ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

POPULATION SIZE AND SEASONAL DISTRIBUTION OF THE HIROLA (*Damaliscus hunteri;* Sclater, 1889) IN SOUTHERN GARISSA, KENYA

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DEDICATION

This work is dedicated to my late grandmother, HABIBA IBRAHIM, to whom I owe my interest to write with the pen.

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ABSTRACT

The study on the population size and seasonal distribution of the Hunters' hartebeest also known as Hirola (*Damaliscus hunteri;* Sclater, 1889), was conducted in southern Garissa, Kenya for 6 months that included a dry and a wet season. Monthly ground counts of this species were carried out in an area of about 12,000 km^2 of its natural habitat. The specific objectives of this study were to determine the current population size, its seasonal distribution, habitat preference and demographic compositions of the Hirola herds. The study showed the Hirola population in Southern Garissa consisted of about 1416 individuals. Vegetation specific observations of the Hirola individuals indicated a marked preference for less wooded vegetation and relative avoidance of the densely wooded habitats. These facts were more marked during the wet season. The chief characteristics of its preferred habitats were shrubby-grasslands with low woody canopy cover. However, habitat preferences were different for the Hirola social classes, period of season and prominent activity patterns. The Hirola distribution in the different range units was not uniform during the dry season. Relative combination of green forages, vegetation cover, livestock and human densities were the primary proximate cause of the Hirola seasonal distribution. These were largely determined by the temporal and spatial patterns of rainfall. The Hirola concentrated in ephemeral areas containing residual green forages during the dry season and dispersed randomly and uniformly when rain falls. The Hirola group structure varied seasonally and locally thus indicating differential distribution of sex and age classes. Apart from eco-climatic determinants of group sizes, other factors such as the social class and male dominance influenced the Hirola herd sizes and composition. Females constituted about 40.3% of the total Hirola observations.

Relatively high proportion of young and yearling indicated a healthy growing population. The study established the main threats of the Hirola to be sporadic hunting, predation, and competition from livestock, expanding human settlements and bush encroachment in its key habitats.

1.0. BACKGROUND AND LITERATURE REVIEW

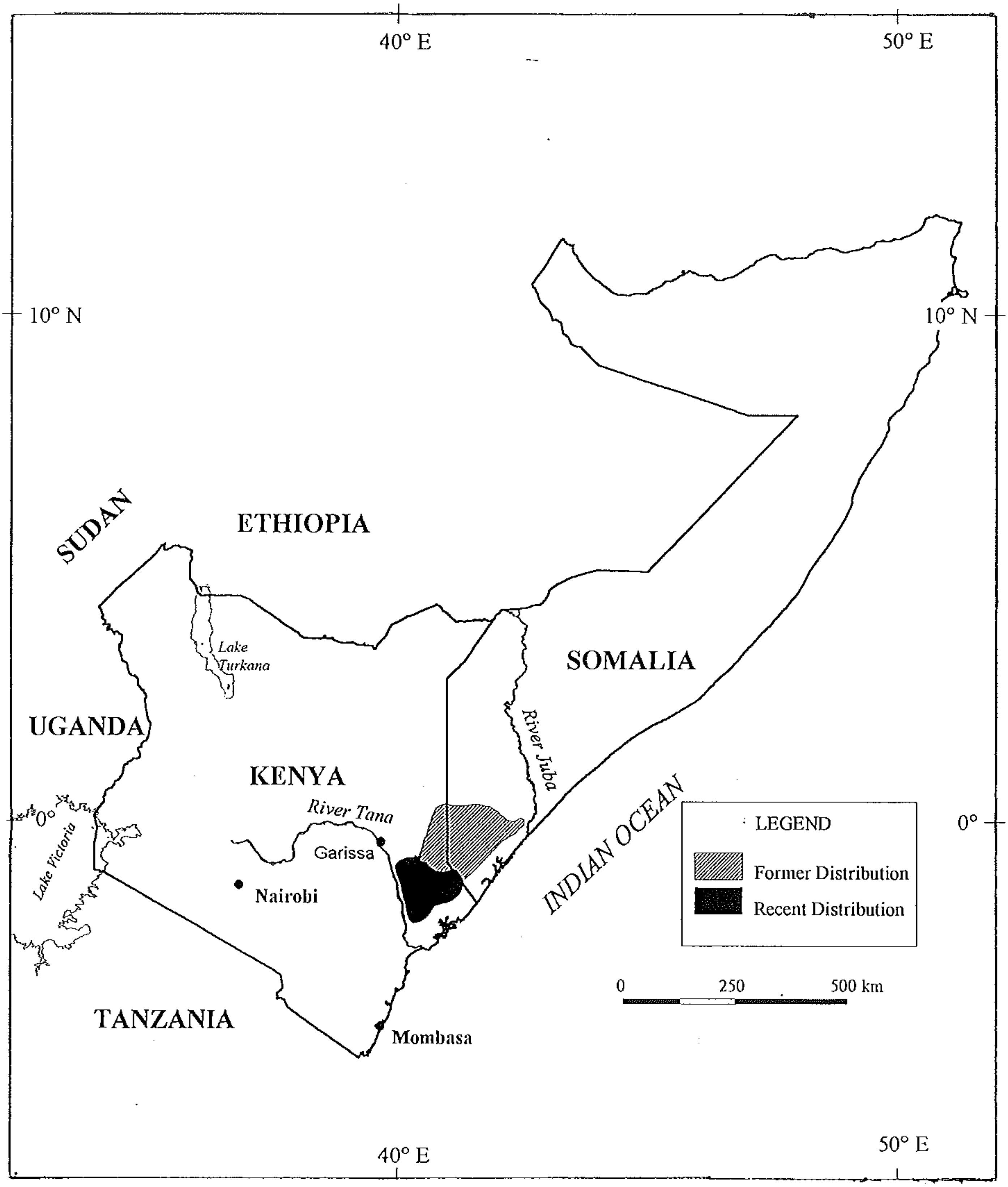
1.1. INTRODUCTION

Animals form a dynamic relationship with their environment that can be studied at two different levels of time and space (Jarman, 1972; Gorfield, 1973; Norton-Griffiths, 1975; Inglis, 1976). The temporal and spatial variation in resource availability is a characteristic feature of many savanna ecosystems of Africa (Jarman, 1974; Pennycuick, 1975; Inglis, 1976; Western, 1976). The seasonal variations in the availability of the required resources affect aspects of ungulate ecology such as its population distribution (Sinclair 1983; Fryxell, 1987), reproductive seasonality (Dunham *et al*, 1982), habitat preference and activity patterns (Duncan, 1985; Kufeld *et al*, 1988). Thus the seasonal distributions of animals are linked with shifting distribution of critical resources (Inglis, 1976; Western, 1976). Seasonal migration is a particularly successful strategy for coping with resource scarcity in the highly seasonal environments.

Non-migratory African herbivores satisfy their nutritional requirements within limited home range by seasonally shifting between habitats within their limited ranges (Lamprey, 1963; Jarman, 1972) and selecting varying plant species (Stanley Price, 1977; Kutilek, 1979; Owen-Smith, 1982). However, due to the increasing human and livestock population pressures, habitat fragmentation, and other exogenous factors, these seasonal migrations and probably the shifting between habitats have become disappearing phenomena (Steflox *et al*, 1986; Ochiago, 1991; Wargute *et al*, 1993; East *et al*, 1995; Sutherland, 1996). Thus, natural populations are continuously declining in numbers due to the shrinkage of their natural habitats, and even some have become extinct (Fryxell, *et* *al*, 1988). In this respect, the declines of large mammals are attributed to starvation resulting from the loss of their habitats and restriction to their ways of coping with seasonally changing habitats (Caughley *et al*, 1994; Williamson, 1987; Rosenzweig, 1995). The Hunter's Hartebeest (*Damaliscus hunteri*), popularly known as Hirola, is among the antelopes in Africa that are faced with possible elimination from their natural habitats (East, 1988; Sinange, 1992; Wargute *et al*, 1993; Ottichilo *et al*, 1995; Andanje *et al*, 1996; Chris, 1996). The recent alarming reports concerning the declining numbers of the Hirola have captured the attentions of conservationists (Agatsiva, 1992; Sinange, 1992; Wargute *et al*, 1993; Ottichilo *et al*, 1995).

The Hirola belongs to the Family *Bovidae* and Subfamily of *Alcelaphinae*, which include the topi, wildebeests and hartebeests. Weighing about 80kg, the species is the smallest antelope in this Subfamily (Bunderson, 1976; Kingdon, 1982). The Hirola is physically different from its congeners by having unusual horn configuration though it possesses the general features of hartebeest (Bunderson, 1976; Dorst *et al*, 1970; Kingdon, 1982). Its historical range is confined to small remote areas between the lower Tana River in the eastern Kenya and River Juba of Somalia (Grimwood, 1964; Bunderson, 1976; Kingdon, 1982) although it has now been exterminated in the Somalia range (Fig. 1). The range is naturally demarcated by these two rivers (Bunderson, 1976) and by the waterless thorn-bush in the north and the coastal forest mosaic in the southern end (Bunderson, 1976; Kingdon, 1982; East, 1988). Owing to its very restricted distribution and low numbers, the Hirola is considered to be one of the most endangered

Figure 1. World distribution of the Hunters Hartebeest (Hirola)
(After Bunderson, 1976)



antelopes in Africa and is now classed in the IUCN list as critically endangered (Wargute *et al*, 1993; East *et al*, 1995; Chris, 1996). Although it was once extremely numerous in Somalia, it is now belied to survive only in Kenya.

