby, 1982; Roberts and Dunbar, 1991). Jarman (1974) suggested that non-cryptic animals have three major strategies available to avoid predation: (i) detecting the predator before it initiates the attack, (ii) outrunning the predator during the attack, or (iii) attacking the predator. This study will examine, in part, the response of the Soemmerring's gazelle to predation in different heights of grass cover.

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 the 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 upon the season (Began *et al.*, 1986). The availability of food resources affect 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 requirement of the species (Caughly, 1977). In addition knowledge in the feeding habits of an animal are essential for making and designing strategies for management.

Many studies have dealt with the various ecological and behavioral aspects of the Wildlife in Africa. Of the nearly dozens of gazelle species found in Africa, only few are well studied: Thomson's and Grant's gazelles are the most studied from East Africa (Estes, 1967; Walther, 1977), while the dorcas (*Gazella dorcas*) and dama (*Gazella dama*) (Salah, 1987; Yoram Yom-tov, 1987; Grettenberg, 1986) gazelles from North Africa and the Middle East have been studied to some extent. Excessive hunting by people, excessive grazing by domestic livestock, agricultural expansion, and other habitat modifications are identified as the main factors that adversely affected most population of the gazelle in the Middle East and North Africa (Salah, 1987). Little is known about the ecology and population status of Soemmerring's gazelle.

Soemmerring's Gazelle (*Gazella soemmeringi*) belongs to the family *Bovidae*, subfamily Antelopini. This Gazelle is large in size, with an elongated head and a relatively short neck (Dorest and Dandelot, 1970). It is adapted to bush and acacia scrub in hilly areas as well as open grassy plain (Kingdon, 1997). This gazelle generally inhabits thorn bush, open and grassy plain in hilly country and is considered to be both browser and grazer (Estes, 1991). It feeds on grass and herb, but may also browse on leaves of shrubs. Like other African wildlife species, Soemmerring's Gazelle is affected by the rapid growth of human population, which has an increasing demand of new land for agricultural expansion and grazing livestock (Hillman, 1988).

In most of its habitats, Soemmerring's gazelle has suffered from decades of uncontrolled hunting with firearms and severe habitat degradation caused by man and domestic livestock, accentuated by recurrent droughts. These factors have reduced this formerly abundant gazelle to scattered, remnant populations and its long-term survival is threatened. It occurs in few conservation areas such as Awash and Yangudi Rasa national parks, which have been considered as the important areas for the conservation of this gazelle.

The status of Soemmerring's Gazelle is classified as "Vulnerable" in the IUCN's (International Union for the Conservation of Nature and Natural Resources) Red Data Book (IUCN 1990). The species is under high pressure of threat to extinction within its highly restricted distribution. The distribution of Soemmerring's Gazelle in Ethiopia was described as locally common in the Northeastern, Eastern and Southeastern lowlands (Hillman, 1988). However, recent reports indicate that the species is exterminated over the greater part of their range, and occurs in numerous pockets (Kingdon, 1997).

Schloeder *et al.* (1997) have reported that large proportion of the population of the species in the Rift Valley of Ethiopia occurs in the Alledeghi Wildlife Reserve and the adjacent Afdem-Gewane Controlled Hunting Area. Thouless (1995) recorded 2,650 gazelles at the Alledeghi plains on the grassland plain to the West of the Awash River and North of the central part of the Awash West Controlled Hunting area. Soemmerring's Gazelle has also wide geographical range in Eastern Ethiopia. Their status was assessed in Aysha-Jijiga region by Thouless (1995) and in the Ogaden Region by Wilhemi (1997). These reports indicated that the population of the species is greatly on the decline.

Although the status of Soemmerring's Gazelle is considered stable in the Awash Valley (Schloeder *et al.*, 1997), its size in the Awash National Park (ANP), which is legally protected, has declined as compared to other antelopes (Almaz Tadesse, Personal Communication). The population has declined by over 82% in 27 years and its important habitat shrunk by a similar margin (Schloeder *et al.*, 1997).

Assessment of the current status and ecology of Soemmerring's gazelle is important for the park management and will also provide some information on the existing knowledge gap on ecology of this gazelle.

3. OBJECTIVES

3.1 General Objective

The general objective of the study is to assess the population status, size, distribution and some aspects of the ecology of Soemmerring's gazelle in Awash National Park and compare it with the population at Alledeghi wildlife reserve.

3.2 Specific Objectives

The specific objectives include:

- to determine whether the gazelle that can successfully exploit a grassland habitat is able to alter its group size and social organization in relation to the change in habitat type,
- to determine the response of gazelles to cover height and vegetation density,
- to study the basic activity pattern of the gazelle,
- to study habitat preferences of the gazelle in both dry and wet seasons,
- to compare some ecological aspects of the gazelle in the two study areas.

4. STUDY AREAS

4.1 Awash National Park

Awash National Park (ANP) is located in the Rift Valley of Ethiopia, between 08°45'N and 09°15'N latitude and 39°40'E and 40°10"E longitude (Figure 2). The total area of the park is 756 km^2. It is bordered by the Awash River to the South and Northeast, and by Awash West Wildlife Reserve to the North and West. The altitude of the topography ranges from 750 m ASL at Awash Gorge to 2007 m ASL at mount Fentalle. ANP was the first national park to be legally gazetted (Negarit gazetta, 1969). Local pastoralists' (Kereyou, Afar, Itu) life styles and practices have been disturbed by politics and developments within the Awash River Basin, particularly, by the building of the Koka Dam since the past 40 years (FAO-SF, 1967 cited in Robertson, 1970). These developments, primarily irrigation for agriculture along the Awash and Kessem Rivers, and the subsequent evacuation of the trans-human pastoralists and loss of access into their traditional dry season grazing areas, have altered the ecology of the immediate and surroundings of the park (Robertson, 1970). Although, the whole national park was assessed for the distribution of Soemmerring's gazelle the main study area was at Ilala Sala (Figure 3).

Vegetation varies from open, semi-arid savanna with occasional *Acacia tortilis, A. nilotica, and Balanites aegyptiaca,* to thorn bush dominated by *Grewia* spp, *A. senegal,* and *A. nubica*. Riverine forest occurs in the hot spring and along the bank of the Awash River. The whole ecosystem has considerable importance for the faunal diversity. 81 species of mammals (46-large and the remaining small species including bats), 453 birds and 348 plant species have been recorded in the park (Hillman, 1993). Herds of Beisa Oryx (*Oryx beisa*), Soemmerring's gazelle (*Gazella soemmeringi*) and Defassa Waterbuck

(*Kobus defassa*) occur in the park. Other mammals include Hammadryas baboon (*Papio hammadryas*), Anubis baboon (*Papio anubis*), Swayne's Hartebeest (*Alcelaphus buselaphus swaynei*), Lesser Kudu (*Tragelaphus imberbis*) and Greater Kudu (*Tragelaphus strepsiceros)*. Seasonal and year-round grazing as well as the shortage of grazing lands in the surrounding areas cause considerable disturbance to the park. The Addis Ababa - Dire Dawa main road and railway pass through the area.

Maximum daily temperature from the nearby town of Merti (Metehara Sugar Factory) ranges between 38.9°C in December to 30.8°C in August, while minimum temperature range between 23.2°C in April and 19.9°C in December. Rainfall is highly seasonal in the area, occurring largely during June – September, with short rains in February and March. Annual rainfall is 562.7 mm. The coefficient of variation in monthly rainfall total is highest during the dry season, indicating that the rainfall is most unpredictable at this time of the year (Figure 1). Seasonal rainfall patterns of the area are closely related to movements of the Inter – Tropical Convergence Zone (ITCZ) (Daniel Gemechu, 1979). The ITCZ is the interface between Southeasterly and Northeasterly winds in the tropics. This zone moves between North during the Northern hemisphere summer, and South of the equator during the Northern hemisphere winter (Norton-Griffiths *et al.*, 1973).

Metehara (970 m) 27.6°C 562.7 mm

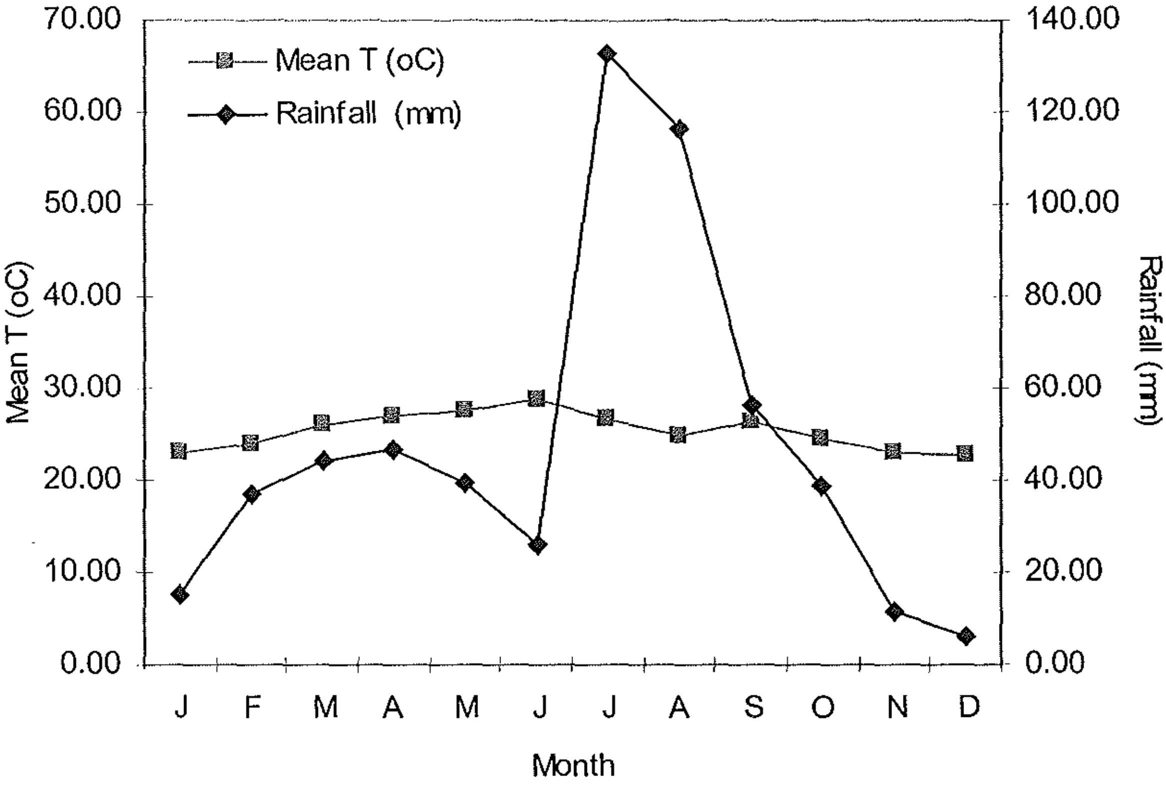
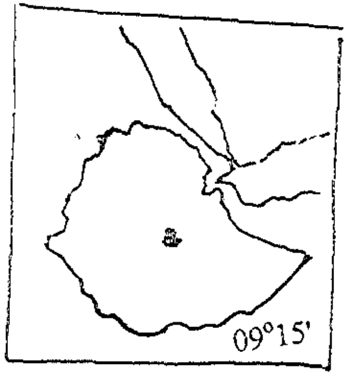


Figure 1. Climate data of Awash National Park (1989-2000)
Source of data: Metehara Sugar Factory



