SINET: Ethiop. J. Sci., 28(2):161–170, 2005
 ISSN: 0379–2897

A STUDY ON ABUNDANCE, GROUP SIZE AND COMPOSITION OF SOEMMERING'S GAZELLE (*GAZELLA SOEMMERRINGII*) IN AWASH NATIONAL PARK AND ALLEDEGHI WILDLIFE RESERVE, ETHIOPIA

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ABSTRACT: Population status, group composition and social organization of the Soemmerring's gazelle (*Gazella soemmeringii*) were studied at Awash National Park (ANP) and Alledeghi Wildlife Reserve (AWR) in 2000. Total count method was used to assess the population size of the gazelle. Thirteen routes, each route being two kilometres away from the other, were designated at AWR for the vehicle survey. Similarly, 10 routes, each being one kilometre away from the other, were designated at ANP. The results revealed a mean population of 457.8 individuals in the selected study site in Alledeghi Wildlife Reserve, and 41.45 in Ilala Sala. Grouping pattern showed that cohesion was stronger. The large females group containing juveniles and of adult males were the two main social units. Mean group size in ANP was 4.4 whereas that of AWR was 16.8 individuals ($p>0.001$). 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. It is presumed that alteration of the original habitats might have an effect on the group pattern and social organization of study population as observed from one of the study site.

Key words/phrases: Abundance, Alledeghi Wildlife Reserve, Awash National Park, group size, Soemmerring's gazelle

INTRODUCTION

Ungulates show variation in ecobehaviour in response to environmental stress through time and space. Phenomena such as excessive herbivore impact and habitat degradation as well as artificial measures such as fencing, water provision, and burning can materially affect and disrupt patterns of ecological separation (MacKinnon *et al.*, 1986). Seasonal movements in water-dependent large communities show wet season dispersal and dry season concentration, which can be related to the seasonality of rainfall and availability of water, but similar patterns do not prevail in the water-independent species (Durant *et al.*, 1986). 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*) (Grettenberg, 1986; Salah, 1987; Yom-tov, 1987) gazelles from North Africa and the Middle East have been studied to some extent. Excessive hunting, excessive grazing by livestock, agricultural expansion, and other habitat modifications are identified as major factors adversely affecting most population of gazelles (Salah, 1987; Hillman, 1988).

Soemmerring's gazelle is one of the few large herbivores that have not been studied extensively. The species was formerly abundant in the Ethiopian lowlands and Somalia (Dorest and Dandelot, 1970). The species, *Gazella soemmerringii,* (family, Bovidae; subfamily; Antelopini) is large in size, with an elongated head and a relatively short neck (Dorest and Dandelot, 1970). This gazelle generally inhabits thorn bush, open and grassy plain in hilly country and is considered to be both

browser and grazer (Estes, 1991). The status of the gazelle is classified as "Vulnerable" in the IUCN Red Data Book (IUCN, 1990). The distribution of Soemmerring's Gazelle in Ethiopia was described as locally common in the Northeastern, Eastern and Southeastern lowlands (Hillman, 1988; Thoulles, 1995; Wilhemi, 1997). However, recent reports indicate that the species is exterminated over the greater part of the previous range, and occurs in numerous pockets (Kingdon, 1997). It occurs in few conservation areas such as Awash and Yangudi Rasa National Parks, which are considered as important areas for the conservation of this gazelle.

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. Thoulles (1995) estimated 2,650 gazelles at the Alledeghi plains on the grassland habitat, west of the Awash River and north of the central part of the Awash West Controlled Hunting Area. Reports indicated that the population of the species is greatly on the decline (Hillman, 1988). 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 more than other antelopes. The population has declined by over 82% in 27 years and its important habitat shrunk by a similar extent (Schloeder *et al.*, 1997). In this context, it is mandatory to evaluate the population status and the various ecological factors adversely affecting them in these natural habitats, so as to enable managers to appropriate management actions for conservation of the populations from further depleting. Hence, the present investigation was designed to gather data on the population size, distribution, and social organization of the species in Awash National Park and in Alledeghi Wildlife Reserve. Assessment of the current population 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 species. The purpose of this work was to study the population size and conservation problems of the gazelle, and 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 locality and seasons.