Kingdon (1982) does not regard Hirola as having peculiar ecological requirements and instead suggested that it is more generalised than the other *Damaliscus* species such as the topi (*D. lunatus jimela*) and species of the genus *Alcelaphus*. Hirola survived in their relict distribution due to the absence of other hartebeests which are the most likely ecological competitors (Kingdon, 1982). The Hirola may be relict population of a formerly widespread damaslicine that was later replaced by successful topi (Sclater, P & Thomas, O, 1894. *In:* Kingdon, 1982).

The typical hartebeests (*Acelaphus bucelaphus*) have evolved very recently and have probably been kept out of the Hirola range by the geographic barriers of the two rivers and the sub-desert to the north (Grimwood, 1964; Bunderson, 1976; Kingdon, 1982). Conservative and sedentary habits have been reported in hartebeests which have evidently inhibited their gene flow (Kingdon, 1982). Sclater, P & Thomas, O (1894, *In:* Kingdon, 1982) recognised eight species of hartebeests which represent very distinct allopatric populations, each of which is adapted to local conditions and climate in well defined vegetation belt. Unlike its close relative member, the topi in East Africa, which is adapted to semi-arid conditions, the Hirola occur in an arid and mostly waterless area (Kingdon, 1982). Hirola habitats have been described as grassy-shrublands and scattered thorny bushlands dominated by evergreen *Dobera-Salvadora* tree species (Bunderson, 1976; DRSRS, 1991, Sinange, 1992, Wargute *et al*, 1993). The Hirola, which occur in social groups, are normally observed in close association with other herbivores (Bunderson, 1976; Andanje *et al*, 1996). The species is mainly grazer (Dorst *et al*, 1970; Kingdon, 1982) and probably can browse during the dry season. The territorial males accompany the female herds and defend their territory aggressively by scent marking on vegetation and dung piles while non-territorial males associate in bachelor herds (Kingdon, 1982).

Little is known about the ecological behaviour such as the seasonal distributions and habitat preferences of the Hirola. The available scanty information is scattered through numerous unpublished conservation literatures (Wargute *et al*, 1993; Agatsiva, 1995; Chris, 1996). Although conservation measures were taken in Kenya, the Hirola populations have declined drastically over the years. Its worst population decline was probably recognised after the civil war in Somalia when the Kenyan ranges came to bear extra pressures from the refugees and their livestock (Wargute *et al*, 1993; Andanje *et al*, 1996; Chris, 1996). This study was conducted as part of the population monitoring process in Kenya and to document aspects of its ecological requirements.

1.2. LITERATURE REVIEW

The conservation measures of the Hirola have been precarious for the last 25 years (Sinange, 1992; Wargute *et al*, 1993; Agatsiva, 1995; Ottichilo *et al*, 1995). In early 1960's, the lower Tana River region was earmarked for an intensive settlement scheme under irrigation and livestock development industry (Bunderson, 1976; Kingdon, 1982;

East, 1988). This aroused great concern about the future of the Hirola since the area included its natural range (Bunderson, 1976). In an effort to preserve the species, Arawale National Reserve was established in 1974, east of lower Tana River (Kingdon, 1982; East, 1988). At the same time the species was introduced into Tsavo East National Park in 1963 in an attempt to extend its ranges (Grimwood, 1964; Bunderson, 1976).

Its natural ranges extend from the southeastern part of Kenya, all the way into the Bush-Bush National Park in the southwestern corner of the Republic of Somalia (Dorst *et al*, 1970; Bunderson, 1976; Kingdon, 1982; East, 1988 & 1995). The greatest numbers of the Hirola reside in the Kenyan part of the range, specifically in the southern Garissa district (Bunderson, 1976; East, 1988). Even though few Hirola individuals were reported in 1982 in Somalia (Kingdon, 1982), its precise population status is presently unknown (Wargute *et al*, 1993; Ottichilo *et al*, 1995; Chris, 1996).

Early accounts of the Hirola in Kenya (Grimwood, 1964; Watson, 1973; Bunderson, 1976, 1977 DRSRS, 1978, 1980, 1983) showed varying Hirola population estimates (Bunderson, 1985; Wargute *et al*, 1993). These population estimates were mostly speculative due to the harsh conditions and difficulties in the accessibility of the terrain and the insecurity situation due to banditry (Bunderson, 1976 & 1981). The Hirola populations in Kenya and Somalia were considered separately since the surveys were usually made on national boundary basis (Chris, 1996). However this does not imply that the Hirola in the two ranges belong to discrete populations. It is likely that Hirola would move freely between the two ranges in an undisturbed condition although such information on its natural movement pattern is lacking (Sinange, 1992; Wargute *et al*, 1993; Chris, 1996). It is possible that the present population decline in the Kenyan range was due to the Hirola movement across the border into the Somalia range since the species is believed to be highly mobile in its natural ranges, (Wargute *et al*, 1993; Ottichilo *et al*, 1995; Western, in press). It has been suggested that pastoralists with their livestock moving out of the war torn Somalia have created an ecological space for wild animals. This may have facilitated the movement of wild animals from the Kenyan ranges into the Somali ranges (Sinange, 1992; Ottichilo *et al*, 1995; East *et al*, 1995; Ottichilo *et al*, 1995).

Much of what is known about the Hirola is from Bunderson (1976, 1981) who studied its distribution (Bunderson, 1976) and interactions with domestic animals (Bunderson, 1981). These studies revealed that the Hirola showed varying distributions between the wet and the dry seasons. This is a common phenomenon observed in savannah ungulates especially when their range size is not limiting (Wargute *et al*, 1993). The increasing humans and livestock densities, the seasonal ranging patterns of the Hirola is brought to restrictions as its natural habitats are bound to shrink (Wargute *et al*, 1993; Agatsiva, 1995; Ottichilo *et al*, 1995). The Hirola has probably suffered the greatest contraction of its range due to competition from livestock and human settlement, which have direct effects on its numbers. Very broad equivalence of diets have been reported in cattle and hartebeest and that the expansion of cattle in Africa is almost certainly the primary cause of the species, decline.

There had been enormous decline of the Hirola population from approximately 12,450 (Bunderson, 1976) to 1725 (Wargute *et al*, 1993). The population estimates by Kenya Wildlife Services (1995) gave alarmingly low numbers of about 300 Hirola individuals remaining in the Kenyan range. This marked a population decline of about 89% within a period of merely two years. However this population estimate is extremely very low and probably not the true picture of the current Hirola population (Butysinki, pers. comm.). Aerial survey is an important method for estimating the populations of large mammals especially in huge areas (Norton-Griffith, 1978). Its use is mostly limited when the area is bushland (Norton-Griffiths, 1978) as observed in the Hirola ranges. Ground counts usually give excellent and consistent result especially in small to medium sized areas which is important in obtaining data on the seasonal patterns and distribution of the species within different vegetation types (Norton-Griffiths, 1973). The underestimation of the Hirola numbers could also be attributed to the discontinuous distribution of the Hirola in the highly changing physical environment within its ranges. In addition, single counts of animals in any area and at one time is not sufficient enough to give the true picture (Heady *et al*, 1986). Animal counts need to be repeated in different seasons and years to show the kinds of changes and trends.

Regardless of the great concerns given to its conservation since early 1960's, the implementation of its protective measures was a problem (Sinange, 1992;Wargute *et al*, 1993; Ottichilo *et al*, 1995). When the declining numbers of the Hirola was noticed, a multi-institutional Hirola Task Force was established in 1994 to examine the Hirola problem and act as a forum for initiatives to conserve the species (Agatsiva, 1995;

Andanje *et al*, 1996). Acting on the recommendation of the Task Force, *ex situ* conservation was emphasised. About 17 Hirola individuals were successfully released into the Tsavo East National Park to reinforce the gene pool of the previously introduced sub-population (Andanje *et al*, 1996). The Hirola Task Force also preferred an *in situ* management of the Hirola in its natural habitats (Agatsiva, 1995). However, before implementing any *in situ* conservation measures, comprehensive field studies on its current population size, the ecological requirements and seasonal movement patterns of the Hirola were important.

1.3. JUSTIFICATION

It is the interest of the conservation community and the local wildlife protection departments to ensure the continued existence of wild animals, particularly those species with endangered status (East, 1995). This is essential for the conservation of biodiversity, ecosystem stability, human economics, recreation and culture (FAO, 1995). To achieve these goals, threatened species must be monitored regularly in order to account for their status. Such updating studies about species' current status are indispensable to facilitate corrective measures at the appropriate times.