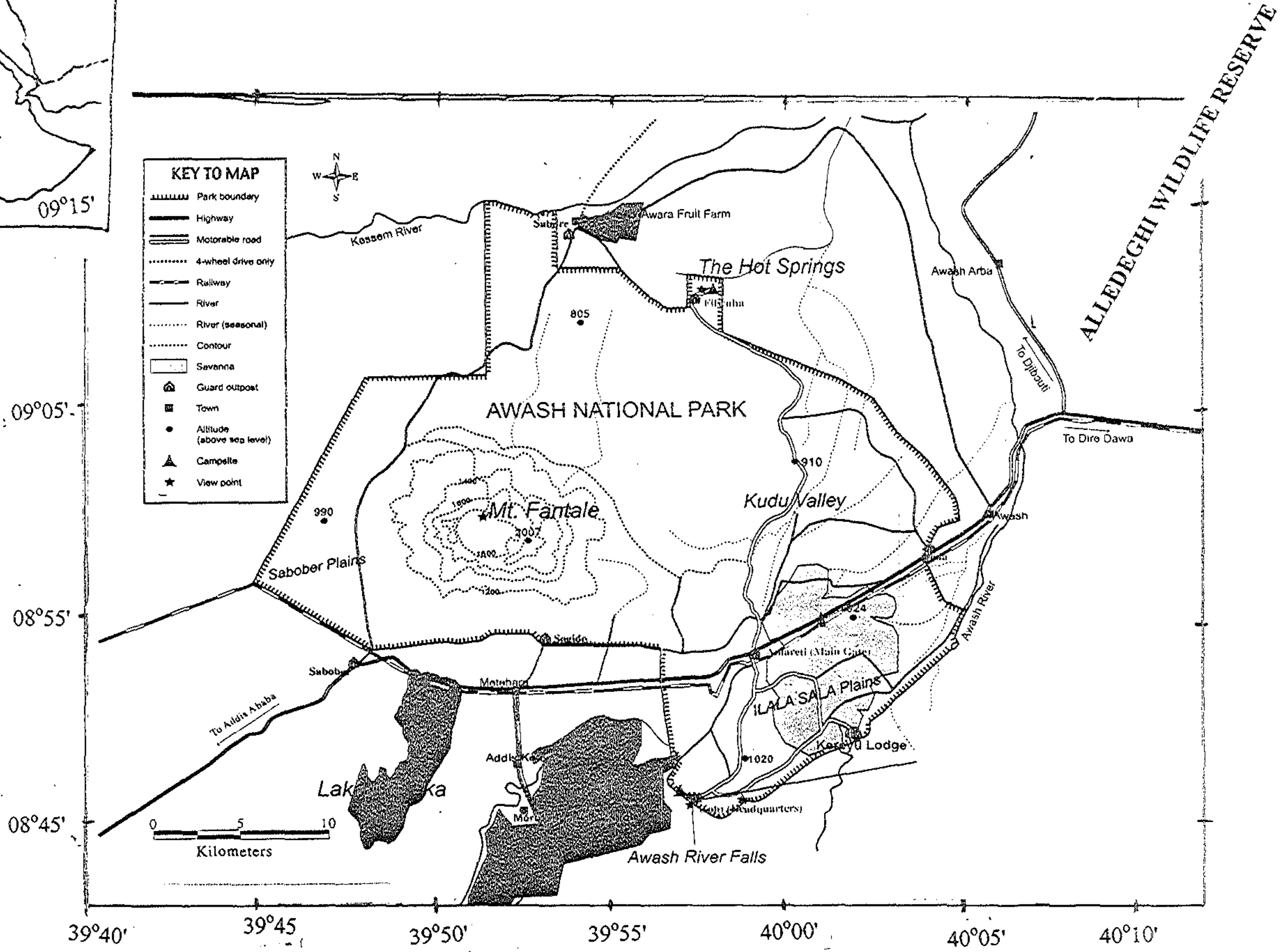


Figure 2. Location Map of the Awash National Park

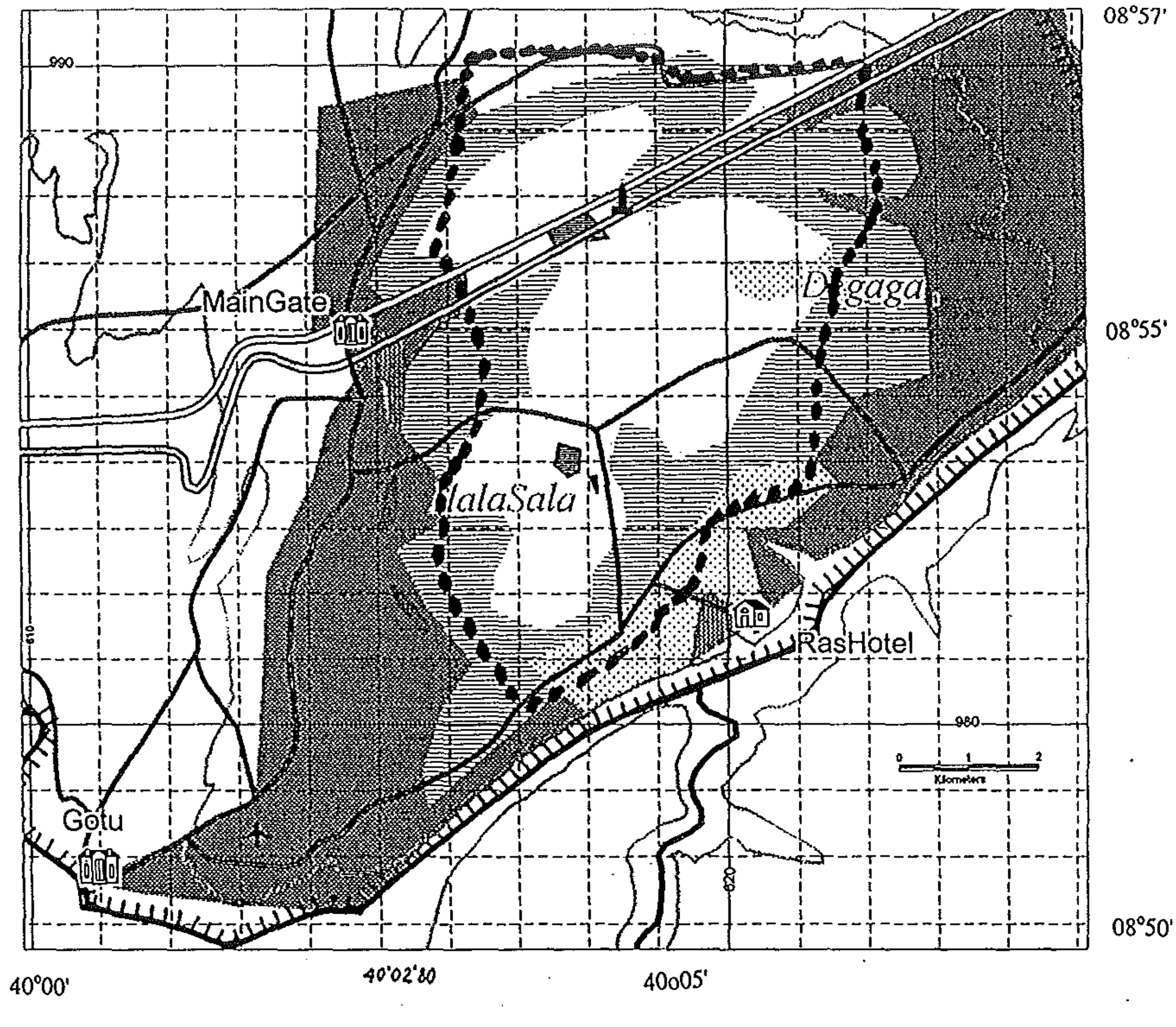


Figure 3. Map of the main study site (Ilala Sala) in Awash National Park

4.2 Alledeghi Wildlife Reserve

Alledeghi Wildlife Reserve (AWR), 09°10'N and 09°23'N latitude, 40°15'E and 40°26'22E longitude, was selected as the second study area because of its high gazelle 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 Railway Bridge that crosses the Awash River. The plain stretches from this point in a broadening manner to the Northeast, skirting the Western foothills of Assebot and Afdem mountains on the Eastern side and having the Awash River as their Western boundary. The Wildlife Reserve is estimated to be about 1800 km^2. However, much of the area is exposed to intensive human activity, which places the wildlife resources under considerable stress in their competition with livestock for survival. It has been observed that over the past two decades there has been a serious decline in the wildlife in general and in gazelle population, in particular. This was attributed to the indiscriminate killing of all species of wild animals by military personnel (Stephenson, 1976) and the pastoral society.

The vegetation is broadly classified as grassland, in which various levels of grasses grow varying from bare land to long grasses. Wooded grassland, shrub land and bush land habitats are also common. The grasses are of various types, the dominants being *Chrysopogon plumulosus* and *Bothriochloa radicans*, which are palatable both to ungulates and domestic livestock. The grass layer is of various heights and its floristic composition is varied. Distribution of the most palatable grasses seems to be even all over the plain.

Climatically, AWR shows striking similarity to that of the ANP. The climate can be regarded as semiarid, its altitude ranging between of 650 - 750 m above sea level. Meteorological data of the last ten years, obtained from the town of Melka Werer Agricultural Research Center indicates that the mean annual rainfall is 544.7 mm. There is a striking similarity in the distribution of rainfall to that of the Awash National Park. The rainfall distribution data reveals that like the ANP, there are two rainy seasons in the area. The bulk of the rain falls between July and September, with short rains being in February and March. Mean monthly temperature ranges from 19.4°C in December to 32.7°C in August (Figure 4).

The wildlife reserve as a whole is currently utilized as grassland by the Afar and Issa people. About 25 km^2 of the area is also used as a modern sheep ranch. The number of domestic herbivores including cattle, camels, sheep and goats exceed that of wild herbivores. Over-utilization has resulted in soil erosion, and bare ground as well as bush encroachment is prevalent. The wild fauna diversity is dominated by Beisa Oryx (*Oryx beisa*) that contribute the highest of the ungulate biomass. The main emphasis of this study is the status and ecology of the Soemmerring's gazelle. However, additional information on the number and distribution of the plain games like Oryx (*Oryx beisa*), Zebra (*Equus grevyi*), Lesser Kudu (*Tragelaphus imberbis*), Warthog (*Phacochoerus aethiopicus*) has been recorded. Data on some carnivores has also been collected.

The Assebot escarpment in the East borders the main study area at AWR that covers a size of 250 km^2 (Figure 5). The terrain is flat over most of the study area being surrounded by a dense thicket at the edge of the plain and the foot of the escarpment bordering the eastern part. Patches of woodland and woody grassland are also found. This plain area is considered to be of relatively high potential and it attracts a sizable proportion of immigrants during the drought/dry season.

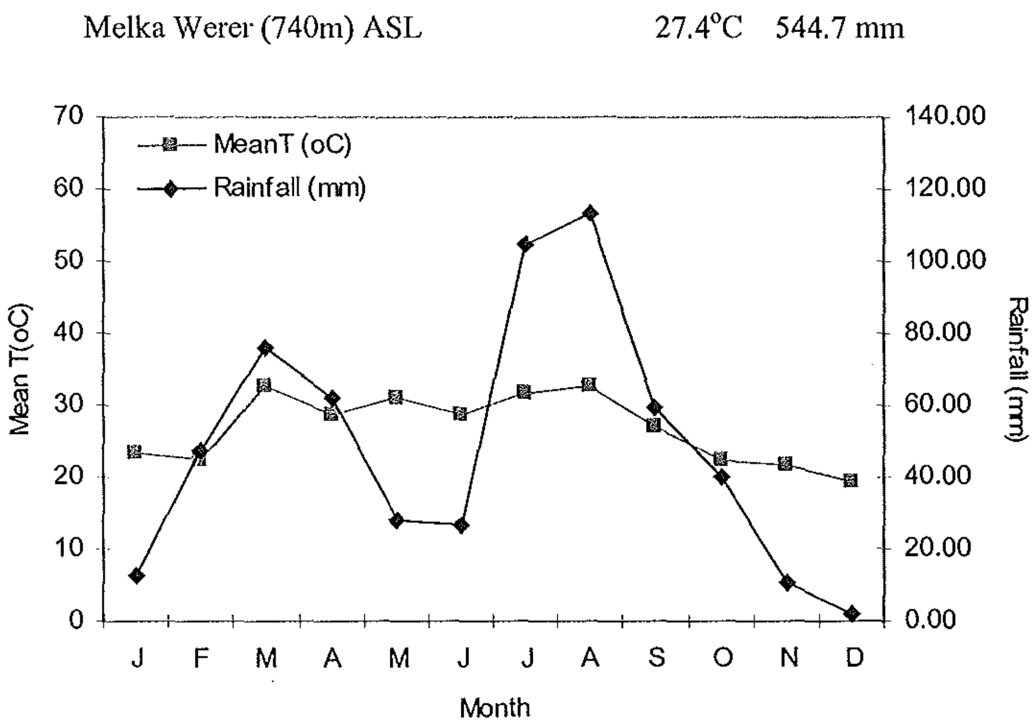


Figure 4. Climatic data of the Alledeghi Wildlife Reserve (1990-1999)