STUDY AREAS

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 (Fig. 1). The total area is about 756 Km², which is bordered by the Awash River on the south and northeast, and Awash West Wildlife Reserve on the north and west. Altitude of the area ranges from 750m a.s.l to 2007m a.s.l. Although, the whole area of the Park was assessed for the distribution of Soemmerring's gazelle, the intensive study area was at Ilala Sala. Maximum daily temperature ranges between 38.9°C in December to 30.8°C in August, while minimum temperature ranges 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 with an annual rainfall of around 550 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. Seasonal rainfall patterns of the area are closely related to movements of the Inter-Tropical Convergence Zone (ITCZ) (Daniel Gemechu, 1977).

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. 81 species of mammals, 453 species of birds and 348 species of plants recorded in the Park (Hillman, 1993). Herds of Beisa Oryx (*Oryx beisa*), and Defassa waterbuck (*Kobus defassa*) also occur in the Park. The less common antelope in the area include Swayne's hartebeest (*Alcelaphus buselaphus swaynei*), Lesser kudu (*Tragelaphus imberbis*) and Greater kudu (*Tragelaphus strepsiceros).*

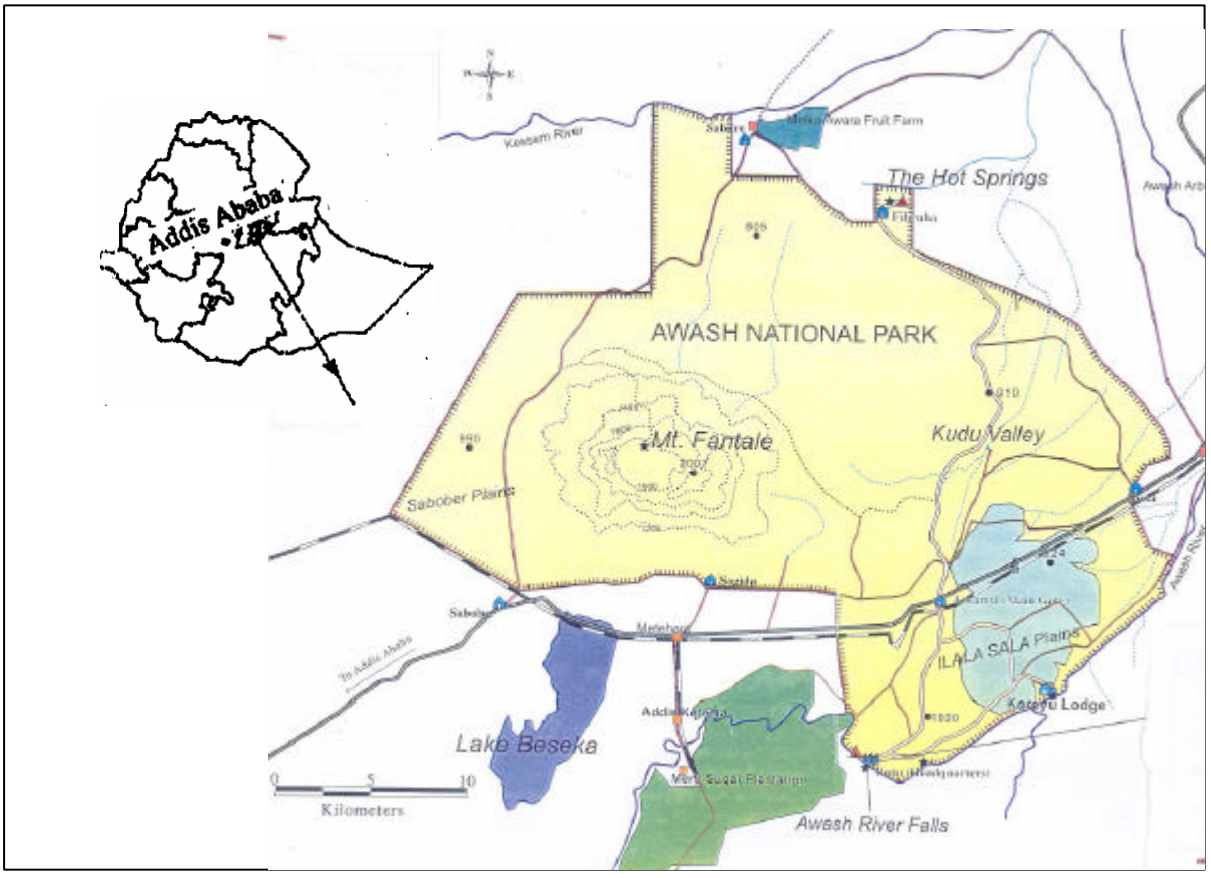

Fig. 1. Location map of the Awash National Park.