Population fluctuations of species are common phenomena, which are usually inter-related with habitat conditions (Jarman, 1972; Inglis, 1976). Thus managers need data on such population fluctuations and trends in order to understand the causes and to manage the species and their habitats. Presently, little is known about the current population status, seasonal distribution and the ecological requirements of the Hirola. Effective conservation measures can not be achieved successfully without being fully knowledgeable about the species' status.

1.4. OBJECTIVE

The main objective of this study was to determine the current population size, the temporal and spatial distribution, and aspects of herd structures and demographic composition of the Hirola in southern Garissa ranges

The specific objectives of this study were to:

i) determine the current population size of Hirola in the southern Garissa and to compare the results with previous estimates in the same range.

ii) describe the seasonal habitat preference of the Hirola in its natural range in order to establish its ecological requirements

iii) investigate the spatial distribution and seasonal movement patterns and compare the result with past distribution patterns

iv) assess the demographic composition of the Hirola herds

v) monitor some dynamic processes (births, deaths and migrations) of selected Hirola groups

1.5. STUDY AREA

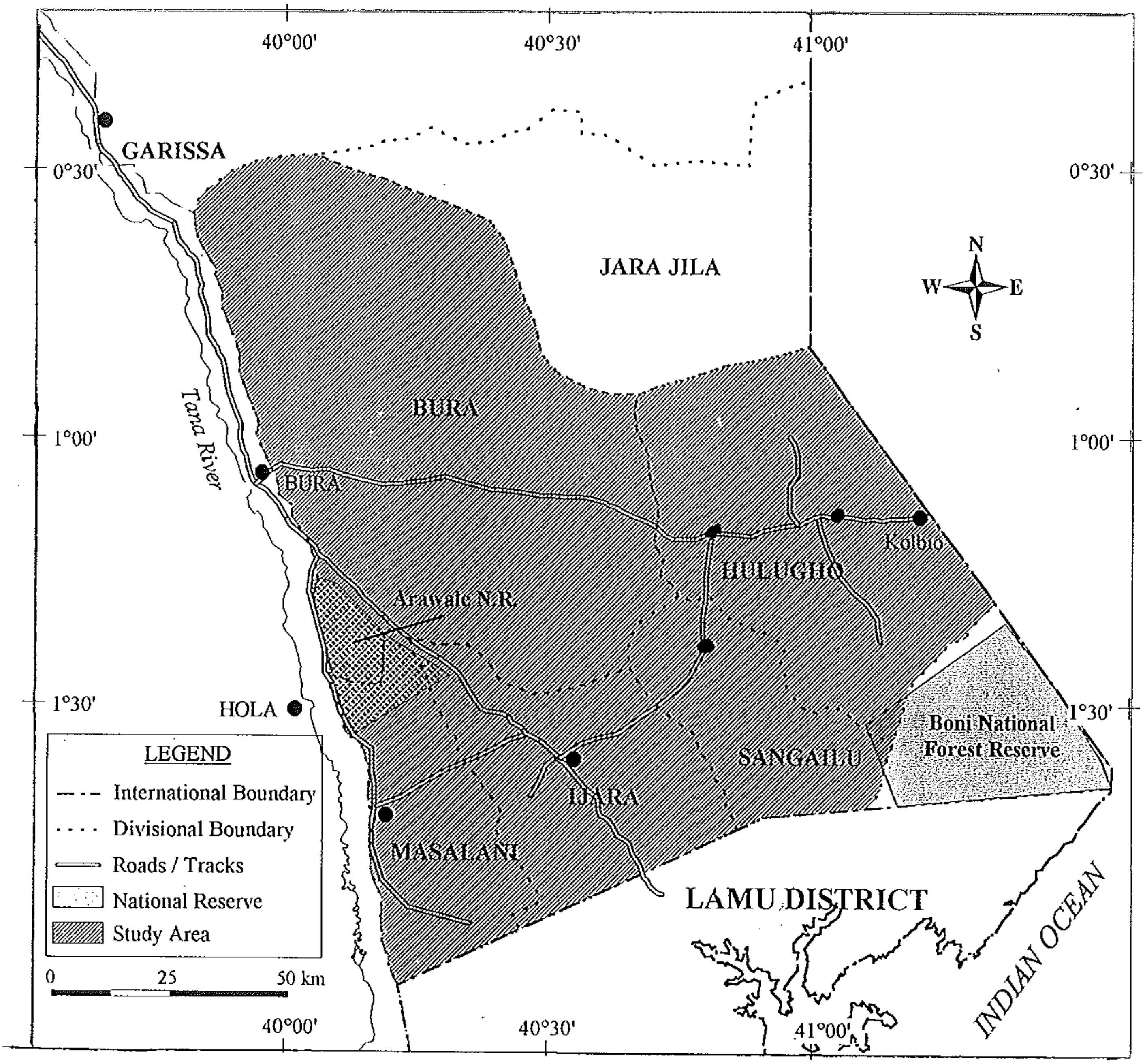
1.5.1. Location and area size

The study was conducted in the southern Garissa range in Kenya, which is the major Hirola concentration area. The study area is located between latitudes of 0° 15′ and 01° 58′S and longitudes of 38° 34′ and 41° 32′ E. The area is administratively within Garissa district, east of River Tana between Bura division to the north and Masalani division to the south (Fig. 2). The study area covered about 12,000 km^2.of the Hirola range in Kenya.

1.5.2. Topography and vegetation

The area has an altitude ranging between 100 m and 450 m above sea level. Its geology of is characterised by quaternary sedimentary rocks (IUCN/UNEP, 1987). The soils range from patchy dark clay alluvial soils along river basins to dominating gray cotton soils (DDP, 1988) which has poor drainage ability during the rainy season when it becomes loose and sticky. Many parts of the Hirola range in the Southern Garissa are mainly drainage basins. The River Tana that runs along the western boundary of the range is the only permanent water source in the area. The river has tremendous influence over the climate, settlement patterns economic activities of the people within the Hirola ranges. The seasonal river basins, flood plains and valley bottoms provide dry season grazing areas for domestic and wild herbivores (Bunderson, 1981). The range is devoid of mountain ridges and deep valleys and is generally flat, liable to flooding. The absence of such topographic features facilitates easy seasonal mobility and distribution patterns of domestic and wild animals in search of better pasture.

Figure 2. Location of the study area in southern Garissa



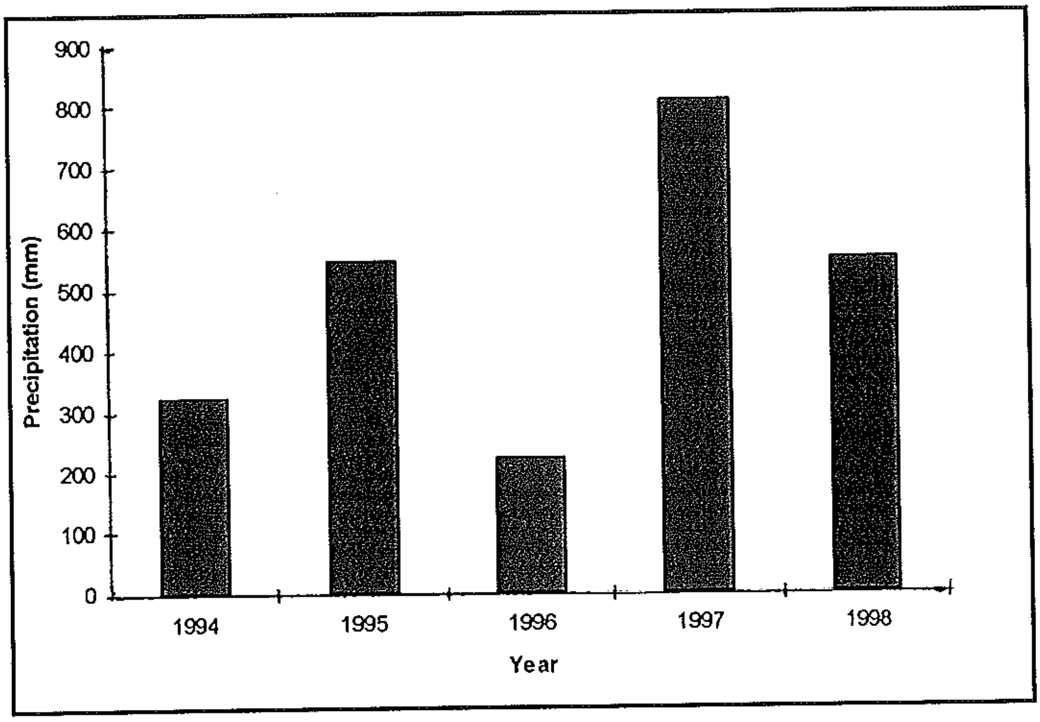
Natural forest occurs as patchy riparian forest along the River Tana and the gazetted Boni Forest Reserve in the southern limit of the range. Based on the LANDSAT and SPOT imagery of the vegetation map of Kenya, the range vegetation is categorised as scattered bushland, dwarf shrubland and grassland habitats (DRSRS, 1991). Generally, the range consists of variably bushed grassland and wooded savanna vegetation with scattered to bushed acacia trees and shrubs of low statures (Bunderson, 1976; IUCN, 1987; DRSRS, 1991). Vegetation of the area consists of *Dobera-Salvadora* and *Acacia-Combretum* and *Brachestegia* woodlands characterised by deciduous tree species. The predominant woody plants include; *Acacia* spp., *Grewia* spp., *Dobera glabra, Salvadora persica, Balanites* spp., *Terminalia* spp., *Combretum* spp., *Cordia* spp. and *Cadaba* spp. The tree cover becomes dense towards the coastal region, which is dominated by *Brachestegia* and coastal mosaic woodlands (DRSRS, 1991) unsuitable for the Hirola.