Source: Melka Werer Agricultural Research Center

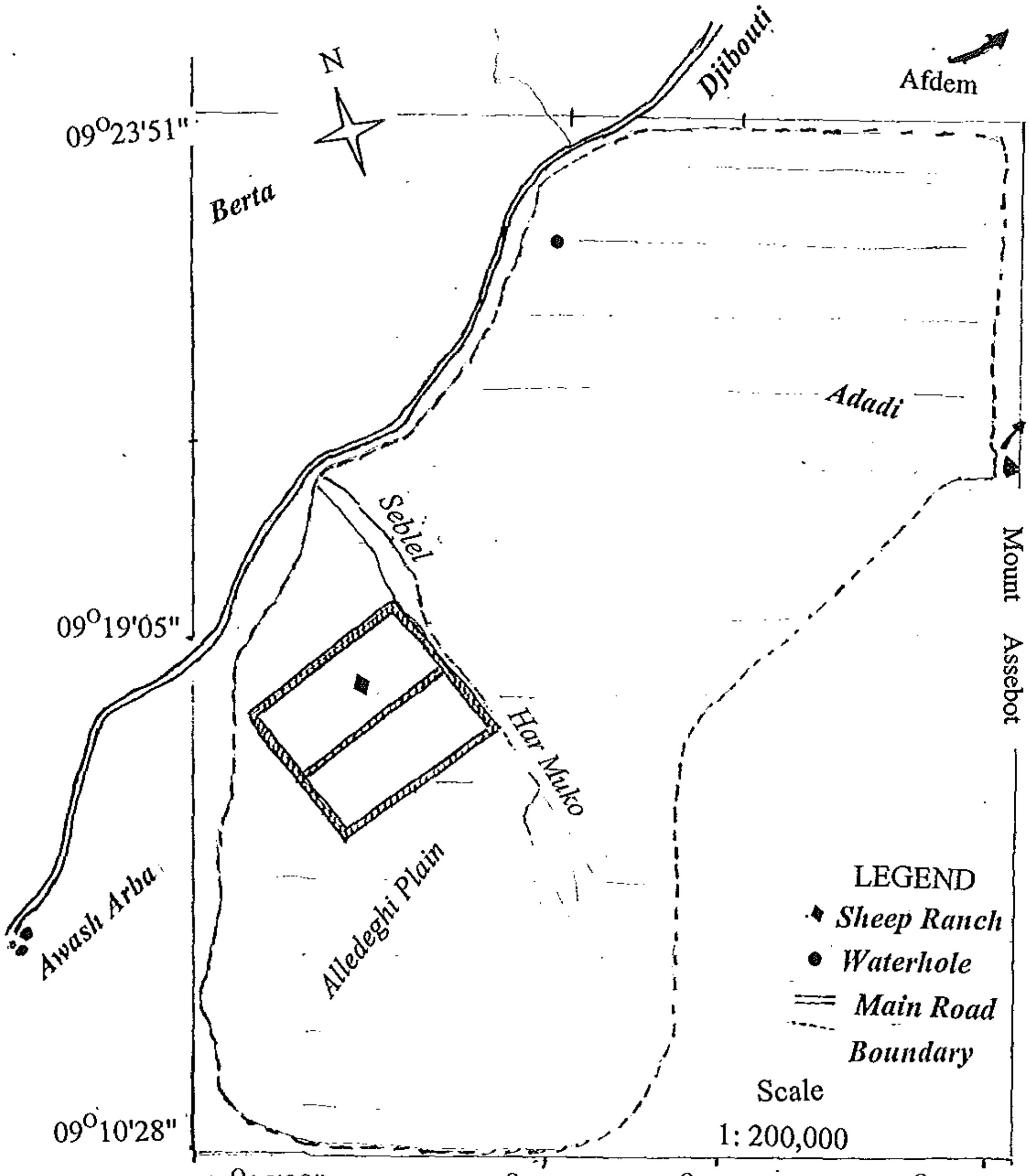


Figure 5. Map of the main study site in Alledeghi Wildlife Reserve

5. MATERIALS AND METHODS

5.1 Counting, Aging, Sexing and Group Size

Preliminary surveys of the two study areas were conducted prior to the actual data collection in order to assess and gather information on distributions of the Soemmerring's gazelle at ANP and AWR. After the surveys study sites were selected in both ANP and AWR. The AWR is a wide plain having a size of more than 1800 km^2. Only an area of about 250 km^2 close to the Southern end of the Wildlife Reserve was selected. In ANP, 33 km^2, which included Ilala Sala and adjacent areas, was selected. Total count method was used to assess the population size of the gazelle. 13 routes (length ranging between 6-15 km), each route being two kilometers away from the other, were designated at AWR for the vehicle to move. Similarly, 10 routes (length ranging between 3-6 km), each being one kilometer away from the other was designated at ANP. The counts were made once per month (from a vehicle at a speed of 20 km/hr) from January to December 2000, except for the month of February in ANP. In AWR the counting was done from April to December of the same year. During each total count all animals seen were noted, counted, age and sex composition was marked. Group size data from all observation were collected and tabulated for each month, and means for monthly group size and standard errors were calculated. From the monthly data, the numbers of group in each class sizes (lone animals, pair, 3-5, 6-10, 11-20, 21-50, 51-100, 101-200, >201) were identified. Data on group size and structure were obtained from the total counts made from 06:30 am until 11:00 am and in the afternoon from 14:30 pm until 06:30 pm, a time that is mainly devoted to feeding.

Data were further broken down into dry and wet seasons to compare the overall change in percentage frequency of group size for the study animal. The population density was estimated by counting gazelles encountered during the counting hours. All counts were conducted during the active periods of the gazelle.

Classifications of the grassland, based on the level of the height and density of the grass cover was made in order to see their preference for grass cover and relate it with the anti-predation behavior of the gazelle. The grass cover heights were estimated and classified as a) 0-25 cm (open area, unrestricted visibility), b) 26-75 cm (moderate visibility), c) 76-100 cm and above (restricted visibility). Preference of cover by the Soemmerring's gazelles was determined by the frequency of animals observed in the respective ranges of the grass height. Differences in the sizes of the major classes of social groups in the three habitat types were treated by one-way analysis of variance, using habitat as the independent variable and group size as the dependent variable. The maximum probability level accepted for statistical significance in all tests was 0.05 and probability values below 0.01 were considered as highly significant. Time budgets of male and female Soemmerring's gazelle were observed between 07:00 am to 07:00 pm. Soemmerring's gazelles were observed with binocular (40x10) and spotting scope (20x, 40x, 60x) from a vehicle. All groups of gazelles observed on the study areas were assigned to one of the vegetation types mentioned earlier. Irregular and opportunistic observations of Soemmerring's gazelle were also recorded to see the difference in group sizes. If animals display no preferences for a particular habitat, then distribution over a selected area containing these habitats should be approximately even. Considering this assumption, the type of habitat where Soemmerring's gazelles were found was recorded. From these, percentage of the frequency of groups of Soemmerring's gazelle was computed. Male herds (sub-adults and immature males) of sizes ranging from 3 to 6 individuals consisted of young males engaged in territorial activities. Females form herds of variable size and composition including adult females of all ages, young males up to the age of weaning, and often some sub-adult males.

5.2 Activity Patterns

Spinage (1968) and Jarman and Jarman (1973) used a 4-minute recording interval when studying Waterbuck (*Kobus dafessa ugandae* NEMAN) and impala (*Aepycerus melampus*), respectively, to study their activity pattern. With a slight modification of the methodology, 5-minute recording interval was used in the present study. Recording started at 0700 hr in the morning and continued until 1830 hr in the evening. Gazelles at Ilala Sala were accustomed to cars and during observations they may continue grazing even at a distance as close as 25 m, but mostly the observations were made from 50 to 150 m from the car. Average observation distance was estimated to be 100 m. All observations were uninterrupted from the starting time until the end of the work for the day. Data were collected using the "focal sampling" technique (Altman, 1973). All activities were classified in to the following five types below:

1. Feeding: feeding on dicotyledons, such as shrubs and herbs, *Acacia* leaves and pods or on monocotyledons (grasses).
2. Walking moving forward at slow or moderate speed
3. Lying recline on the ground, either, with head raised above the ground or resting on the ground
4. Standing standing on all four legs. (Part of the time in this position is spent ruminating),
5. "Others" includes activities like defecating, urinating, grooming, and rutting etc.

Observations on time budgets were made mostly on groups in open grassland and shrub land. Given an animal involved in one type of activity during the five minutes observation time set as one sample doesn't necessarily mean that the sample time for that activity was 100%, i.e. animals could also be involved in activities other than the main one. However, the amount of time spent could be very brief. Hence, activities that took longer time (> 3 minutes) were taken as the main state for that specific observation. That is, activities are frequently interrupted by another activity. A total of 4606 samples of different activities were taken between 0700 to 1900 hr during the study period. The data for the activity patterns are from known individuals of males and females.

Number of observations was equally distributed through out the course of the day. For each hour, the number of observations of each activity was expressed as the percentage of all observations during this particular hour; the daytime mean was then calculated from these percentages. When comparing the two sexes, their daytime means were reconverted into frequencies of observations on the basis of the total numbers of observations. The proportions of activities in the total time budget (e.g. numbers of grazing versus number of observations of all other activities) were then compared by statistical tests. When there were fewer than 100 observations for one activity pattern, this pattern was excluded. Daily time-budget of male and female Soemmerring's gazelle was calculated by combining the data for each sex in the proportions at which they were collected, i.e. by simply summing all observations per day.

Student's *t*-test and spearman's correlation coefficient and one-way ANOVA were used to compare the difference in time budgets of female and male Soemmerring's gazelle, both monthly and seasonally. Statistical package (Software) used to analyze the data was

SPSS (SPSS Inc. Version 7.5, 1995). 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, Spearman's correlation co-efficient were used.

6. RESULTS

6.1 Population Status

During the study we observed a mean population of 457.8 individuals in the selected study site at AWR and 41.9 individuals at Ilala Sala in ANP, respectively (Table 1, 2 and 5). The count at the AWR cannot be used to estimate the total population of gazelles in the reserve, since the survey did not include the total area. However, the total count at ANP can be taken as the total estimate for the whole park, because virtually, no gazelle populations are left in their previous (West and North of the park) ranges, as determined from the repeated surveys of the areas.

Table 1. Group size range and mean total population of Soemmerring's gazelle at Awash National Park during the study period (11 months).

Sex/age	Range	Mean ± SE
Male	4 – 18	9.1 ± 1.1
Female	11 - 29	18.3 ± 1.5
Juvenile	0 - 10	4.4 ± 0.9
Fawn	2- 12	6.8 ± 0.8
Unknown	0 - 9	3.3 ± 1
Mean number of Soemmerring's gazelle	=	**41.9 ± 2**

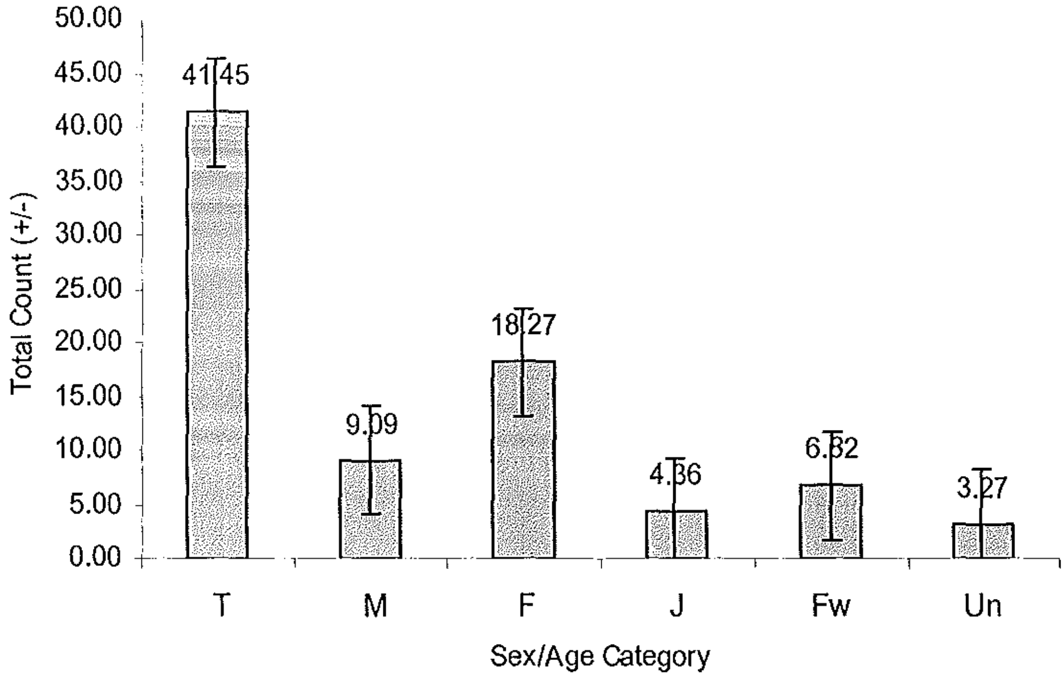


Figure 6. Mean total number of Soemmerring's gazelle at Awash National PARK (T=TOTAL, M=MALE, F=FEMALE, J=JUVENILE, FW=FAWN, UN=UNKNOWN)

Table 2. Group size range and mean total populations of Soemmerring's gazelle at Alledeghi Wildlife Reserve during the study period (9 months).

Sex/age		Range	Mean ± SE
Male		2 - 50	32.1± 5.0
Female		5 - 196	125.7 ± 19.0
Juvenile		0 - 63	28.4 ± 7.0
Fawn		0 - 69	28.4 ± 7.2
Unknown		31 - 715	243.2 ± 84.8
Mean number of Soemmerring's gazelle	=		**457.8 ± 151**

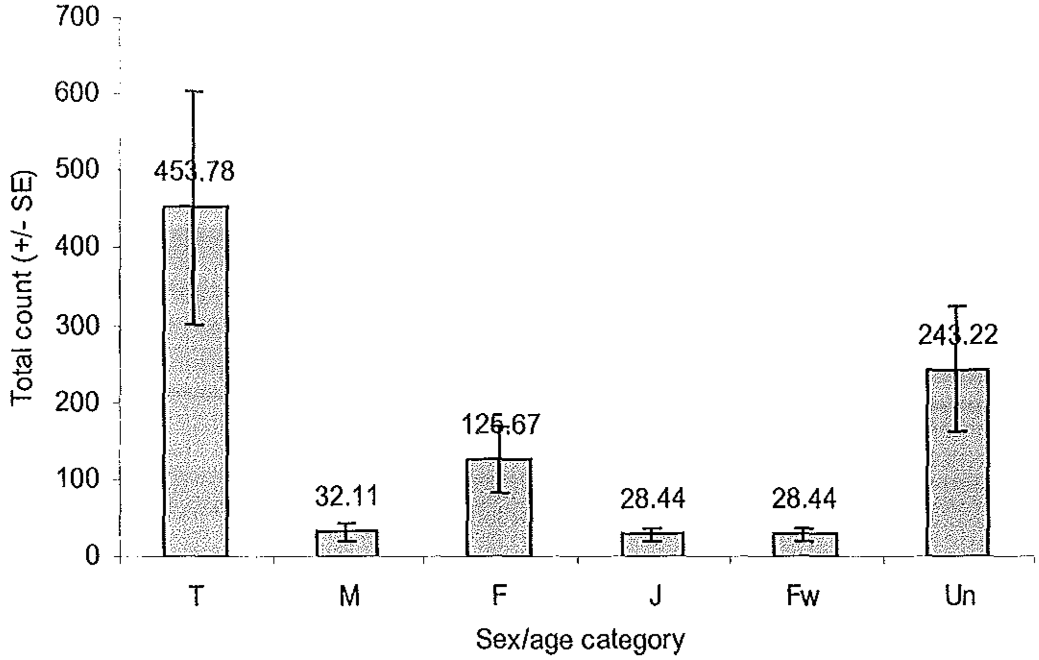


Figure 7. Mean total number of Soemmerring's gazelle at Alledeghi Wildlife Reserve (T=Total, M=Male, F=Female, J=Juvenile, Fw=Fawn, Un=Unknown)

6.2 Group Size

Student's t-test used to test the differences in mean group sizes of the gazelle between the two study sites shows that the differences are significant. However, they were not found to be significant for mixed herds (p=0.795) (Table 3). Even though it has smaller population size and were more separated, Soemmerring's gazelle herds seem to be more stable and have a well-defined home range. Mean group size at Ilala Sala (ANP), based on observation of groups, was 4.4 (SD=1.1, SE=0.32) with a range of 1-11. Mean group size at selected study site of AWR, based on similar observations was 16.8 (SD=8.6, SE=2.9) with a range of 1-51. Comparison of the frequency of group sizes of gazelles in different habitats is based on the encounter of the gazelles either opportunistically or during the total count, not on samples of equal area sizes from each habitat types. A Known territorial male and mixed group was observed in an area of approximately 7 km^2 at Ilala Sala. There may be a minor peak of births in February and April, between the short and long rains. Herds of females, juveniles and fawns are commonly seen together. This tendency of new mothers to associate has an apparent bearing on the defense of the young against predators (Walther, 1972). Jackals may be the most important predators on fawns, as they are common in both study sites. The adults are large for jackals to be preyed. Under healthy conditions juveniles and adult gazelles are large to be attacked by common jackals. The only other predator to be considered as a major cause of mortality is the spotted hyena, which also takes a certain number of fawns.