Alledeghi Wildlife Reserve

Alledeghi Wildlife Reserve (AWR) is located between 09°10'N and 09°23'N latitude, 40°15'E and 40°26'22E longitude with about 1800 km² area was selected as the second study area because of its high gazelle population and accessibility. The Reserve begins from the Arba River, near the railway bridge that crosses the Awash River. The plain stretches from this point to the northeast, skirting the western foothills of Assebot and Afdem mountains on the eastern side. Awash River forms the western boundary of the Reserve. The vegetation is broadly classified as grassland, varying from bare land to long grasses. Wooded grassland, shrub land and bush land habitats are also common. Dominant grasses are *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. The climate can be regarded as semiarid. The altitude ranges between 650–750 m a s l. The mean annual rainfall is 544.7 mm. The rainfall distribution data reveals that like the ANP, there are two rainy seasons in the area. The bulk of the rain falls during July - September, with short rains during February and March. Mean monthly temperature ranges from 19.4°C in December to 32.7°C in August.

The Afar and Issa people currently utilize the whole wildlife reserve as grazing land. About 25 km² of the area is also used as a modern sheep ranch. The number of domestic herbivores including cattle, camels, sheep and goats exceeds that of wild herbivores. Over-utilization of the habitat has resulted in soil erosion, and in the formation of bare ground. Bush encroachment is prevalent. An invasive plant species, *Prosopis juliflora* are invading considerable portion of the Reserve. The wild faunal diversity is dominated by Beisa Oryx (*Oryx beisa*) that contribute the highest ungulate biomass. The Assebot escarpment in the east borders the main study area at AWR of about 250 km². This study area is on the Afar side of the reserve located in Amibara Woreda, Afar Region (Fig. 2). 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 dry season.