1.5.3. Climate and rainfall

The geographical range of the area falls within a climatic zone intermediate between humid coastal strip and the semi-arid hinterland (Kingdon, 1982). Although there was no specific rainfall data for the study area, the climatic conditions recorded at Garissa meteorological station somewhat holds true for the study area too. The mean annual rainfall in the range measured over the past five years was about 500 mm (Fig. 3). The annual distribution of rainfall pattern in the region is bimodal type. Normally the peak rains fall in May while the minor rains fall in November. The main dry period is from June to October with a shorter dry season between January and March.

The mean monthly temperatures are relatively constant throughout the year but diurnal variations can be considerable (DDP, 1997). The mean temperatures were about 34^0C during the dry season and 28^0C during the wet season. Predictably, relative humidity follows the rainfall patterns and the weather conditions. During the dry seasons, the cloud covers are at minimum and wind speeds are at its annual maximum. These contribute to high level of evapotranspiration in the area associated with tropical climatic patterns.

Figure 3. Mean annual rainfall (mm) from 1994-1998



(Source: Garissa Meteorological Department, 1998)

1.5.4. Land use and Human settlements

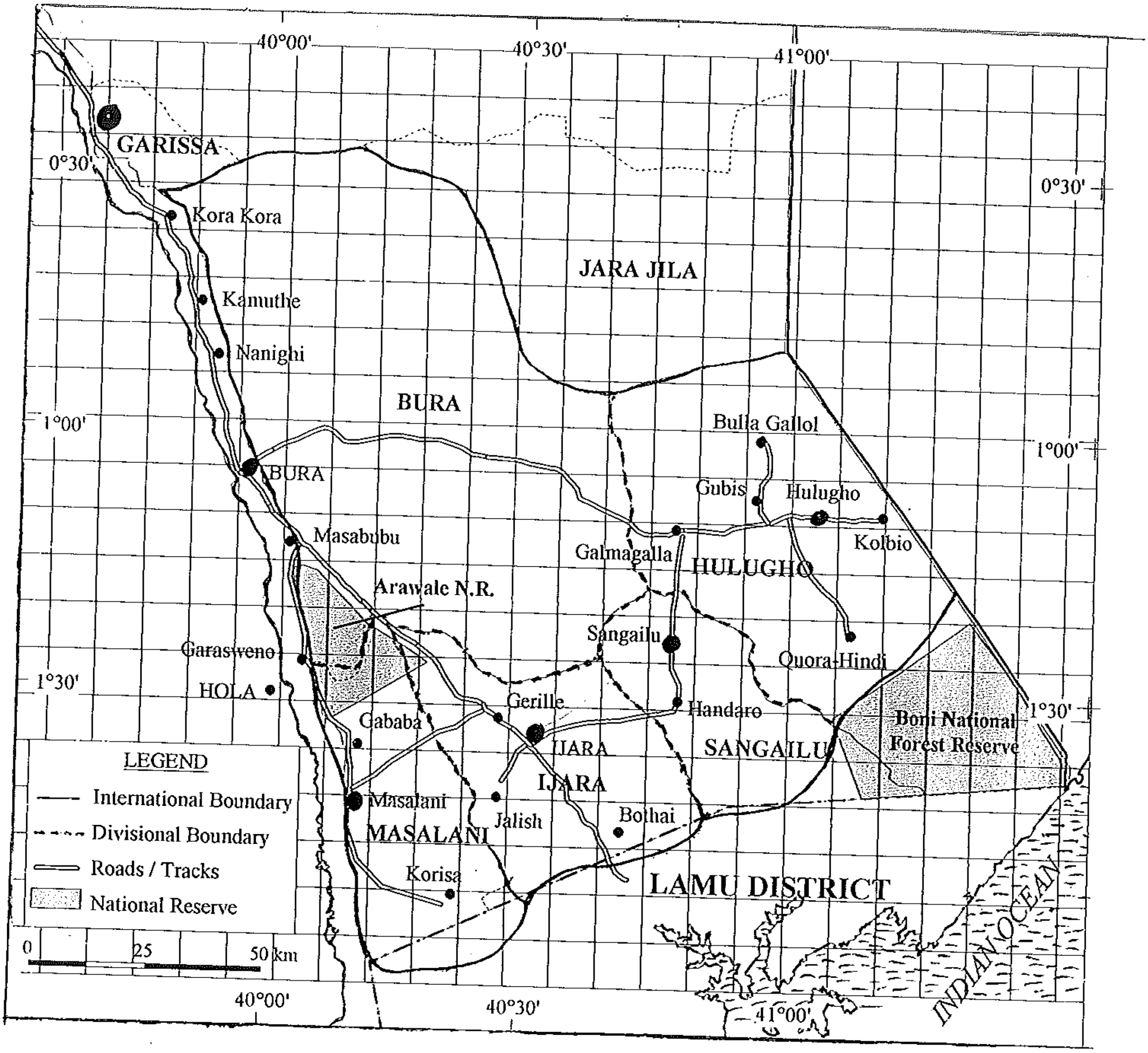
Given the arid condition of the area, nomadic pastoralism is the major occupation and all other activities depend on livestock production. The people that inhabit the Hirola ranges belong to 3 main ethnic groups, namely the Pokomo, Orma and the Somali communities. These ethnic communities have varying traditional lifestyles and socio-economic activities. The Pokomo are sedentary river community whose livelihood depends on cultivation and some fishing activities. The Somali and the Orma communities depend on large herds of cattle and are semi-nomadic pastoralists. The farming activities and the pastoralism have affected the stability of the range ecosystems. Shifting cultivation by the farmers and setting of fire on the grassland by the herders are both problematic (Ochiago, 1991). Subsistence farming activities are presently concentrated along the riverside alluvial soils and flood reseeding zones. The river is useful for irrigation when rainfall is minimal. Rainfed cultivation is also carried out in the area beyond the river. The main subsistence crops grown include cereals like sorghum, millets, maize and beans, and fruit trees of mango, papaya, banana and tomato. The Pokomo community also practice bee keeping.

A survey conducted by DRSRS (1996) showed the presence of some 230,000 cattle and 140,000 sheep and goats in the Hirola range, although these numbers have declined compared to the past years. Livestock distributions in the range significantly depend on the patterns of rainfall and pasture quality. During the dry season most of livestock are concentrated in the areas adjacent to the Tana River for water and better pastures (Bunderson, 1981). Tsetse flies menace and other animal diseases, which are common in the area also affect the distribution of livestock in the range. Livestock development industry established in the Hirola ranges in early 1970's increased the cattle populations. The subsequent competition between domestic and wild herbivores was intense and perhaps contributed to the decline of the latter.

In addition to the natural communities of the range, there are about fifty settlement centres and villages established in the Hirola area (Fig. 4). Most settlements are situated along the River Tana. Some of them such as Bura East and Bura Tana had dense populations resulting from an earlier employment in the agricultural irrigation schemes. Settlements such as Ijara, Sangailu and Hulugho are dominantly inhabited by semi-nomadic pastoralist and are sparsely populated (DDP, 1997). The expanding human settlements in the range caused the reduction and impoverishment of the rangeland pastures for both domestic and wild animals. The depletion of vegetation covers in and around these settlements centres became common resulting from increasing demand for fuel wood and building materials.

The sudden and often massive loss of livestock due to persistent droughts, diseases and cattle raidng forced the formerly pastoral people to settle. In addition, the government through modern social services such as schools and health services encourages people to become sedentary. Such sedentarisation led to the loss of critical grazing areas and overgrazing of areas around the settlement areas. Cultivation in the floodplains and watercourses deprive domestic and wild herbivores of the best dry season grazing areas.

Figure 4. Settlements in the study area (showing divisional boundaries)



Overgrazing and the haphazard establishment of settlements led to the deterioration of the range conditions and the invasion of undesirable range plant species composition (Wargute, 1992).