Adult male Soemmerring's gazelles are territorial for most of the year (Estes, 1991), although the individuals forming this category change frequently. Female herds move through the males' territories, each male attempting to hold females as long as possible. Non-territorial males form bachelor herds, which may be tolerated within male's territory at times, but are kept away from females by the territorial male. Many of the adult males in the study were individually recognizable. Although there was no enough data to substantiate, individuals of Soemmerring's Gazelle were virtually restricted to the study area immediately north of Ilala Sala, for at least 7 months of the year.

Table 3. Independent Samples t-test for the analysis of mixed group sizes of Soemmerring's gazelles between the two study sites (EVA=Equal Variances Assumed; EVNA= Equal Variances Not Assumed).

	Levene's Test		t-test for equality of means					
	F	Sig.	t	df	Sig (2-tailed)	Mean Difference ± SE	95 % Confidence interval	
							Lower	Upper
EVA	0.57	0.45	0.26	74	0.795	0.19 ± 0.71	-1.23	1.60
EVNA			0.30	55.06	0.77	0.19 ± 0.62	-1.05	1.42

Table 4. Correlation for group size frequency of Soemmerring's gazelle during dry and wet seasons for Awash National Park (N = 6).

		Dry Season	Wet Season
Correlation Coefficient (r)	Dry Season	1.00	0.56
	Wet Season	0.56	1.00
Significance (2-tailed)	Dry Season	-	0.25
	Wet Season	0.25	-

The measures for effective concealment of the young are displayed by this species. Once it has gained strength, the newborn searches for a suitable hiding place, watched by the mother gazelle, which evidently memorizes its position by observations from several vantage points before moving away and begin to graze.

Comparison of the frequencies of the fourteen group types of the gazelle populations for the two areas independently did show significant difference, i.e. paired sample t-test comparison was found to be significant at 0.05 level (p=0.026). Taking group size categories as a factor of the variables, comparison of the group sizes of Soemmerring's gazelle showed a very high significant difference (p=0.00) irrespective of the months and localities. Similarly, the difference was found to be significant at 95% confidence level when group size frequency was compared based on localities (p=0.00). When test was based on the monthly distribution of the frequency of the group sizes, the difference was not significant at 95% confidence level (p=0.06).

6.2.1 Local Variations in Group Size

Group size data recorded from the two study areas were treated separately. As it can be expected from the size and suitability of the vegetation types and grass cover, greater numbers of animals were observed in AWR than ANP. From the records, it was found that the mean group size for ANP had smaller standard deviation and standard error. The mean group size for AWR was rather high, reflecting the high population of gazelles in the area and the wide range of group size (Table 5).

The data for AWR suggest that real differences in monthly mean group size did exist, and they were statistically significant on the basis of the observations (p=0.021). In the case of the ANP the changes in monthly mean group size did not show statistically significant value (p=0.414), and the difference between the two localities was highly significant (p=0.00). The proportion of single animals is slightly higher at AWR than ANP, the difference being more significant than categories of the other classes. Herds of 3-5 are most common at both Ilala Sala and AWR. However, herd size ranges from 3-250 individuals in the later.

6.2.2 Seasonal Variation in Group Size

The climate of the study areas is characterized by two rainy seasons and two dry seasons (February-March – short rains, April-May – short dry season, June-September – long rainy season, October-January – long dry season). Due to the different duration of the seasons, records include unequal proportions of wet and dry season data. Investigation on the possibility of the seasonal variations in mean group size of the species at the two study sites was carried out. One way ANOVA comparing for group sizes of Soemmerring's gazelle observed in open grassland in AWR between the two seasons showed no significant difference ($p=0.091$) where as for group sizes observed in wooded grassland and shrubby grassland the differences were significant ($p=0.031$ and $p=0.015$, respectively). Similar comparison of change in group size for the habitats in ANP between the two seasons showed no significant differences for all habitats.

6.3 Group Structure

From the recorded data six group types were distinguished; 1) Single male 2) Male-male groups, 3) Single female 4) Male-female 5) One adult male and females, with or with out young, 6) Mixed groups consisting of bachelors, females, juveniles and calves.

Table 5 Number of sightings of sex-age category and groups of Soemmerring's gazelle in the two study areas (from Jan.-Dec., not include Feb. for ANP and from Apr.-Dec. for AWR).

Age/ Sex	Ilala Sala (ANP)											Study Site at AWR								
	J	M	A	M	J	J	A	S	O	N	D	A	M	J	J	A	S	O	N	D
M	36	19	22	8	16	18	11	20	10	6	6	9	47	33	45	27	59	40	38	9
F	54	36	46	21	39	22	31	34	4	8	15	42	196	134	136	123	183	232	156	25
J	4	1	3	3	15	2	6	5	2	8	6	21	41	39	55	17	48	19	55	9
K	21	11	14	12	18	7	11	6	2	3	4	14	74	45	43	18	55	16	32	2
U	8	17	26	0	10	5	0	3	1	5	1	207	30	797	129	110	27	86	573	5
T	127	84	111	44	98	54	59	68	19	29	32	293	391	1048	408	295	372	393	854	50
x	4	3.1	6	6	3.4	6	5.9	4	3.8	3.6	4.6	29.3	26.1	20.2	18.5	11.8	9.8	8.9	22.5	3.9
N*	32	27	8	8	22	9	10	17	5	8	7	10	15	52	22	25	38	44	38	13

M= Male, F=Female, J=Juvenile, K=Fawn, U=Unknown, T=total number of individuals, x=Mean group size, N*=Total number of groups

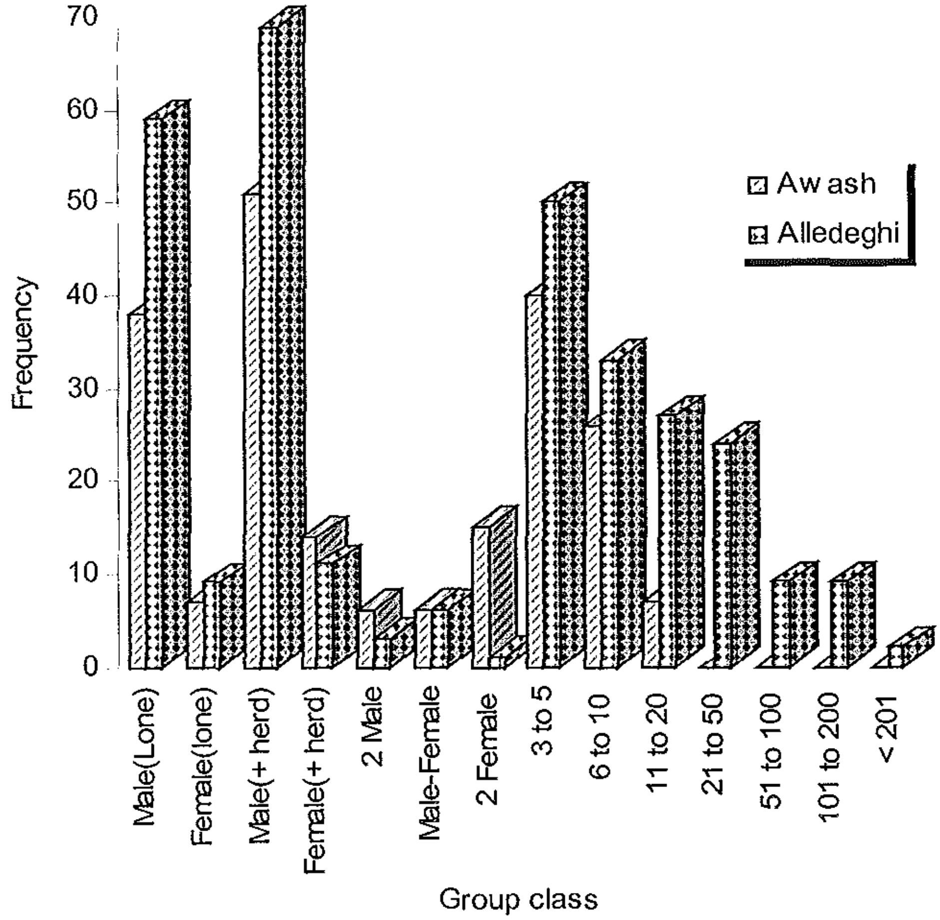


Figure 8. Frequency distribution of group sizes of Soemmerring's gazelle in the ANP and AWR (Jan-Dec)

Figure 8 shows that large proportion of the group types was observed as lone male and territorial male tending herds in both study sites. Frequency of observations of the Soemmerring's gazelle and mean sizes of all female and mixed groups are both larger at AWR than ANP ($p<0.05$ and $p<0.01$, respectively). Thus accounting for the larger overall mean in AWR.

6.4 Feeding Habit

Gazelles were observed to feed on the following plants: *Abutilon fragrensis*, *Lintonia nutans*, *Chrysopogon plumulosus*, *Echlochea* sp, *Cucumis* sp., *Chorchorus* sp. These food plants are the most common constituents of the grassland habitats. Most of the food plants are herbs, grasses and shrubs and some trees. Other plant species observed being eaten include *Dactyloctenium sindicum, Dichrostachys cinerea, Eleusina africana, Ischaemum afrum, Pennisetum* sp., *Blepharis edulis* and fruits of *Solanum incanum.* They were observed to feed on the leaf as well as fruit part of *Balanites aegyptiaca*, pods of *Dichrostachys cinerea,* leaves and pods of *Acacia nubica, A. tortilis, A. seyal, A. senegal* and other *Acacia* species, and forbs of various species during the dry season, shortly after the dry season and the wet season. They were also observed to dig out and feed on tuber of an unidentified plant. These observations of plants were largely from Ilala Sala.

6.5 Habitat and Grass Cover Preference

A comparison of the percentage of monthly habitat preference shows that Soemmerring's gazelles have high preference for open grassland than the other habitat types (Figure 9 and 10). During April and May all sightings of the species in both areas were at grassland. Preference to open grassland may be related to the availability of high proportion of forbs interspersed with the grass species. There are eight types of habitats at ANP classified as grassland, shrub-grassland, shrub land, bush grassland, woodland, wooded grassland, shrub thicket, and riverine forest (Schloeder and Jacobs, 1993; Robertson, 1970). However, the percentage of each habitat type in the national park is not known. The vegetation at AWR generally is similar to that of the ANP. Records on the distribution of the frequency of group sizes of Soemmerring's gazelle were considered. The main vegetation types that are most frequented by gazelles were open grassland, wooded grassland and shrubby grassland. Other habitat types were less frequented and are represented as 'others'. In attempting to determine the degree of habitat preferences, statistical tests (t-test and ANOVA) were performed. Comparing the distribution of the gazelle in grassland habitats shows that there was a highly significant difference in the frequency of group sizes between the two areas ($p=0.000$). Similar result was found in shrubby grassland ($p=0.008$). The difference in mean occurrence of similar group sizes in the two sites was not significant ($p=0.444$). The association of group sizes in the two areas was also not significant in wooded grassland ($r=0.293$). However, t-test for the means of the group size change in ANP and AWR showed that the difference in their means was highly significant ($p=0.00$). And there is no correlation between the two ($r=0.000$). Differences existed between habitats in distribution of group sizes or in the distribution of number of gazelles. The result of the analysis for the distribution of the Soemmerring's gazelle at wooded grassland and shrubby grassland was found to be significant (p=0.031 and p=0.015, respectively). However, even though, the proportion of habitat type classified as 'others' between the two areas varied greatly, the one-way ANOVA for the two sites were not found to be significant (p=0.755). Changes in habitat preferences were also analyzed for their distribution in seasons, localities and sexes. The changes in the distribution of habitat preference in the two seasons showed almost no difference.