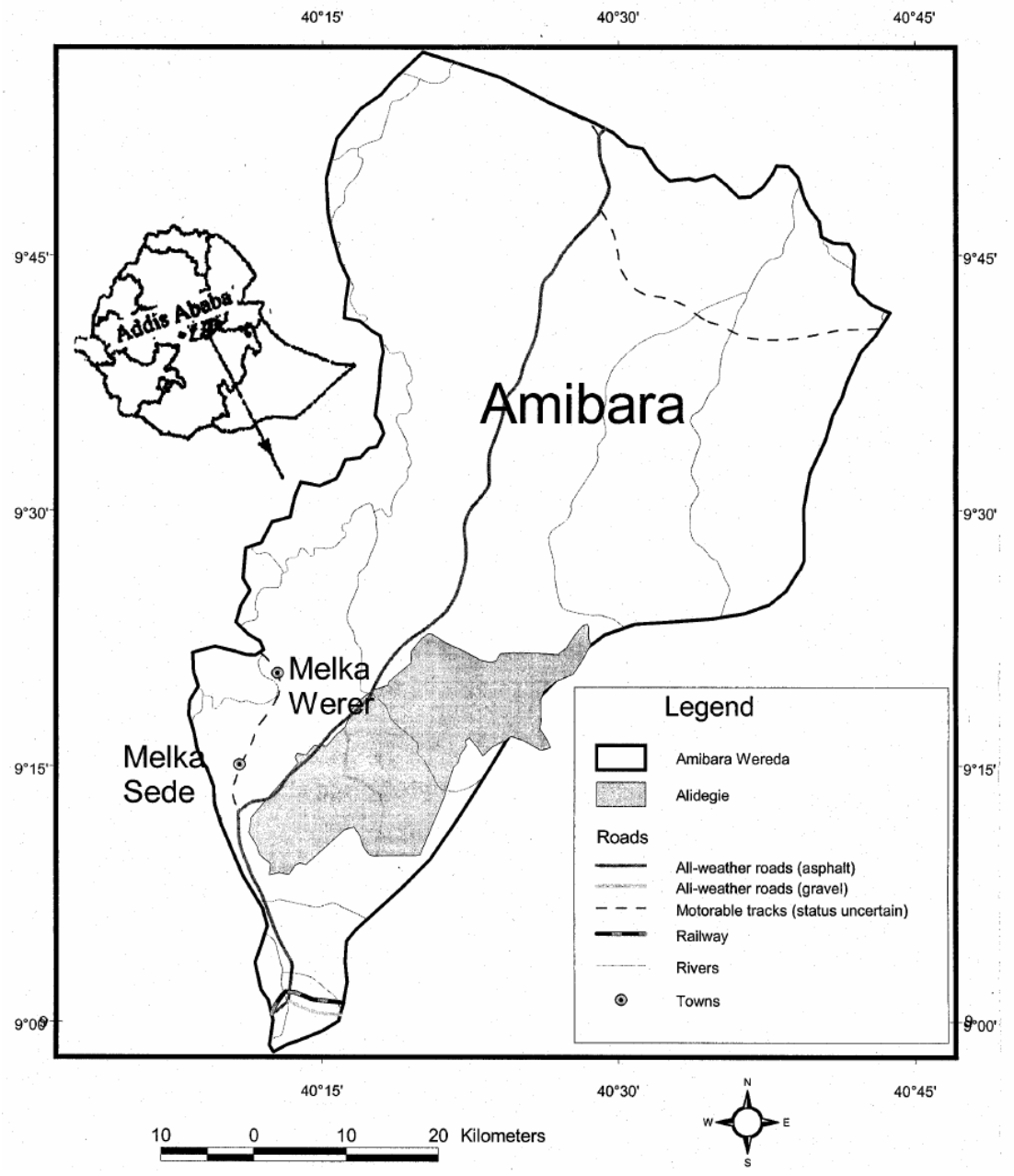

Fig. 2. Location map of the study site at Alledeghi Wildlife Reserve .

METHODS

Preliminary surveys were conducted in the study areas prior to the actual data collection, in order to assess and gather information on intensive distribution of the Soemmerring's gazelle at ANP and AWR. After the surveys, the study sites were selected. 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 (Norton-Griffiths *et al*., 1973). Thirteen routes (length ranging between 6-15 km), each route being two kilometres away from the other, were designated at AWR for the vehicle survey. Similarly, 10 routes (length ranging between 3-6 km), each being one kilometre away from the other was designated at ANP. Data were further grouped into dry and wet season to reveal the changes in group size. The data on population also assessed to estimate population density. Soemmerring's ga-

zelles were observed with binoculars (40x10) and spotting scope (20x, 40x, 60x) from a vehicle. Irregular and opportunistic observations of Soemmerring's gazelle were also recorded to see the difference in group size. 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, age and sex composition were recorded. Data on group size from all observations were collected and tabulated for each month. Mean group size for each month 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. Observations were made during 06:30 a.m.—11:00 a.m. and 2:30 p.m.—06:30 p.m. when the species is more active. 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. Data on group size from the two study areas were treated separately. Investigation on the possibility of the seasonal variations in mean group size of the species at the two study sites was carried out.

RESULTS

Population size and group structure

The present study has revealed a mean population of 453.8 individuals in this study area in AWR and 41.45 individuals at Ilala Sala in ANP, respectively (Table 1). The following six group types of the gazelle were distinguished based on their interactions with one another; 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 males and females, juveniles and calves. Large proportion (Fig. 3) of the group types was observed as lone male and territorial male tending herds in both study sites. Mean size of all female and mixed groups was larger in AWR than in ANP ($p<0.05$ and $p<0.01$, respectively), thus, accounting for the larger overall mean group size in AWR. Male herds (sub-adults and immature males) of size 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.

Group size

Analysis of the data for mixed herds of gazelles in the two populations showed no significant difference ($p=0.795$). Even though, they have smaller population sizes and were more separated, Soemmerring's gazelle herds seem to be more stable. Mean group size at Ilala Sala (ANP), was 4.4 (SD=1.1, SE=0.32) with a range of 1–11. Mean group size at selected study site in AWR, was 16.8 (SD=8.6, SE=2.9) with a range of 1–51. Comparison of frequencies of group types of the gazelle populations for the two areas independently did show significant difference, (i.e. paired sample t-test, $p=0.026$). 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 ($p=0.001$). When test was based on the monthly distribution of the frequency of the group sizes, the difference was not significant at 95% confidence level ($p=0.06$).

Table 1. Group size range and mean total population of Soemmerring's gazelle at the two study areas.