2.0. STUDY METHODS

Reconnaissance survey conducted prior to the fieldwork revealed that the study area, which is extensively large, was not homogenous in vegetation cover, human settlements, and livestock population and rainfall distribution. These factors influenced the Hirola population distribution. Hence the study area was divided into five range block units following the boundaries of the divisional administrative units, namely Bura (block 1), Masalani (block 2), Ijara (block 3), Sangailu (block 4), and Hulugho (block 5). The area proportions of the range block units are shown in Table 1. Each range block unit was then subdivided into five sample quadrats. Out of the total 25 possible quadrats in the whole study area, 20 sample quadrats were randomly selected and marked for sampling using random numbers. Foot counts method was designed in each sample quadrats since vehicle count was impracticable due to the limited ground access.

The survey on the population size, habitat preferences, seasonal distribution and the observations on the groups demographic composition were carried out in the 20 sampling quadrats of the 5 range block units within the study area (Table 2).

Table 1. Estimated area sizes and proportions of the range block units (Estimated from District Administrative boundaries 1997)

Range Block Unit	Block area (km^2)	Block Proportion
Bura	2970	0.24
Masalani	2240	0.18
Ijara	2600	0.21
Sangailu	1950	0.15
Hulugho	2780	0.22
Total	12540	1.00

The censuses were conducted for 3 months of the dry season (August to October 1998) and 3 months of the wet season (November 1998 to January 1999). Specific methods followed to achieve the various objectives of the study are detailed below:-

2.1. Population size estimate.

Intensive ground survey within the established sampling quadrats was used to obtain the Hirola population size. Animal observations began at the same in all the 20 sampling quadrats, between 0630h and 1030h; 1530h and 1830h for 5 consecutive days per month, with help of trained Hirola scouts. This was achieved by walking systematically in East-west direction with help of pair of compasses at the speed of 3-4 km per hour.

Table 2. Number and sizes of the randomly selected sample quadrats in the range block units

Range Block Units	Number of Quadrats	Total area Samples (km^2)	Proportion of Sampled area
Bura	4	2380	0.24
Masalani	5	2240	0.23
Ijara	3	1560	0.16
Sangailu	5	1950	0.20
Hulugho	3	1668	0.17
Total	20	9798	1.00

Whenever Hirola herds were observed, the number of individuals in the group, observable coordinated activities and the presence of other animal species in the vicinity were also recorded (Appendix 1). Minimal disturbances were maintained to avoid scaring away or to cause abnormal animal movements. Repeated counting of the same groups was avoided using easily recognisable features such as the individuals' body condition, group size, group composition and distinct individuals with broken or malformed horns as in Yoaciel (1981). The censuses were repeated for the two seasons (dry and wet) in order to achieve representative population estimates. The discrepancy in the population estimates between the dry and wet season was noted. Jolly's method 1 (Jolly, 1969a) was used to calculate population estimate (PE) assuming equal sample quadrats.

The formula used to calculate the population estimate (PE) and population standard error (SE) was: -

$PE = N\bar{y}$; $SE = \sqrt{N (N-n) s2/n}$

Where: - **PE** = Population estimate

N = Number of sample quadrats in the study area

$\bar{y}$ = sample population mean

SE = Population standard error

n = Number of sampled quadrtas

s^2 = Sample variance

2.2. Habitat preference

Seasonal habitat selections of the Hirola were determined from the same set of 5 range block units (Table 1). During reconnaissance study, the area's vegetation was classified into seven main structural types with increasing density of wood components and quantified on the basis of the criterion developed by Pratt *et al* (1977) (Table 3). These are grassland (G), wooded grassland (WG), bushed grassland (BG), woodland (W), bushed woodland (BW), Shrubland (SH) and bushed shrubland (BSH). Differences in grass cover determined the main vegetation types whereas tree and shrub cover provided a secondary classification of the grasslands into wooded and bushland (Pratt *et al*, 1977). Each vegetation type was assumed to have represented a distinct category of resources such as food, water, shade and cover.

At each observation of the Hirola herds, records were made on the site vegetation type and estimated size, cover conditions and the dominating trees and grass species. Taking group sightings as scores with respect to habitat types and comparing their frequencies to the relative availability of vegetation types, it was possible to detect habitat preferences (Harvey, 1974). The preferred habitats were deduced from the categories of vegetation types that had the highest frequency of Hirola herds observed. The numbers of the Hirola herds sighted in the different vegetation types during the presumed active feeding periods between 0730h to 1030h and 1530h to 1830h were also used to predict habitat preference and the critical resource areas. The average Hirola observed in each vegetation types were compared with the numbers expected if the animals had been randomly distributed in respect to vegetation types using chi-square goodness of fit.

Table 3. Estimated sizes of the sampled vegetation

Vegetation Type	Area cover (km^2)	Proportion (%)
Grassland (G)	1587	16.2
Wooded grassland (WG)	1470	15.0
Bushed grassland (BG)	1372	14.0
Shrubland (SH)	1577	16.1
Bushed shrubland (BSH)	1391	14.2
Woodland (W)	1274	13.0
Bushed woodland (BW)	1127	11.5
Total	**9798**	**100.0**

The plants and grass species observed to be consumed by the animals were collected for Herbarium identification. The most commonly taken plant species during the dry and wet season were observed.

the relative availability of vegetation types, it was possible to detect habitat preferences (Harvey, 1974). The preferred habitats were deduced from the categories of vegetation types that had the highest frequency of Hirola herds observed. The numbers of the Hirola herds sighted in the different vegetation types during the presumed active feeding periods between 0730h to 1030h and 1530h to 1830h were also used to predict habitat preference and the critical resource areas. The average Hirola observed in each vegetation types were compared with the numbers expected if the animals had been randomly distributed in respect to vegetation types using chi-square goodness of fit.

Table 3. Estimated sizes of the sampled vegetation

Vegetation Type	Area cover (km^2)	Proportion (%)
Grassland (G)	1587	16.2
Wooded grassland (WG)	1470	15.0
Bushed grassland (BG)	1372	14.0
Shrubland (SH)	1577	16.1
Bushed shrubland (BSH)	1391	14.2
Woodland (W)	1274	13.0
Bushed woodland (BW)	1127	11.5
Total	**9798**	**100.0**

The plants and grass species observed to be consumed by the animals were collected for Herbarium identification. The most commonly taken plant species during the dry and wet season were observed.

2.3. Seasonal distribution

The seasonal distribution patterns of the Hirola population were determined from the seasonal observations made on the 20 quadrats of the five different range block units. Seasonal changes of the Hirola populations were monitored on monthly basis in each range block. The Hirola observations in each range block units were lumped for the analysis of seasonal distribution. All the Hirola herds sightings made in the different range block units were plotted on a distribution map to obtain the seasonal distribution of the species.

The variations of Hirola numbers in the range block units were used to predict the seasonal mobility and distribution patterns of the species. Changes in the Hirola range size and ranging patterns were also determined from the observed distributions. The natural and human factors such as forage and water availability, predation, livestock and human densities that could be responsible for the observed Hirola distributions were deduced from discussions with local informants.

2.4. Demographic composition

Population structure is an important prerequisite for assessing the direction of change of a natural population (Senzota, 1988). The various aspects of social organisation such as group sizes, age and sex compositions were observed in order to monitor the influences of seasons on the Hirola group compositions. The population dynamics and the reproductive potential of the Hirola were also determined from the demographic structures of the herds. Whenever a group was sighted, records were made on the age class and sex of the individuals. The number of individuals of each sex and each age class were determined from all the Hirola group observations. These were achieved by use of a pair of binocular (8 X 40 mm) and observing the relative body and horn sizes for the approximate age classes and the external genitalia for sex determination. Females were distinguished from males by their different body and horn sizes and external genitalia. The information on the approximate demographic composition and structure such as the age classes and sex ratio were used to predict the recruitment and general trend of the Hirola population as to whether it is declining, increasing or stagnating.

A detailed demographic data such as group size, age-sex ratios, group dynamics and bondage were collected from 10 selected Hirola herds within Ijara range unit. The groups were selected on the basis of easy accessibility for observation and their acceptance to the presence of the observers. These groups were closely monitored for 2 months of the dry and wet seasons. Visual contacts were maintained between 0630h and 1830h on weekly basis in predetermined days for the two months. The aim was to detect whether there was significant change in herd sizes and sex-age compositions among groups during that period. Inter-group movements and events of group dynamic processes (births, migration and death) were observed. Emigrations were inferred from the reduction of a group size and missing individuals while immigrations was assumed when an increase was observed in the adult members of a group. Births were assumed whenever an adult female was seen in the company of a young calf while deaths were recorded when the carcass of a missing individual was traced.

3.0. RESULTS AND DISCUSSIONS

3.1. POPULATION

3.1.1. Population estimates

Totals of 1030 and 1234 Hirola populations were counted during the dry and wet seasons censuses respectively (Table 4). This gave a mean of 1132 Hirola individuals in the study area (Table 5). The population estimate (PE) was calculated to be 1416, using Jolly's method 1 (1969a) assuming equal sized sample quadrats.