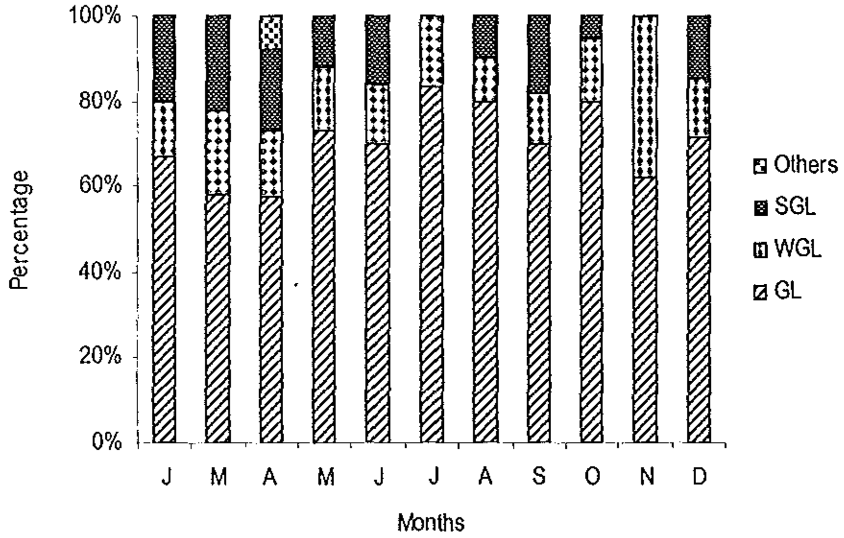


Figure 9. Percentage of monthly distribution of habitat preference of Soemmerring's gazelle in ANP

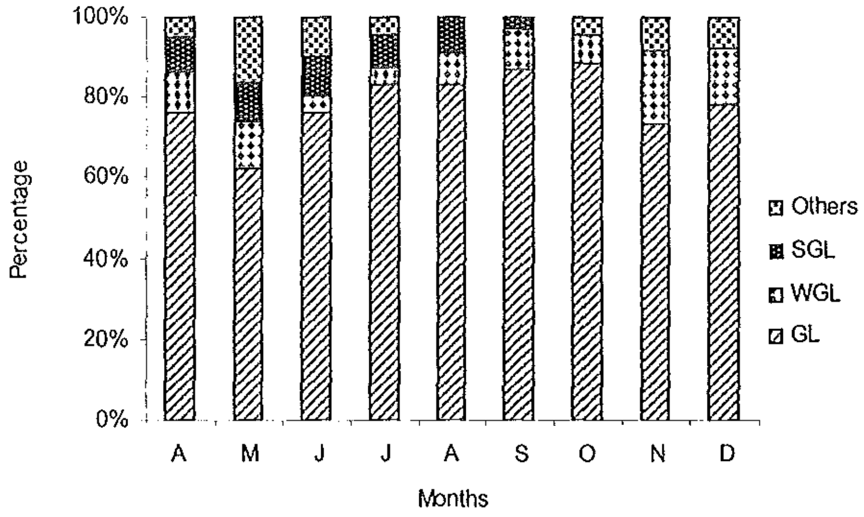


Figure 10. Percentage of monthly distribution of habitat preference of Soemmerring's gazelle in AWR (SGL=Shrubby grassland, WGL=Wooded grassland, GL=Open grassland)

Measuring the grass cover preference is important in studying the behaviour of the gazelle's anti-predation behavior. Having this in mind the height of the grass cover as determined from visual estimates were recorded and analyzed for the percentage and significant difference in mean variability, based on season and locality. Many of the observations from ANP were at medium-sized grass height (26-75 cm) (Figure 11). Unlike the case in ANP, high percentages of Soemmerring's gazelle observations were noted in short-sized grass cover at AWR (Figure 12). The mean group size frequencies of the two areas had highly significant differences (p=0.000). Medium height grass cover had also highly significant difference in the number of gazelles observed as compared to the long grass cover (p=0.001). Mean frequency of the group sizes observed in the two seasons (wet and dry) in short-sized (0-25) grass height at AWR was found to be highly significant (p=0.002) and similar result was found for the medium-sized grass cover (26-75) (p=0.002), but not for long-sized grass (76-100) (p=0.091).

However, the difference in group sizes observed in dense (long grass) cover between the two localities was not significant (p=0.091), while between the other two (short and medium-sized) habitats, the differences were highly significant (p=0.000 for short grass, p=0.002 for medium grass). There was significant difference in sizes of mixed groups in dense covers between the study areas or in sizes of male groups in dense cover. All female and male group comparisons between study areas were highly significant. This difference is related to the high preference of gazelles to short and medium-sized grass, as they were more abundant in short-sized grass at AWR. However, the proportion of short-sized grass at Ilala Sala is low. Therefore, the variation is due to the difference in the proportion of the grass height.

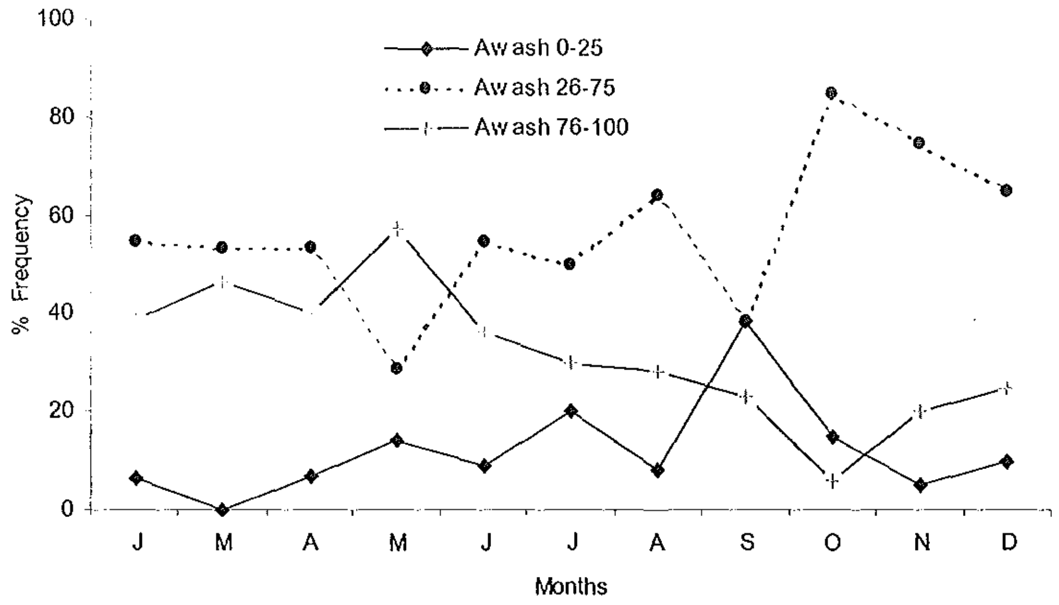


Figure 11. Change in grass cover preference of Soemmerring's gazelle in ANP

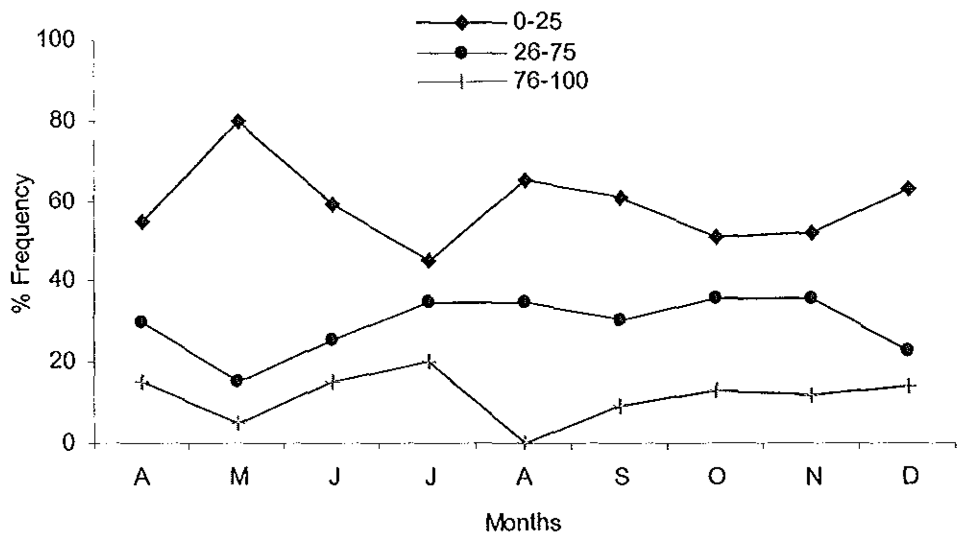


Figure 12. Change in grass preference of Soemmerring's gazelle in AWR

6.6 Activity Patterns

To determine the activity pattern of the species, ANP was selected due to the ease to observe the gazelles. During the study of the activity pattern, a total of 4606 observations were taken between 07:00 to 19:00 hrs. Both sexes of Soemmerring's gazelles were followed for the whole day for two or three days every month. Average data from the observations were taken. Most of the data for activity patterns are generated from known individuals of both sexes. In some cases data on activity pattern was condensed in to two major activities (active and inactive) and analyzed. The proportions of time budgets apportioned to the five activity categories showed slight variation between the wet season (the small rains which usually begins in February and extends to the end of April and the big rains from July to September) and dry season (short in May and long between October and January) (Figure 13 and 14). Variation in time budgets was also prevalent in the sex categories of the gazelle. Time spent feeding by male ranges from 39.8 to 50.7% during the dry season and from 38.4 to 45.7% in the wet season, and from 51.0 to 59.6% during the dry season and 59.8 to 64.6% during the wet season in females. Foraging intensity was higher during the wet season for female and lower for male gazelles. Comparison of means and correlation between percentage of time devoted for the active hours of the day (feeding, walking) and the "others" during the dry and wet season was not significant (p=0.837) and the correlation was also high (r=0.785). The diurnal pattern of the activities consisted of morning and afternoon peaks in foraging, separated by a mid-day lull. Feeding activity began to intensify near down, peaked at about 0700 hr, and declined to minimum level by about 1100 hr. The afternoon foraging peak starts at about 1500 hr, and reached a maximum between 1600 to 1900 hrs.

Morning peaks in foraging ranged between 32 to 37%, afternoon peaks between 48 to 68%. On average, Soemmerring's gazelle spent 50.9% of its time feeding (grazing plus browsing), 6.2% standing, 27.9% lying, 8.3% walking and less than 6.7% for all other activities. These percentage values show the distribution of the major activities throughout the year. There was a morning and evening peak of the activities of feeding and walking and corresponding mid-day peak of lying.

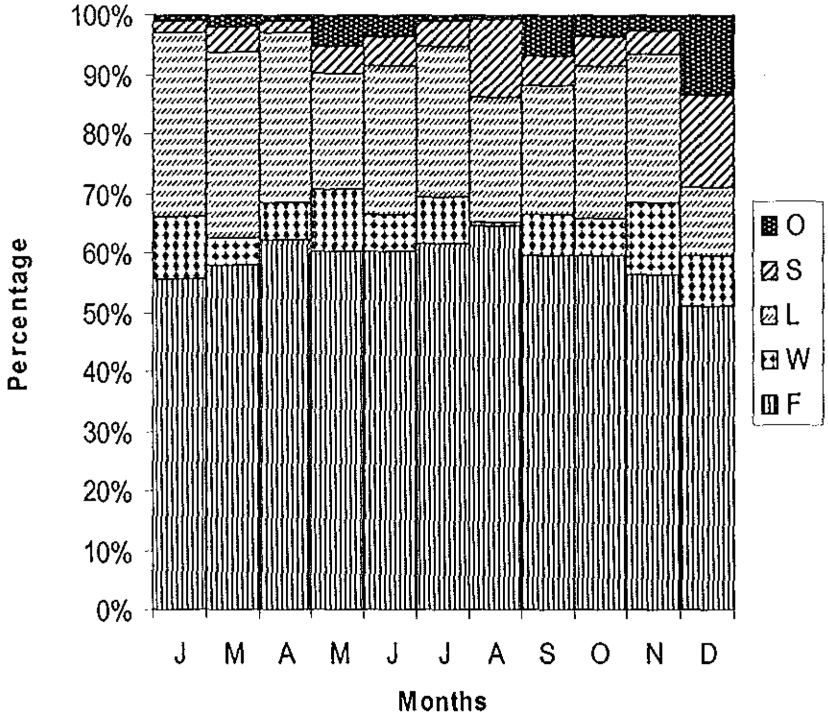


Figure 13. Monthly average percentages of diurnal activity patterns of female Soemmerring's gazelle (F=Feeding, W=Walking, L=Lying, S=Standing, O=Other activities).

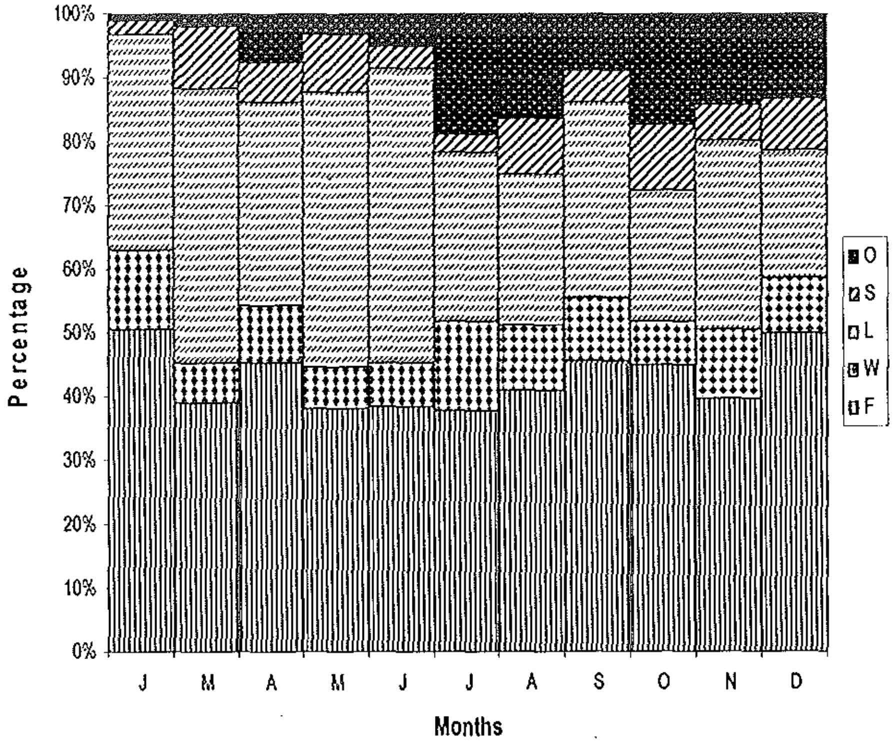


Figure 14. Monthly average percentages of diurnal activity patterns of male Soemmerring's gazelle (F=Feeding, W=Walking, L=Lying, S=Standing, O=Other activities).