Sex/age	ANP		AWR	
	Range	Mean ± SE	Range	Mean ± SE
Male	4 – 18	9.1±1.1	2 – 50	32.1± 5.0
Female	11 – 29	18.3 ± 1.5	5 – 196	125.7 ± 19.0
Juvenile	0 – 10	4.35 ± 0.9	0 – 63	28.4 ± 7.0
Fawn	2 –12	6.4 ± 0.8	0 – 69	28.4 ± 7.2
Unknown	0 – 9	3.3 ± 1	31 – 715	243.2 ± 84.8
Mean number of Soemm. gazelle		**41.45 ± 2**		**453.8 ± 151**

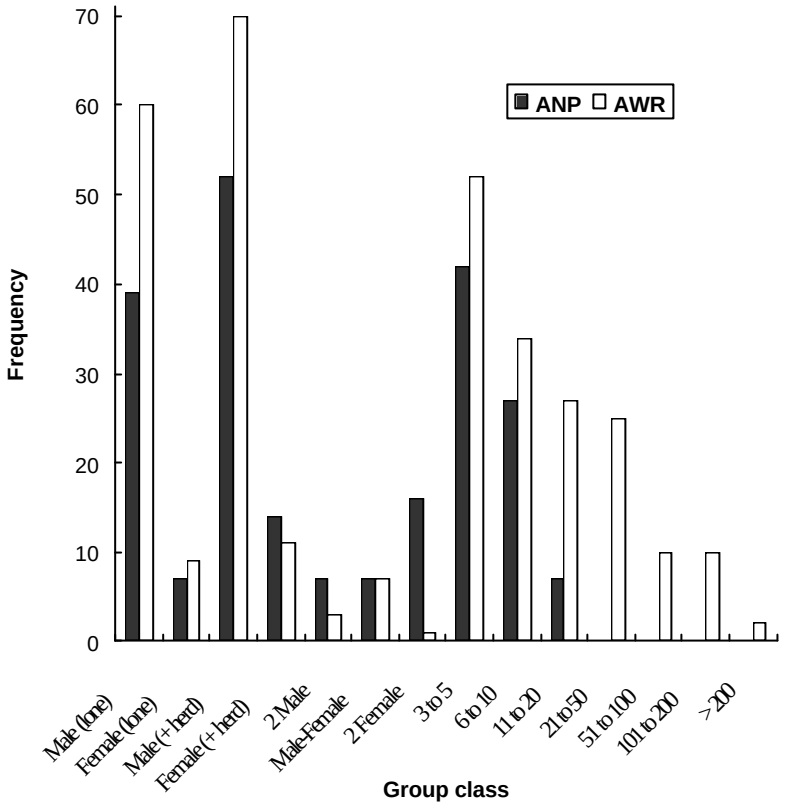

Fig. 3. Frequency distribution of group sizes of Soemmerring's gazelle in the ANP and AWR (Jan-Dec).

Variations in group size:

i) Between the two study areas

Data on group size from the two study areas were treated separately. 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 (Tables 2 and 3).

Table 2. Number of sightings of sex-age category and groups of Soemmerring's gazelle in Awash National Park (from January to December, February was not included).

Age/ Sex	Ilala Sala (ANP)										
	Jan	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
M	36	19	22	8	16	18	11	20	10	6	6
F	54	36	46	21	39	22	31	34	4	8	15
J	4	1	3	3	15	2	6	5	2	8	6
K	21	11	14	12	18	7	11	6	2	3	4
U	8	17	26	0	10	5	0	3	1	5	1
T	127	84	111	44	98	54	59	68	19	29	32
x	4	3.1	6	6	3.4	6	5.9	4	3.8	3.6	4.6
N	32	27	8	8	22	9	10	17	5	8	7

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

Table 3. Number of sightings of sex-age category and groups of Soemmerring's gazelle in Alledeghi Wildlife Reserve (from April to December).

Age/ Sex	Study site at AWR								
	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
M	9	47	33	45	27	59	40	38	9
F	42	196	134	136	123	183	232	156	25
J	21	41	39	55	17	48	19	55	9
K	14	74	45	43	18	55	16	32	2
U	207	30	797	129	110	27	86	573	5
T	293	391	1048	408	295	372	393	854	50
x	29.3	26.1	20.2	18.5	11.8	9.8	8.9	22.5	3.9
N	10	15	52	22	25	38	44	38	13

Note: Same as in Table 2.