PE = $N\bar{y}$; SE = $\sqrt{N(N-n)s^2/n}$

Where:- $N = 25$; $n = 20$; $\bar{y} = 56.6$; $s^2 = $ **752.2**

PE =N $\acute{y}$ = 25 (56.64) = **1416**

SE = $\sqrt{25(25-20)\ 752.2/20}$ = **68.5**

95% Confidence limit = $\pm\ t_{0.05}(SE)$ = 2.093 X 68.5 = **143**

With a 95% confidence limit of 143 and standard error of 68.5 (04.8%) (Table 5) also in (Appendix 2). The range of alternative population estimates lie between 1273 and 1559 animals.

Although the animals were not normally distributed in the range, this did not affect the estimation of the population estimates. Taking the mean population in the sampled areas allows to correct any biases resulting from the unequal sample quadrats. Since the sample quadrats were randomly selected, the mean animal observed in the sampled area corresponded to the mean number of animals in the whole study area. The total population is therefore found by multiplying the sample mean (56.6) by the total number of quadrats (25) in the census area.

The Hirola population estimates showed variations seasonally both the previous aerial and the present ground surveys. The wet season census obtained high Hirola estimates compared to the dry season estimates. Such high estimates of the Hirola population during the wet season was attributed to the greater animal visibility (Bunderson, 1976). This was primarily due to the greenish vegetation background during the wet season that contrasted more distinctly against the animals. Also the availability of lush growing plants and grasses caused the animals to spend less time in shades under trees and bushes but spend more time in moving and feeding out in the open areas. Similarly the moderate temperatures and more cloudy conditions tended to cause the animals to be more active compared to dry season.

Table 4. Hirola groups observed and numbers counted in the 5 block units during the two season censuses.

Range Block units	Dry season		Wet season		
	Groups	Individuals	Groups	Individuals	Average
Bura	11	99	23	206	152
Masalani	15	139	26	244	192
Ijara	24	276	15	174	225
Sangailu	14	161	31	343	252
Hulugho	28	355	27	267	311
Total	92	1030	122	1234	1132

Table 5. Estimated Hirola population size in both dry and wet seasons

Season	Observed Population	Estimated population	Confidence Interval (95%)	Standard Error (%)
Dry	1030	1288	208	99.3 (07.7%)
Wet	1234	1543	112	53.7 (03.5)
Average	1132	1416	143	68.5 (04.8%)

Although inevitable problems of standardising the counting methodology may require scrutiny of each method, we can still show that the trend of Hirola population has been irregular and thus the possibility of specific conclusion may be difficult. Generally the trend of the species has been on the decline before some two decades ago. The long and persistent droughts caused immense population decline in both domestic and wild animals. Compared to the recent past estimate of about 1359 individuals (DRSRS, 1996), the Hirola population perhaps did not decline further. Presently these factors cause minimal effects on the Hirola problem as observed during the study. Hirola population declines were previously attributed to the livestock development industry and irrigation schemes in the lower Tana River (Kindon, 1982; Bunderson, 1976; East, 1988).

Bunderson (1976) reported balanced equilibrium between wild and domestic animals in the range, he predicted an upset of this equilibrium resulting from the establishment of livestock development industry and mechanised agriculture under irrigation in the region. During the operations of these large-scale human activities in the range led to drastic decline of the Hirola population. However, the livestock industry and the irrigation scheme in the range have currently been abandoned (DDP-Garissa, 1988) followed by decline of domestic herbivores. This probably allowed the increase of wild animal populations in the range. Presently the major threats to wild animals emanate from the expanding human settlement in the range, especially along the Tana River (Wargute, 1992). Other factors such as hunting, predation and diseases were considered to be the main causes of its population decline (Bunderson, 1976; Sinange, 1992; Wargute *et al*, 1993).

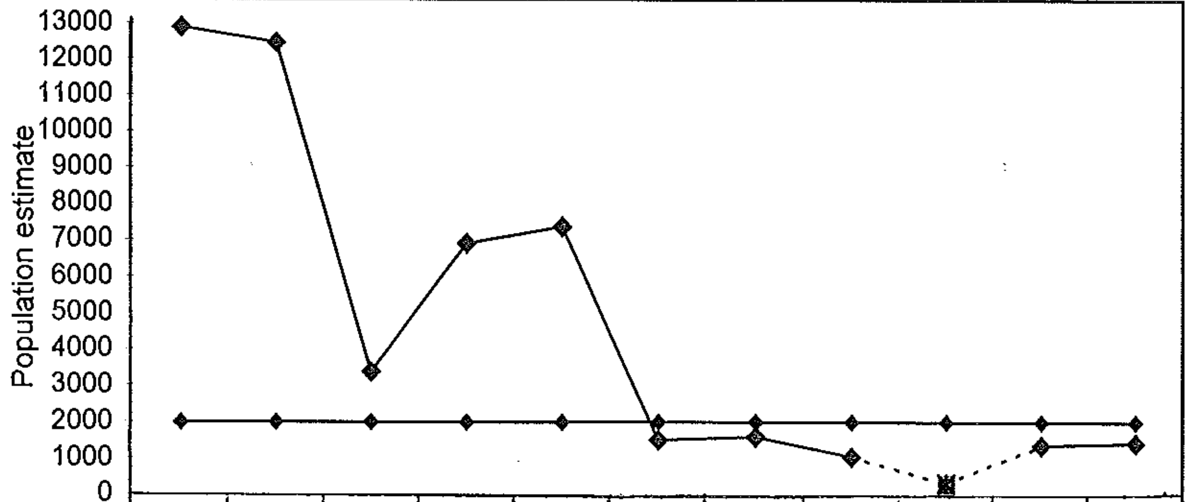
Due to its very restricted distribution and small population size, Hirola remains highly vulnerable in its natural range. The fact that radical changes in land use within the Hirola natural ranges could cause a drastic population decline was also observed by many authors (Bunderson, 1981; Wargute *et al*, 1993; Ottichilo *et al*, 1995). The displacement of the species from its dry season aggregation and wet season dispersal areas by the expanding human settlements and probably recovering domestic animals population could possibly precipitate major Hirola population crash (DDP, 1997).

2.1. Population trends

Comparing the present estimates with the previous population counts, the Hirola numbers are not alarmingly very low. From the population result of the study, the Hirola population could be recovering probably due to the general decline of livestock populations in the range. The high proportions of immature individuals in the population also indicated healthy populations. The population trend of the Hirola currently seemed to have stabilised around 1400 individuals since 1985 after drastic decrease between the years 1973 and 1985 (Fig. 5). The Hirola numbers probably recovered partly due to general decline of livestock population in the area and the abandonment of the irrigation settlement schemes at Bura and the improved moisture regimes in the past years. Hunting pressures could still be major limiting factor. High proportions of females and immature individuals were believed to be determinants of the Hirola population increase.

The fact that the Hirola has declined rapidly in numbers throughout much of its ranges since the 1970's has consistently been observed in repeated estimates (Bunderson, 1976 & 1981; DRSRS, 1977-88; East, 1988; Grunblatt *et al*, 1989; and Wargute *et al*, 1993). Very early documented works gave the species numbers to be between 1000 and 2000 (Grimwood, 1964; Scott, 1965; The Red Data Book, 1969; Dorst and Dandelot, 1970; Watson *et al*, 1973). Comprehensive aerial surveys (Bunderson, 1976-7; DRSRS, 1977-88; East, 1988; Grunblatt *et al*, 1989; and Wargute *et al*, 1993) yielded much fluctuating estimates. Population counts made by Bunderson (1976) surprisingly numbered 12500, contrasting a previous estimate of 1500 Hirola individuals in the range. The populations estimate given by KWS (1995) were extreme underestimation of its numbers and did not show the true picture of the Hirola population and has not been included in the trend.

Figure 5. Population trend of Hirola in southern Garissa (1973-1999)



	1	2	3	4	5	6	7	8	9	10	11
Series1	1973	1976	1977	1978	1981	1985	1988	1993	1995	1996	1998
Series2	12880	12450	3367	6902	7360	1500	1580	1035	300	1359	1416

Note: The broken line shows the survey estimate by KWS (1995) which was believed to be an extreme underestimation of the Hirola numbers.

3.2. HABITAT PREFERENCES

3.2.1. Habitat selection

The patterns of habitat use were studied during the dry and wet seasons. The relative patterns of habitat selections were derived from the numbers of animals observed in the different vegetation communities. The results were summarised in Table 6 and Fig. 6 showing the proportion of seasonal habitat use associated with the sightings of the animals in each habitat type. The data showed that the Hirola fulfilled its resource requirements in all the vegetation types at the different seasons. If Hirola displayed no preference for any habitat, then its distribution in the vegetation types should have been approximately even. The Hirola is therefore able to move into the more extensive woodland and grassland areas at different periods of the year. As each particular season progressed, there were changes in the number of the Hirola at the different vegetation types. This showed that the Hirola changed its habitat preferences seasonally and occupied areas that contained plenty of the most required resources such as forages and water, cover and protection as also reported for most species in habitats where resources are scarce (Jarman, 1974; Pennycuick, 1975; Inglis, 1976).