The percentage of the main activity recorded as feeding during the wet season when the pasture was good was 51.5% of the day, while in the dry season when there was poor pasture, it was 50.3%. One-way ANOVA was applied to test the difference in various activity patterns. The results indicate that the diurnal activities of feeding ($p=0.650$), walking ($p=0.296$), lying ($p=0.456$) and standing ($p=0.255$) did show no significant difference in both male and female Soemmerring's gazelle, while "others" which includes grooming, playing, defecating, urinating, etc. showed significant difference in both male and female ($p<0.05$). Levene's test was used to see the homogeneity of the data and was found to be homogenous.

Student's t-test was used to test the seasonal difference in the mean percentage of distribution of the various activities. The result indicated that there were no seasonal fluctuations in the activity patterns and percentage distributions of the time devoted to each of the activity categories. The significance values for feeding, walking, lying, and standing were not significant ($p>0.05$). However, the fifth category-"other"- showed significant difference seasonally. Spearman's correlation coefficient was also used to investigate whether there is any relationship between the diurnal activity patterns of male and female gazelles seasonally. The output of the analysis indicated that there was a significant correlation in the activity patterns of male and female during the dry season ($p=0.042$), but it was less significant during the wet season ($p=0.072$). The distribution pattern of the activities throughout the course of day as shown in Figure 15 & 16 was essentially the same for both sexes. Feeding and "others" of male Soemmerring's gazelle were found to be not significant in their distribution of time budgets ($p=0.383$). Theses were similarly found to be insignificant for female ($p=0.087$).

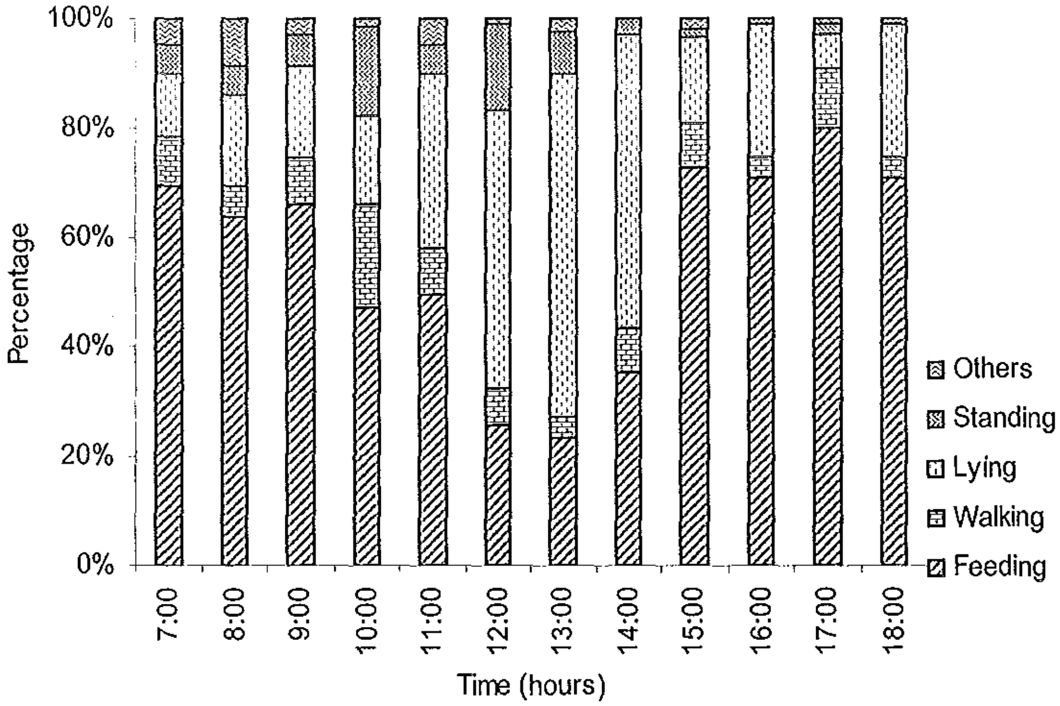


Figure 15. Mean percentage of hourly time budget distribution of female Soemmerring's gazelle

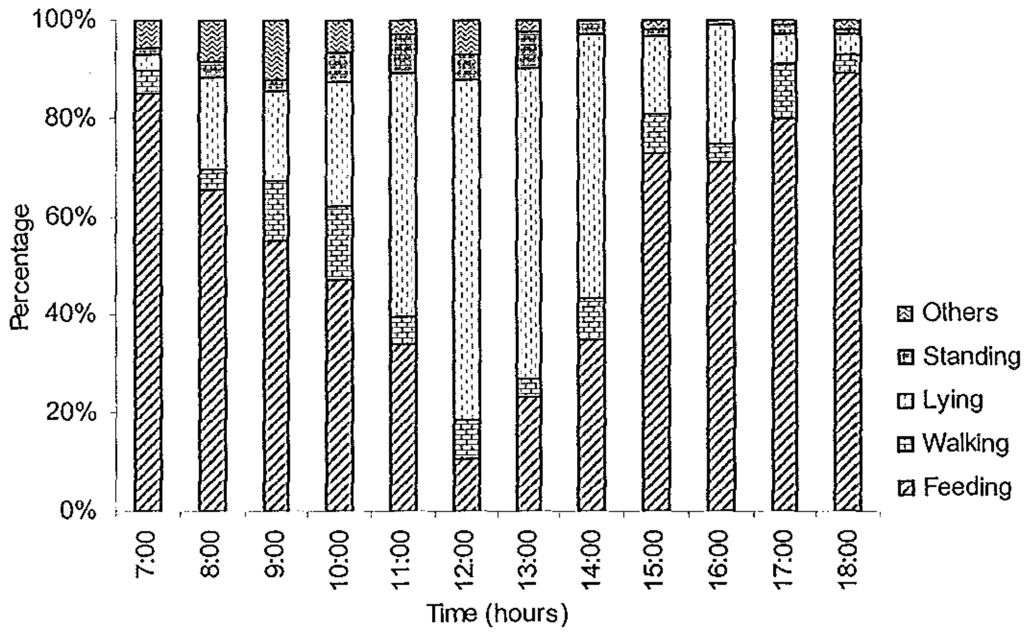


Figure 16. Mean percentage of hourly time budget distribution of male Soemmerring's gazelle

Active hours of male and female gazelles were also compared. The variation in the mean hours spent by both sexes during the study period was not significant (p=0.167). Associations of the active hours of both sexes were significant at 0.01 levels. The twelve diurnal hours of the day were divided in to distinct activity periods (0700-1100, 1100-1500, 1500-1900 hrs). Feeding as the major activity of the day was compared for the proportion it occupies during these activity period for each sexes. Comparing the mean variability of feeding and lying for each month in both sexes showed that no significant difference was observed between them (p=0.002 for male) and (p=0.000 for female). Comparison of activities (feeding and "others") was also made for an average Soemmerring's gazelle, (i.e. the values of average percentage of activities of the day for both male and female were summed and divided by two to obtain a mean value for an average gazelle). The time spent actively didn't show significant difference (p=0.834) in the dry and wet seasons. Testing for the active hours spent for the seasons suggested that the correlation is significant at the 0.05 significance level and the result was as expected from the abundance of green vegetation during the wet season (r=0.656). Male and female had slightly different activity patterns diurnally, but this was not statistically significant (p=0.429). Female and male gazelles were tested if they have similarity in their devotion of time for active hours in dry season and the result obtained shows that there was high correlation in their time budget of active hours (r=0.916). One-way ANOVA was also used to see the difference in the mean active hours for female and male during the dry season. The output of the analysis indicated that difference between them was not significant (p=0.609). Overall proportions of diurnal activity of both sexes, as shown in Table 6 and 7, varies during the morning, noon and dusk

Table 6. Proportion of diurnal activity patterns of female recorded based on classification of diurnal hours into morning, noon and dusk.

Hours	Season	Feeding	Walking	Lying	Standing	Others
0700 to 1100	Wet	0.7	0.0	0.1	0.2	0.0
	Dry	0.5	0.1	0.2	0.1	0.1
1100 to 0200	Wet	0.4	0.1	0.2	0.3	0.0
	Dry	0.25	0.1	0.45	0.1	0.1
0200 to 0700	Wet	0.8	0.1	0.1	0.0	0.0
	Dry	0.8	0.1	0.0	0.0	0.1

Table 7. Proportion of diurnal activity patterns of male recorded based on classification of diurnal hours into morning, noon and dusk.

Hours	Season	Feeding	Walking	Lying	Standing	Others
0700 to 1100	Wet	0.55	0.04	0.25	0.04	0.12
	Dry	0.67	0.13	0.08	0.03	0.09
1100 to 0200	Wet	0.24	0.04	0.63	0.03	0.06
	Dry	0.23	0.10	0.54	0.10	0.03
0200 to 7000	Wet	0.52	0.07	0.27	0.05	0.09
	Dry	0.54	0.07	0.20	0.01	0.18

The percentage of active hours of "average" Soemmerring's gazelle during the dry and wet seasons was closely correlated (r=0.916). A comparison of wet and dry months (Figure 17) showed that, in dry months, animals were more active between early morning and 1100 hr and then became less active than in wet months throughout the afternoon although there were little differences between 1400 and 1500 hr. The proportion of time spent feeding was less during the beginning of the rainy season for male, but the seasonal variation in female was not significant even though there is a slight decline in the driest months. The active hours for male and female Soemmerring's gazelles are slightly correlated and similar (Figure 18) and it was significant at 0.05 level (r=0.656).

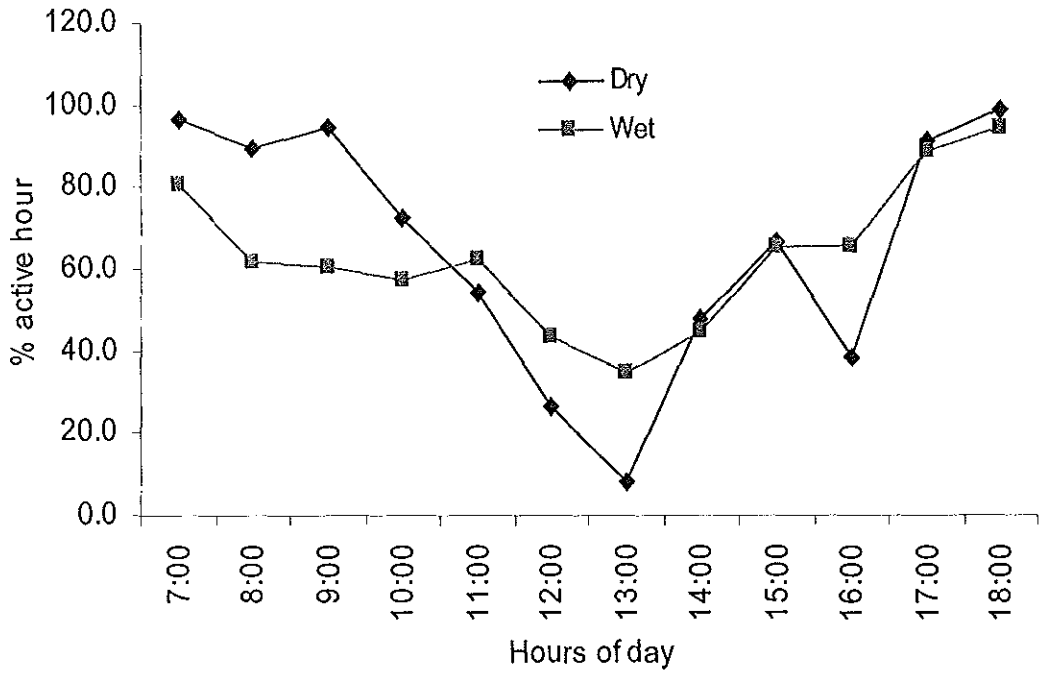


Figure 17. Comparison of percentage of active hours of Soemmerring's gazelle during wet and dry seasons

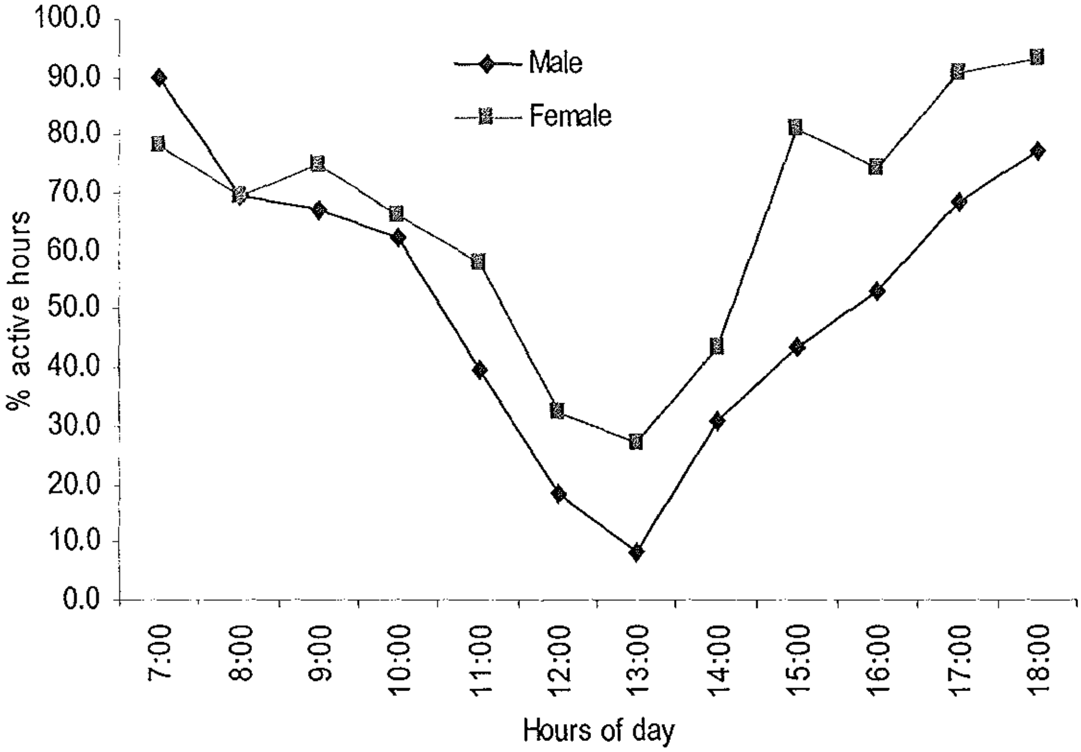


Figure 18. Percentage of active hours of male and female Soemmerring's gazelle

7. DISCUSSION

7.1 Population Status

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 in the area. The number of male Soemmerring's gazelle was lower than the female in ANP. As in most ungulates, male Soemmerring's gazelles are territorial (Jarman, 1974). The reason for the low number of males may be because of competition for the existing small suitable habitats and illegal hunting. Fighting and competition could force bachelor animals to marginal habitats that are poor in food quality and also exposed them to predator attacks. The number of fawns counted in the area was also very low. The actual reason for the reportedly low proportion of newborns is not well understood. However, one possible reason is the presence of jackals, hyena and foxes in the area.