The data for AWR show differences in monthly mean group size ($p=0.021$). In the case of the ANP the changes in monthly mean group size did not show statistically significant value ($p=0.414$). The difference in the group size of the gazelles between the two localities was highly significant ($p=0.00$). The proportion of single animals is slightly higher at AWR than ANP. Herds of 3–5 were most common at both Ilala Sala and AWR. However, herd size ranges from 3–250 individuals in the latter.

ii) Between seasons

Due to the differences in the duration of the seasons, data show unequal proportions for wet and dry seasons. 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 ($p=0.091$). Comparisons of group size in different habitats in ANP between the two seasons also showed no significant differences.

DISCUSSION

Population size and group structure

Compared to earlier surveys data in ANP (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, may be because of competition for the existing small suitable habitats. As in most ungulates, male Soemmerring's gazelles are territorial (Jarman, 1974). Fighting and competition could also force bachelor animals to marginal habitats that are poor in food quality, and are more exposed to predation. The number of fawns counted in the area was also very low. The reason for the reportedly low proportion of newborns is not well understood. However, predators could be the possible reasons. Judging from the abundance of the gazelle and the number of groups, the hunting pressure 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 to the earlier report (Thoulles, 1995). However, from the increased nomadic activity in the area, the decline of the gazelle population is a reality. Large portions of the population in AWR is observed at the Southern part of the Reserve, also inhabited by the Afar pastoralists.

The range distribution of Soemmerring's gazelle showed that the species at ANP is confined to the area around Ilala Sala (Fig. 1). It was noted that, they have been eliminated from their previous habitats and localities in the Western and Northern (Sabober, Metehara and North of Filwoha) part of the Park. The currently available habitat for the gazelle is the only well save in the Park for their survival. Human interference such as grazing of domestic animals and hunting are relatively less in this area than in other parts of the Park. Unlike the ANP, AWR possesses large population of the gazelle.

However, the gazelle population in the Reserve has declined drastically when compared to the earlier years (Schloeder and Jacobs, 1993). Human interference in AWR is serious than in ANP. Part of the gazelle population is found in the Southern part of the plain, which is a grazing land of 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 in the Wildlife Reserve ranged from 29 to 54 and from 194 to 892, respectively. 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 surveys, but not for AWR (Fig. 4). Assessments in previous localities of the gazelle revealed that they were absent in most of their earlier range. The present population density of Soemmerring's gazelle in ANP is only 1.3 animals/km^2. Suitable habitats of the gazelle in ANP were calculated to be about 430 km^2. But, unlike the estimate of Robertson (1970) (7.1/km^2), the current estimate for the overall habitats is too small (0.1 individuals/km^2). The mean density in AWR is 1.82 individuals/km^2. These figures show that the density is higher in the Wildlife Reserve than in Awash National Park.

Currently, there are only few non-domestic ungulates, in both ANP and AWR, the dominant being Beisa Oryx and Soemmerring's gazelle. Livestock are the most numerous animals, resulting in a year round grazing and trampling, and thus affecting the vegetation structure of the areas. Prolonged association between grazers with slightly different feeding habits could result in the creation and maintenance of conditions favourable to one or several species in the area (Bell, 1970), provided that the density is limited to the carrying capacity. Ungulates have the strategy of utilizing their habitats developed through their evolutionary adaptation (Western, 1975; Rodgers, 1977). Such evolutionarily developed strategies could have enabled the gazelles to use the wide habitats sustainably to ensure their survival. However, the rapid increase of domestic animals disrupts this adaptive strategy.

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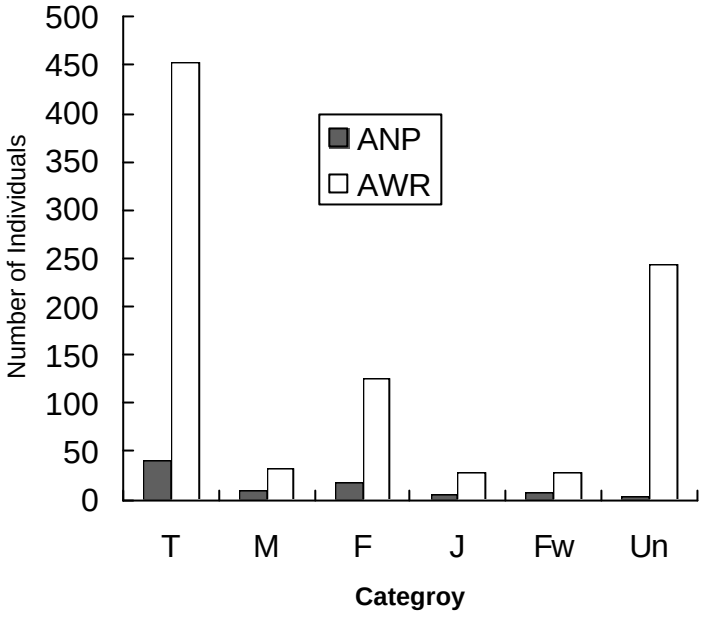