In this respect, the Hirola highly responded to the seasonal environmental changes by utilising a finer grain of vegetation heterogeneity with more localised movements between the vegetation communities in the range. Change of habitats by most ungulates provided access to both green forage and water resources where these are scarce in the ecosystem (Fryxel *et al*, 1988).

During the wet season, most of the Hirola were seen to utilise less diverse and less dense vegetation covers. However, in the dry season the Hirola occupied diverse and more wooded habitats. Hirola mostly occurred in open savanna areas with low vegetation cover and high stands of short grass cover during the wet season, consistent with observations made by Bunderson (1976).

Table 6. Total Hirola numbers observed in different vegetation communities

Vegetation Type	Dry season	Wet season	Average	Per cent (%)
Grassland (G)	84	415	250	22.0
Wooded grassland (WG)	261	207	234	20.7
Bushed grassland (BG)	229	178	204	18.0
Shrubland (SH)	225	148	186	16.4
Bushed shrubland (BSH)	127	99	113	10.0
Woodland (W)	83	118	100	8.9
Bushed woodland (BW)	21	69	45	4.0
Total	1030	1234	1132	100.0

The daily habitat alterations seemed to depend on the animal activities such as feeding, resting and need for cover. The presence of domestic and wild herbivores was observed to affect the daily habitat utilisation by the Hirola. In an undisturbed situations the Hirola occupied the open areas with low wood cover especially during morning and evening hours of the day, which are associated with active feeding activities. This fact was widely reported in many bovids (Jarman, 1974; Estes, 1974). Like most herbivores in hot days, the Hirola groups were observed to occupy habitats with high tree densities so as to rest under the shades.

Figure 6. Seasonal utilisation in different vegetation types

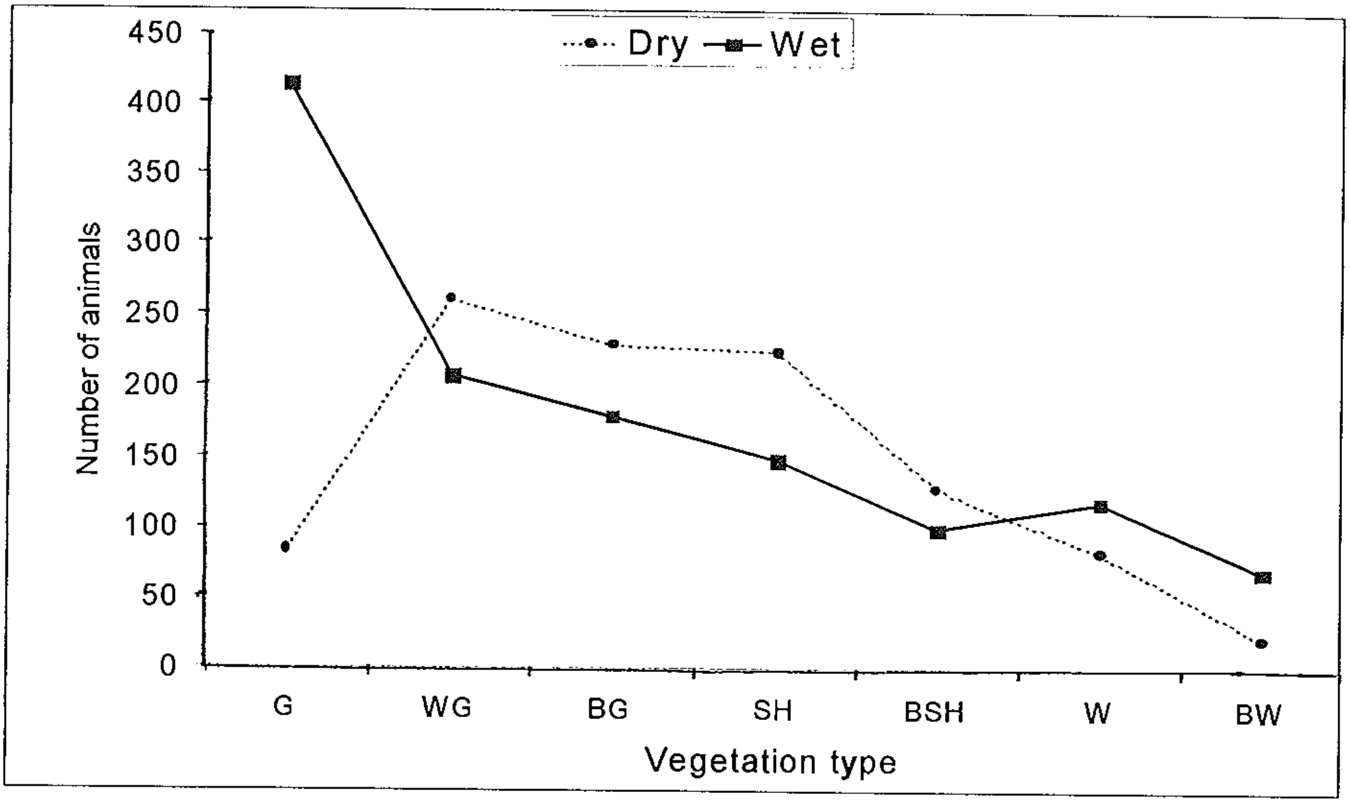


Table 7. Number of Hirola sightings in the different vegetation types

Vegetation type	Dry season	Wet season	Average	Percent (%)
Grassland	7	41	24	22.4
Wooded grassland	23	20	21	19.6
Bushed grassland	20	18	19	17.8
Shrubland	20	15	18	16.8
Bushed shrubland	12	9	11	10.3
Woodland	7	12	9	8.4
Bushed woodland	3	11	5	4.7
Total	92	122	107	100.0

Table 8. Deviations from an assumed uniform distribution of Hirola in the different vegetation types (independent of vegetation types) and their seasonal changes (Chi-square based on the actual numbers of Hirola in the respective vegetation proportions)

	Dry season	Wet season	Cumulative
Calculated value	286.5	128.5	146.4
Tabulated value	12.60	2.60	12.60
df	6	6	6
P-value	< 0.05	< 0.05	< 0.05

The Hirola observations in each vegetation categories determined habitat preference both during the dry and wet seasons. The preferences largely explain the differences in the Hirola densities in the different vegetation types. It was lowest in bush woodlands and highest in the grassland habitats (Table 7). However, the deviations from an assumed uniform distribution of the Hirola observations in the different vegetation types were highly significant during the dry season (Table 8). A general preference for less wooded vegetation and relative avoidance of densely wooded vegetation were both more marked in the dry season. Minimum deviation was observed during the dry season compared to the wet season (Table 8). This showed that Hirola utilises all the vegetation types, wooded or open grassland habitats although densely wooded areas were mostly avoided during the wet season. Hirola intensified its relative preference in the open areas at the start of the rainy season and made significant use of the wooded grasslands and shrublands.

The pattern of vegetation use changed as the dry season approached and the Hirola population seemed to move towards the areas with high tree cover. The wooded habitats were particularly important as dry season refuges since this contained remnant green forages and provided shelter. Similar observations were reported for the Swaynes hartebeest (Messana, 1993) and the topi (Yoaciel *et al*, 1982). Basically, positive relationship was observed between the availability of quality forage and Hirola habitat preference. However, the more trees and bushes cover an area, it was less preferred by the Hirola. This was possibly due to the effect of vegetation cover on the visibility and detection of danger. As in most ungulates, the wooded habitats influenced the visibility of the con-specifics and predators as well as providing hideout cover for calves, mostly during the calving period (Jarman, 1974; Watson, 1976).