The population count conducted in AWR was in an area located south of the plain, which is about 250 km^2. According to local informants, illegal hunting is common in the reserve and the distribution of the gazelle is fragmented and uneven. Judging from the abundance of the gazelle and the number of the groups, the hunting pressure over the species in the Issa area seems to be harsher than in the Afar area. Extrapolating the number of individuals in the study area shows an increase when compared with the report of Thouless (1995). However, from the increased nomadic activity in the area, the decline of the gazelle population is a reality. The population at AWR is observed at the Southern part of the reserve that is inhabited by the Afar.

The range distribution of Soemmerring's gazelle showed that the species at ANP is confined to the area around Ilala Sala in about 33 km^2 (Figure 3). From the repeated surveys of Soemmerring's gazelle, they have been eliminated from their previous habitats and localities in the Western and Northern (Sabober, Metehara and North of Filwoha) portion of the park. The currently available habitat for the gazelle, Ilala Sala, is the only well protected area in the park. Human interference such as grazing of domestic animals and hunting are relatively less pronounced than they are in the other portions of the park. Unlike the ANP, Alledeghi plain possesses "large" population of this species. However, the population has declined very seriously when it is compared with the figures of earlier years (Schloeder and Jacobs, 1993). Human interference in this area is even heavier than at ANP. Part of the gazelle population is found in the Southern part of the plain, which is a grazing land for the Afar pastoralists.

The population size of the gazelle reported in the present study at Ilala Sala showed a slight decrease from that estimated by Schloeder and Jacobs (1993) and Robertson (1970). Number of gazelles counted each month both in the park and the wildlife reserve ranged from 29 to 54 and from 194 to 892 respectively, in the monthly total count. From the total count it can be seen that some groups of Soemmerring's gazelles leave the study area at AWR as indicated by the number of females and juveniles changing each month (Table 5). The population of this species at the ANP did not show seasonal or monthly fluctuation, as the suitable habitat is limited. There is a possibility for the population of Soemmerring's gazelle of the study area selected from of AWR to move to other localities. However, local migration between the two sites does not seem possible due to the presence of the Awash River Gorge, which is difficult to cross from either side. Historical distribution of the Soemmerring's gazelle, which were abundant in ANP, showed that they occurred in various localities (Robertson, 1970; Schloeder and Jacobs, 1993; Park Office). Current assessment of these previous localities of the gazelle showed that they are absent in most of their range. Habitat change as well as indiscriminate hunting by local people could account this for. However, even in protected areas, such as the ANP its density is low. The population density of Soemmerring's gazelle for ANP, taking only the current population distribution and available suitable habitats, is 1.3 animals/km^2. Suitable habitats of the gazelle in ANP were calculated to be about 430 km^2. But, unlike Robertson's (1970) estimate (7.1/km^2) the density estimate for the overall habitats is too small (0.1 individuals/km^2). The mean density for the study area at AWR is 1.82 individuals/km^2. These figures show that the highest density of gazelles is found at the Wildlife Reserve than the Awash National Park.

Water is not a limiting factor for the distribution of group sizes of the gazelles as they can survive the dry season without 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 the gazelle (Western, 1975). Browsers are less water-dependent than grazers (Estes, 1991). Herbivores that are dominantly browsers are less water-dependent than grazers. The observation of the gazelle species feeding on herbs more often than grasses may be related to their water-independent behavior. This point may support the fact that these gazelles browse most of the time.

Currently, there are only few non-domestic ungulates in both ANP and AWR (few in both diversity and abundance), the dominant being Beisa Oryx and Soemmerring's gazelle. Livestock (cattle, camels, sheep and goats) are the most numerous animals as a 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. Prolonged association between grazers with slightly different feeding requirements, particularly with regard to vegetation structure, could result in the creation and maintenance of conditions favorable to one or several species (Bell, 1970), provided that the density is not beyond the carrying capacity of the area. Ungulates have the strategy of utilizing their habitats developed through their evolutionary adaptation that are not observed in domestic livestock. Cattle have no such evolutionary developed adaptive strategies for grazing, i.e. they don't have the knowledge as to where to graze, when to graze (Rodgers 1977; Western, 1975). Such evolutionarily developed strategies could have enabled the gazelles to use the wide areas of important habitats sustainably and ensure their survival. However, the rapid increase in domestic animals in the areas disrupts their adaptation.

7.2 Social Organization and Group Size

Soemmerring's gazelle is a social species to the extent that animals live in groups that can number from few to several hundred. 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 spend several days holding their territories and waiting for female groups. Bachelor groups live together in marginal habitats that are not occupied by territorial males and some times join the mixed groups without getting access to the estrus females.

The gazelle populations of the two sites (in 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 the gazelles at ANP. Where as the AWR population occupied a brushy 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 same two primary predators, jackal and hyena.

Based on the size of the plain (AWR) and seasonal changes in food quality and quantity in the areas, one would expect the largest group of gazelles to be formed during the wet season and decline throughout the dry season as the case is in many ungulates (Durant, *et al.*, 1986). However, this was not observed from the result obtained during this study.

Soemmerring's gazelle exhibit grouping pattern consistent with a territorial organization, characterized by high incidence of lone adult males, a large proportion of the harem groups and a small percentage of the mixed groups. In general, the male is considered to be territorial. The findings of the study emphasize the difficulty of drawing conclusion on the social organization from data on group structure alone. Group size and composition may be influenced by a variety of environmental factors, in addition to being broadly determined by each species propensity for a certain type of social organization.

The pattern of group size in the different habitat types in both of the study areas was entirely different. Despite the highly significant difference indicated for groups in the open grassland in AWR, compared to those dense and intermediate habitats very little differences could be detected when female, male and yearling groups were examined. Group size varies in relation to different external conditions. Data on grouping patterns of herbivores may be indicative of the effects of a changing environment (Leuthold and Leuthold, 1975), reproductive behavior

(Jarman, 1973) 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. The difference in mean group sizes between populations in the two study areas may be attributed primarily to habitat types. Ungulate species living in open habitats generally form larger 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 habitat. This would explain most of the group size differences between ANP and AWR, as the later contains more open habitat. Walther (1972) reports similar findings for Grant's gazelle in the Serengeti area. Several hypotheses have been proposed to explain this very pronounced inverse relationship between group size and density. The more widely accepted explanation for this is that it is an adaptation for predator avoidance (Estes, 1974 cited in Estes, 1991). The predator avoidance hypothesis holds that an animal is more likely to avoid detection by a predator in dense cover when it is alone or in a small group. In dense cover, a single animal can be effectively concealed, whereas this concealing effect is lost when the group or herd is large. In open habitat, the reverse is true. Most ungulates are too large to be able to feed in the open and be concealed from potential predators at the same time. For that reason species that normally utilize open grassland habitat typically occur in larger groups or herds. This group size difference explains the difference observed in cover-loving and cover-avoiding herbivores such as reedbucks and gazelles, respectively. The density of food resources alone may also explain the occurrence of small groups of ungulates in woodland habitats because of limited vegetation at the forest floor, which is too sparse for a large feeding group (Owen-Smith, 1982). In open fields or grasslands food resources are more abundant and sufficient to support large feeding groups of ungulates (Hirth, 1977).

7.3 Diurnal Activity Pattern

Feeding and resting activities of an animal fluctuates diurnally, but exceptions occur at some times of the year. This observation suggests that activity fluctuations vary in response to environmental factors. The responsible variation could probably be food availability and temperature. The difference in percentage of time spent feeding is directly correlated to the abundance of food materials during the wet season. The difference in the distribution of time budgets (fluctuations in activity pattern) of the wet and dry seasons, may lead to the conclusion that temperature and food availability seem to be the determinant factors governing the activities of gazelle. Seasonal variations in daily activities were perhaps related to temperature, rainfall and ground plant biomass in reedbuck (Roberts and Dunbar, 1991). The increase in feeding time on poor pasture in males (Figure 13 & 14) during the dry season may be at the expense of ruminating time. Female gazelles have to feed for much longer hours to meet their requirement for pregnancy and parturition, while males spent much time defending their territories and tending estrus females.

Although, there was a clear difference in the percentage of feeding hours between the two sexes, the correlation in their active hours could be attributed to the territorial behavior of males, which may obligates them to be active at the time when they would otherwise be resting. The data were a combination of activities observed when the male is alone as well as with a herd (harem), and this could have a significant impact in the distribution of the daily activity pattern. An increase in forage quality and availability at the onset of the rains will usually result in less time for feeding as observed in males.

Variations on the basic activity pattern of the gazelle can be influenced during the peak-breeding season. Fawns share the time spent for other activities by mothers. Similarly, lone males spend much time feeding than males in mixed or bachelor groups (all-male groups). Diurnal activity patterns seem to be influenced by factors other than food availability and temperature. It was observed that short-period wind waves disrupt resting animals. Moreover, flying insects tend to inhibit the formation of resting groups. Generally, the gazelles were active at down and dusk. Similar findings were observed in studies of other antelopes (Jarman and Jarman, 1973; Irby, 1982) and Sea Otters (Estes *et al.*, 1986).

7.4 Seasonal Changes in the Basic Pattern

The often irregularly distributed rainfall in the areas creates patches of green vegetation. In the dry season food and water become scarce in the areas. Conditions in the dry season and size of available habitats account for the overall difference in group size between the two study areas. In males, feeding time increased as pasture quality fell in dry season.

Females were observed more often in territorial areas than non-territorial ones. This shows that better quality of forage exists inside the territories held by the territorial males. However, there could also be additional reasons for the female preference for territories. Female groups seem to get advantages being with territorial males, since bachelor males would disturb them when they are outside of the areas of territorial males. When in mixed groups (Harem) male gazelles spend much time tending the herd, which could affect the amount of time, spent on feeding. Wirth and Oldkop (1991) found similar result on Waterbuck. The spatial and temporal distribution of receptive females, in turn, determine the distribution of males and hence the nature of the mating system of the animal (Jarman and Jarman, 1973).

7.5 Habitat and Grass Cover Preference

It was indicated that the vegetation of the ANP consists of eight vegetation types (Almaz, 1997; Schloeder and Jacobs, 1993; Robertson, 1970). The vegetation types of Ilala Sala can be considered dominantly as grassland with various levels of bush land, shrub land, 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 do not have significant variation in their altitudinal range. The plains are quite extensive in AWR. Generally, based on the preliminary survey of the distribution of Soemmerring's gazelle in ANP and AWR, attempts were made to investigate the habitat preference of this gazelle. They were mainly observed in grassland (GL), shrubby grassland (SGL), and wooded grassland (WGL) in both ANP and AWR (Figure 9 & 10).

Grass cover preference in herbivores is correlated with predator avoidance. Many studies have shown that dependence on cover is a principal part of avoidance strategy in Reduncinae (Hendriches, 1975; Irby, 1979; Roberts and Dunbar, 1991). However, not all ungulates follow this strategy to avoid predators. Plain games should escape their predators to survive an attack and hence they have to see their enemy at a distance in advance. High preference to short grass cover at AWR and ANR could be related to this situation. The high proportion of observations of gazelles in medium-sized grass cover at Ilala Sala is caused by absence of wide areas of short grass and the abundance of grass height range of medium to long heights.

The gazelle populations exhibited a highly distinctive pattern in their use of grass cover. However, variation has not occurred seasonally, i.e. the proportion of animals found in short grass, medium grass and long grass cover did not change seasonally. Gazelles in ANP tended to remain within shade of trees for longer hours during the hot dry season, while they stay in the open short grass cover during the late dry and wet season of the year. This can be correlated to their behavior of anti-predation. Van Ordsol (1984) suggested grass cover to be an important factor for hunting success of predators during the day. It minimized the energy expenditure of big predator at hot temperature and also maximizes the hunting success by opportunistically hunting for prey, which was particularly easy to catch.

Several factors have been shown to influence sizes of territories in animals, which include quality and quantity (Walther, 1972), animal density and bush encroachment (Wittenger, 1981 cited in Schloeder and Jacobs, 1993) and human settlement. Based on these factors, small sizes of territories reported in this work can be explained either by the high quality of food in the study area, or high population density of herbivores and human interferences or both. Most ungulates are territorial and defend their territories from being occupied by other males (Jarman, 1974). It is true that habitat destruction by fire, over grazing and other human factors could cause an increase in competition for resources, which could eventually end up, either in migration of herbivores to other localities or in confining them to marginal habitats where there are poor food resources. This was evidenced by Boshe's (1984) study of the territory size and structure of Kirk's dikdik where he observed reduced population of the dikdik with reduction in shrub density of the territory.