Fig. 4. Population Distribution of Soemmerring's gazelle at the two study areas (T=Total, M=Male, F=Female, J=Juvenile, Fw=Fawn, Un=Unknown).

The gazelle populations of the two sites show a number of similarities and differences in their group sizes. Relatively dense cover and open grassland areas characterized the gazelle habitat in ANP. But the AWR population occupies a brushy savanna region with areas of bare, moderate and dense cover and large expanses of open grassland. Females containing juveniles and separate groups of adult males were the two main social units. In most ungulates, seasonal changes in group size seem to be linked with the distribution and abundance of food. It is the availability of green vegetation or its patchy distribution, as well as over-stocking of domestic stock that affect the abundance of vegetation and hence the distribution and group size of the gazelle (Western, 1975). The study population showed similar pattern.

Ungulates form large group size during the wet season and decline throughout the dry season (Durant *et al*., 1986). However, this was not observed from the results of the present study possibly because of the degradation of the natural habitats. 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. Data on grouping patterns of herbivores may be indicative of the effects of a changing environment (Leuthold and Leuthold, 1975), reproductive behaviour (Jarman and Jarman, 1973) and environmental disturbance resulting from heavy grazing, fire, alien invasive species and other factors.

Group size

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. Group size and composition may be influenced by a variety of environmental factors, in addition to being broadly determined by a species propensity for a certain type of social organization. It was noted that some groups of Soemmerring's gazelles leave the study area in AWR as indicated by the changes in the number of females and juveniles, each month (Tables 2 and 3). The population of this species in ANP did not show seasonal or monthly fluctuation, as suitable habitat is limited. There is a possibility for the population of Soemmerring's gazelle of the study area in AWR to move to other

localities. However, local migration between the two sites is not possible due to the presence of the gorge, which is difficult to cross from either side. 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. The difference in the mean group size 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 in forest (Walther, 1972; 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. The widely accepted explanation for very pronounced inverse relationship between group size and density is that it is an adaptation for predator avoidance (Estes, 1974 cited in Estes, 1991). 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).

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. Females were observed more often in territorial areas than in non-territorial areas. This shows that better quality of forage exists in the territories held by the territorial males. Furthermore, female groups seem to get advantages being with territorial male. When in mixed groups, male gazelles spend much time tending the herd, which could affect the amount of time spent on feeding. Wirth and Oldekop (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).

It was 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 in the two sites. The two sites are under high pressure being used as grazing lands. Biomass of livestock far exceeds that of the wild ungulates in the area. The tradition of nomadism, moving cattle from one locality to the other, seems to have changed to a kind of sedentarism, perhaps as a result of increase in human population and livestock. This situation has resulted in habitat change due to overgrazing. Establishment of waterholes in both the National Park and in the Wildlife Reserve has attracted many pastoralists to settle around these conservation areas permanently, affecting the wildlife population size.

Territorial ungulates require ample size of suitable habitats that are good enough to attract reproductive females. Loss of ecologically important habitats would have a serious impact on the continuity and survival of the breeding population. Survival of viable populations of this species in the areas is dependent on the existence of resourceful habitats. 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 habitats can be maintained only through ecologically acceptable measures and by avoiding bush encroachment. With the prevailing situations in both the study areas, it is difficult to maintain the population size of the gazelle.

ACKNOWLEDGMENTS

We would like to express our sincere gratitude to the Research Programme on Sustainable Use of Dryland Biodiversity (RPSUD)/SIDA/SAREC for providing financial support to carry out the study. One of the authors, B.G.M., would also like to thank the Amhara National Regional State Agricultural Bureau for allowing and sponsoring part of his MSc study. The help offered by the staff at EWCO, and Awash National Park is also acknowledged.

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