Herbivores require a certain maintenance level of protein in their forage. The study made by Almaz (1997) showed that during the wet season the biomass of the grass 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 around the Awash National Park and the corresponding reduction in pastureland is expected to increase the rate of competition between domestic animals and the Soemmerring's gazelle. The monthly population counts at Ilala Sala showed a uniform trend, indicating that the gazelle population is becoming resident because of the absence of other suitable areas other than Ilala Sala. But as the monthly fluctuations in the number of gazelles in AWR is related to movement of the gazelles to other areas in the plain, although we have insufficient records in these areas to detect the magnitude of this movement. Small proportion of Soemmerring's gazelle moved into wooded grassland during the dry season. This could be related with their being water-independent and to get high protein from dicotyledonous plants, which maintain higher dry season levels of protein than grasses (Stelfox and Hudson, 1986 cited in Durant, *et al.*, 1986). It seems that seasonal change in selection of plant species (trees, shrubs, forbes and grasses) does occur. In browsing and grazing, the greater part of the diet consisted of the leaf part of the plants. The observations made suggested that Soemmerring's gazelle is primarily a browser.

7.6 Other Behaviors

The reproductive and territorial behavior of male Soemmerring's gazelle affects the diurnal activity pattern and time budgets of the male. Aggressive behavior is not so fierce in male Soemmerring's gazelle. Territorial males could detect and follow the movement of neighboring territorial or bachelor males at a distance as far as 3 km. The common fighting displays of gazelle species are exhibited. Serious fighting among territorial males is very rare. Only on two occasions was fighting observed. In one occasion the fighting continued as long as sixteen hours. It is expected that there could be a departure from the basic activity pattern of the male Soemmerring's gazelle when it is with and without females. However, data recording did not consider the variation that could arise from this. When the territorial male tends herds (especially during the breeding season) it spent considerable time in activities of territorial marking and rutting amidst of the major categories of activities.

8. CONCLUSION

One of the objectives of this study has been to see the population status of Soemmerring's gazelle in the two study areas having different conservation status and examines those factors involved in the population decline. It is apparent that change in habitat quality, overgrazing, habitat degradation and competition with domestic livestock are the main human induced factors for the decline of the species. The Awash National Park and Alledeghi Wildlife Reserve are under high pressure being used as grazing lands for pastoralists. Livestock are grazing in the area extensively. Pastoralists used to move their cattle from one locality to the other in response to the change in environmental factors. However, this tradition seems to have changed to a kind of sedentarism with the increase in human population and livestock, resulting in habitat change due to overgrazing. Establishment of waterholes in both the national park and the wildlife reserve has attracted many pastoralists to settle around these conservation areas permanently. This has, partly contributed to the reduction of important wildlife species.

Territorial ungulates such as Soemmerring's gazelle require ample size of suitable habitats that are good enough to attract reproductive females. It was found that gazelles, largely, need short to medium-sized open grassland habitats that are rich in dicotyledons. 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 the breeding population. Territorial males will be forced into marginal habitats. Survival of viable populations of this species in the areas is partly dependent on the existence of resourceful habitats. Maintaining this habitats 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 the gazelle. A definite pattern, which is relating group size to habitat type, exists commonly among ungulates. That relationship appears to have evolved: (1) as a means of avoiding predation and (2) perhaps also as 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 factors can be generalized as:

i) the rapid increase in human population and the need for additional land to increase production for sustainability of the family,

ii) the coming of improved technologies to bring a serious threat for wild animals such as the use of guns, wire snares, gin traps, insecticidal poisons, scattering of indestructible litter, plastic and metals that are ecologically incompatible with conservation of nature,

iii) use of modern veterinary medicines to increase stock numbers have also contributed to over gazing and degradation of the ecosystem,

iv) the desire of monetary wealth inspired people to misuse resources.

The above problems are prevalent in the study areas. Effective management of the gazelle and other wildlife resources can be realized only if the current pressure in 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 the current situations of the areas indicated that the gazelle population and its 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.

Records made by Robertson (1970), Schloeder and Jacobs (1993) and the park office indicated that the gazelles were abundant at the park. In the surveys of this study it was observed that there is a substantial decline in the populations of the species in and around the park and a concurrent decline in their distributions. The sub-populations of the northern, western and southwestern parts of the park have lost their qualities as important habitats for Soemmerring's gazelle. Recent observations indicate that the population is totally absent from these areas being confined to a very small area in the southern part of the park.

9. RECOMMENDATIONS

The conservation future of the Soemmerring's gazelle cannot be considered secure in the long-term in both the national park and wildlife reserve with the present wildlife management. The species has been under a great threat and the problems have been aggravated with the increase in 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 sub-optimal habitats. It is obvious that attempts to preserve these species for future generations will entail a greater commitment to habitat procurement and conservation than has hitherto been the case.

Though, there is no substantial information to witness for the death of Soemmerring's gazelle, it is expected that other environmental factors like disease, nutrient deficiency and malnutrition might also be involved in the decline of the population, but these were not investigated, as it was beyond the scope of the study.

Habitat restoration is perhaps the only appropriate, conservation strategy that may save the rapid decline and eventual extinction of Soemmerring's gazelle. Uncontrolled over-grazing on the western and northern part of the Awash National Park and the year-round utilization of the Alledeghi plain will prevent the regeneration of the palatable plant species in the area. Cattle, sheep, goats and camels are found in large numbers and at high densities in the areas. They are estimated in tens of thousands of individual livestock. Livestock do not feed strategically as do by other wild herbivores; hence resource of a given area will be eaten until it is totally exhausted. This may damage the vegetation cover and degrade the habitat qualities that are required by Soemmerring's gazelle and other herbivores. Erosion is common in the study areas. Certain exotic plant species, such as *Prosophis juliflora* are spreading from the margin of the main road expanding in to the open grassland. This may have a serious impact for the future unless measures are undertaken to control its expansion as it is unpalatable and even kills herbivores if taken as food.

Carnivores like hyenas, foxes, leopard and cheetah could hunt on Soemmerring's gazelle. However, the number of these hunters is not large. Leopard and cheetah although there existence in the area is recorded, no sign of them were noted. Two species of hyena, two species of foxes and one species of jackal were observed, hunting, new born and grown up fawns. Pastoralists are affecting the population of Soemmerring's gazelle not only through their domestic livestock, but also by hunting them. Therefore they are impediment to the conservation of the whole wildlife in the area.

Clearly, further work is needed on feeding rates and food selectivity of Soemmerring's gazelle in both seasons. 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.

i) for declining species such as Soemmerring's gazelle, understanding the causes of decline is crucial to the development of effective conservation program. Further and continuous studies of ecological problems are required to exactly pin point the causes for the population decline of the species, to assess the population dynamics and trend and range condition in order to develop better management approach and strategies for the park and the whole conservation areas and to ensure the of this species and the diversity of life in general.

ii) open grassland habitat constitute the major preference of the gazelle. Mea controlling the invasion of the plains by bush encroachment should be und through burning.

iii) while the management strategy should involve local people, the park manag should form strong link with the police authorities, military personne judiciary body in order to control illegal hunting and misuse of the resourc strengthening law enforcement.

iv) effectiveness of conservation measures that are to be taken should be monit and assessed at every steps.

v) local people should benefit from the conservation of the areas either from income generated from tourism and controlled hunting or from do organizations interested in the conservation of the areas (as the area is impo both biologically and anthropologically), so that they understand the importan the conservation areas and develop sense of belongingness of the natural resou

vi) local people should be given conservation education on sustainable utilizati natural resources and importance of the conservation areas, to create awarene the value of biodiversity.

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APPENDICES

1A. Test of homogeneity of variances of for comparison of active hours of male and female Soemmerring's gazelle during dry season.

	Levene			

1B. One-way ANOVA for comparison of active hours of male and female Soemmerring's gazelle gazelles during dry season.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MALEDRY	Between Groups	192.667	1	192.667	.269	.609
	Within Groups	15747.167	22	715.780		
	Total	15939.833	23			

2. t-test for comparison of active hours of male and female Soemmerring's gazelle

Group Statistics

	HOURS	N	Mean	Std. Deviation	Std. Error Mean
MALE	1.00	12	52.4167	24.6741	7.1228
	2.00	12	65.9167	21.4453	6.1907

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Mean	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MALE	Equal variances assumed	.404	.532	-1.431	22	.167	-13.5000	9.4371	-33.0714	6.0714
	Equal variances not assumed			-1.431	21.581	.167	-13.5000	9.4371	-33.0935	6.0935

3. One-way ANOVA for comparison of active hours of male and female Soemmerring's gazelle.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MALE	Between Groups	1093.500	1	1093.500	2.046	.167
	Within Groups	11755.833	22	534.356		
	Total	12849.333	23			

4. Correlation of feeding hours of male and female Soemmerring's gazelle.

Correlations

			FEEDING	OTHERS
Spearman's rho	Correlation Coefficient	FEEDING	1.000	-1.000**
		OTHERS	-1.000**	1.000
	Sig. (2-tailed)	FEEDING	.	.000
		OTHERS	.000	.
	N	FEEDING	12	12
		OTHERS	12	12

**. Correlation is significant at the .01 level (2-tailed).

5. One-way ANOVA comparing mean percentages of active hours of diurnal activities of dry season against wet seasons of average Soemmerring's gazelle.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
DRY	Between Groups	28.167	1	28.167	.045	.834
	Within Groups	13787.167	22	626.689		
	Total	13815.333	23			

6A. Test of homogeneity of variances for comparison of active hours of Soemmerring's gazelle seasonally.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
DRY	5.140	1	22	.034

6B. One-way ANOVA comparing active hours of Soemmerring's gazelle seasonally.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
DRY	Between Groups	28.167	1	28.167	.045	.834
	Within Groups	13787.167	22	626.689		
	Total	13815.333	23			

7A. Test of homogeneity of variances for comparison of active hours of male and female Soemmerring's gazelle during the wet season.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
MALEWET	.882	2	21	.429

7B. One-way ANOVA comparing active hours of male and female Soemmerring's gazelle during the wet season.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MALEWET	Between Groups	2687.508	2	1343.754	4.393	.025
	Within Groups	6423.826	21	305.896		
	Total	9111.333	23			

8. One-way ANOVA for comparison of feeding and "Others" time budgets of male Soemmerring's gazelle.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
FEEDING	Between Groups	468.167	1	468.167	.794	.383
	Within Groups	12979.167	22	589.962		
	Total	13447.333	23			

9A. Homogeneity of variances for comparison of means of percentage of feeding and "Others" for female Soemmerring's gazelle.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
FEEDING	.000	1	22	1.000

9B. One-way ANOVA comparing means percentage of feeding and "Others" activities for female Soemmerring's gazelle

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
FEEDING	Between Groups	1472.667	1	1472.667	3.211	.087
	Within Groups	10091.333	22	458.697		
	Total	11564.000	23			

10. One-way ANOVA for comparison of time budgets of feeding and lying activities of male Soemmerring's gazelle.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
FEEDING	Between Groups	682.667	1	682.667	1.026	.322
	Within Groups	14639.167	22	665.417		
	Total	15321.833	23			

11. t-test for comparison of the means of percentage of feeding and "Others" for females.

Group Statistics

	HOURS	N	Mean	Std. Deviation	Std. Error Mean
FEEDING	1.00	12	57.8333	21.4172	6.1826
	2.00	12	42.1667	21.4172	6.1826

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Mean	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
FEEDING	Equal variances assumed	.000	1.000	1.792	22	.087	15.6667	8.7435	-2.4663	33.7997
	Equal variances not assumed			1.792	22.000	.087	15.6667	8.7435	-2.4663	33.7997

12A. Test of homogeneity of variances for feeding and lying activities of female Soemmerring's gazelle

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
FEEDING	.208	1	22	.653

12B. One-way ANOVA comparing mean percentage of feeding against lying activities of female Soemmerring's gazelle.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
FEEDING	Between Groups	6144.000	1	6144.000	14.467	.001
	Within Groups	9343.333	22	424.697		
	Total	15487.333	23			

13A Test of homogeneity of variances for comparison of the frequency of groups of Soemmerring's gazelle observed at short-sized grasses (0-25 cm).

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
SHORTGRA	.006	1	18	.937

13B. One-way ANOVA comparing the frequency of group sizes of Soemmerring's gazelle observed at short grass (0-25 cm) between the two localities.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SHORTGRA	Between Groups	10934.550	1	10934.550	105.932	.000
	Within Groups	1858.000	18	103.222		
	Total	12792.550	19			

14A. Test of homogeneity of variances for comparison of the frequency of groups of Soemmerring's gazelle observed at medium-sized (26-75) grass cover 0f the two areas.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
MEDIUMGR	2.716	1	18	.117

14B. One-way ANOVA comparing the frequency of group of Soemmerring's gazelle observed at medium-sized (26-75 cm) grass height of the two areas.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MEDIUMGR	Between Groups	3605.851	1	3605.851	22.671	.000
	Within Groups	2862.949	18	159.053		
	Total	6468.800	19			

15A. Test of homogeneity of variances for comparison of the frequency of groups of Soemmerring's gazelle observed at long grass (76-100 cm) between the two areas.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
LONGGR	4.604	1	18	.046

15B. One-way ANOVA comparing the frequency of group sizes of Soemmerring's gazelle observed at long-grass (76-100 cm) between the two areas.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
LONGGR	Between Groups	2073.069	1	2073.069	16.695	.001
	Within Groups	2235.131	18	124.174		
	Total	4308.200	19			

16A. Test of homogeneity of variances of the frequency of groups of Soemmerring's gazelles observed at various habitats in the two areas.

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
GL	1.832	1	18	.193
OTHERS	23.770	1	18	.000
SGL	1.359	1	18	.259
WGL	11.002	1	18	.004