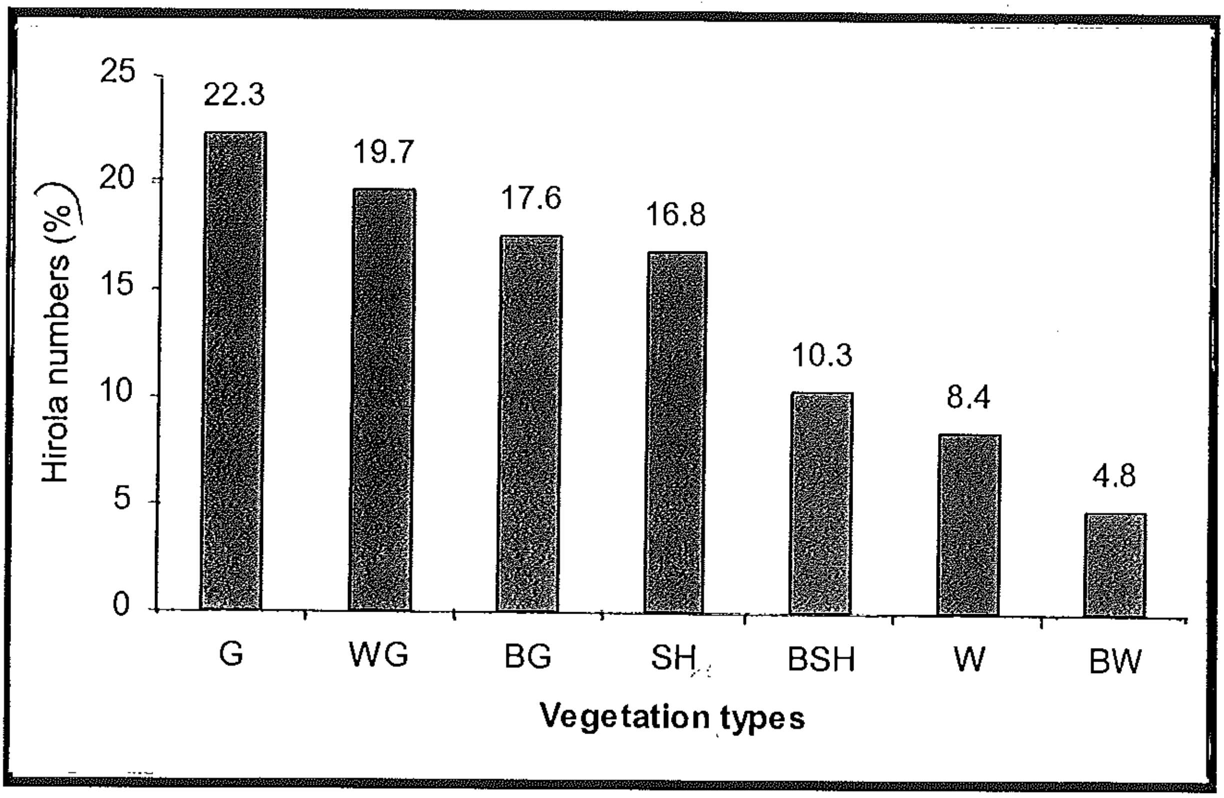
Apart from the eco-climatic determinants of the range utilisation, social factors of the Hirola herds seemed to influence the patterns of habitat use. The Hirola groups showed profound spatial habitat use by different social groups. The different Hirola social classes used different habitats that could be associated with different activity patterns as studied in most ungulates (Estes, 1974; Jarman, 1974). The territorial male groups effectively prevent bachelor herds from using high quality food resources. This observation was consistent with behaviour of other territorial species (Estes, 1974). The percentages of habitat utilisation by different Hirola social groups are shown in Table 9. Bachelor herds often occupied less favourable habitats compared to the nursery herds since dominant males force the subordinate males out of the most favoured grazing areas. Messana (1993) observed such territorial resource defence in Swaynes' hartebeest, which excluded the weaker males and bachelor herds.

Table 9. Percentage habitat utilisation by different Hirola social groups as observed in both seasons

Vegetation types	Nursery herds	Bachelor herds	Total
Grassland	15.9	6.5	22.4
Wooded grassland	14.0	5.6	19.6
Bushed grassland	9.3	8.4	17.7
Shrubland	10.3	6.5	16.8
Bushed shrubland	3.7	6.6	10.3
Woodland	3.7	4.7	8.4
Bushed woodland	0.9	3.9	4.8
Total	57.8	42.2	100.0

The presence of increased nursery herds in areas of high vegetation cover during the short wet period in November may be related to calving activity. Calves of most ungulates are usually left to lie-out among the tall stands of grasses and under the bushes (Gosling, 1969), thus tall stands of grasses and wooded habitats in the range are preferred.

Figure 7. Hirola population proportions in the different vegetation types of varying wood density



3.2.2. Feeding habits

Although the total food spectrum of the Hirola was beyond the scope of this study, it was observed that grasses comprise the greatest parts of the diet during the wet season

(Appendix 3). Feeding trials showed that the Hirola selected higher proportion of leafy grasses especially during the wet season and feed selectively on green bunchgrasses. During the dry season Hirola were observed to browse on woody vegetation in the shrubs and lower understory growths more often. Bunderson (1976) and Andanje *et al* (1996) also observed this. Although most alcelaphines are grazer, occasional browsing on forbs and herbs have been reported, especially during the dry seasons (Gosling, 1974; Stanley-Price, 1974). Observation on the plant availability and feeding rates suggested that the Hirola do not go for the most common plants available but appeared to have a preference for particular plant species. The Hirola were frequently observed to feed on luxuriant regrowth in and around abandoned homesteads, on the accumulated manure and bottoms dried water pans and flood plains, consistent with the observations made on the Swayne's hartebeest (Messana, 1993). This probably confirms that species select the most nutritious plants during the wet season and those with high water content during the dry season (Inglis, 1976; Jarman, 1976; Messana, 1993).

Non-migratory herbivores have been reported to satisfy their resource requirements within limited home range by shifting between habitats and selecting different plants (Western, 1978; Murray *et al*, 1993). Such animals successfully utilise wide range of food resources within limited areas on seasonal basis (Jarman, 1972; Inglis, 1976). Observing the feeding behaviour of the Hirola across the seasons in the different vegetation types, it showed such seasonal utilisation of the ranges. This is because of the fact that the habitat vegetation conditions and forage quality are subject to seasonal changes (Yoaciel, 1981; Western, 1984).

Hirola groups were rarely observed close to waterholes although the Hirola tracks were several times observed to approach the water points, which suggested an actual drinking. Reports by the local people indicated that the Hirola drinks water in the evening and night hours. However, it was extremely difficult for the Hirola to gain access to waterholes since it involves passing through areas of dense human settlements and cultivations. During the dry season when surface water is limited, the Hirola spend many hours under shades in wooded areas. During this period, feeding takes places in the late hours of the evening when grasses had adsorbed moisture so that the animals could obtain their water requirements even without drinking as also reported for the Swayne's hartebeest. The Hirola spent more time feeding in the night, especially during the dry season. This result differs from the observation by Andanje *et al* (1996). Sinclair (1974) suggested that the longer period of grazing at night during both wet and dry seasons is probably related to control of energy and water.

3.3. DISTRIBUTION

3.3.1. Seasonal distribution

Seasonal distributions of the Hirola were obtained from its total sightings in the different range units (Table 4). Hirola population showed relative seasonal change in distribution both spatially and temporally (Table 10). The seasonal locations of the Hirola and its use of the different parts of the range depicted its distribution in the natural habitat. The seasonal uses of the different parts of the range defined the patterns of Hirola seasonal distributions. These seasonal patterns of range utilisation enabled the Hirola to cope up with the seasonally changing habitat conditions. The variations of the habitat conditions caused small-scale seasonal movements of the Hirola within the range. The species movements and its subsequent distributions were therefore highly influenced by the availability and abundance of forages, vegetation cover, human and livestock populations.

The seasonal distribution of the Hirola population significantly varied in the different parts of the range. High densities of the Hirola population were particularly observed in Hulugho (17.0/100 km^2) and Ijara (12.8/100 km^2) range units during the dry season. Sangailu block had highest Hirola density (21.4/100 km^2) during the wet season, while Hulugho block units retained high population densities throughout the study period (Fig. 9). Human disturbances and livestock densities actually displaced wild animals from the

Table 10. Seasonal distribution densities (100 km^2) of the Hirola in the different range units

Range blocks	Density (per 100 km^2)			
	Dry season	Wet season	Average	Percentage (%)
Bura	4.0	8.2	6.0	10.5
Masalani	5.2	11.0	8.2	14.4
Ijara	12.8	9.6	11.3	19.7
Sangailu	7.2	21.4	14.3	25.0
Hulugho	17.0	17.9	17.4	30.4
Average	9.2	13.6	11.4	100.0

preferred habitat zones. As the nomadic pastoralists move between seasonal grazing areas within the range, the Hirola seemed to have adapted an alternate distribution pattern with the pastoral livestock population. In effect there was an indication that the species has extended its range northwards and possibly to the southern parts. Such changes of its distribution and range size were partly preceded by changes in the range conditions and increased human settlements.

The overall Hirola distribution density on the basis of the total range in the Garissa south was 11.4/100 km^2. In the early surveys, the distribution densities of the Hirola in the range have been fluctuating but rather declining trends were reported. For instance, Wartson, *et al,*(1973) gave 90.0/100 km^2; Bunderson, (1976) estimated about 80.0 /100 km^2; while DRSRS estimates the density as 90.0/100 km^2 (1981); 70.0/100 km2 (1983) and between 1985 and 1993 its densities reduced to about 10.0/100 km^2 in the whole Kenyan range (Wargute *et al*, 1993). The present Hirola population density in the range almost agrees with the observations given between the years 1985 and 1993.

These observed seasonal distributions are certainly correlated with the availability and abundance of green forages in the ranges. The Hirola range area was greater during the dry season due to largely isolated and reduced availability of green forage as it was also reported for the Swayne's hartebeest (Messana, 1993). Since the forage resources are neither uniformly distributed nor permanently found in the range, the Hirola always move within the range to occupy areas containing the required forage resources which are dependent on the seasons. During dry season (August -October) Hirola had somewhat clumped distribution within two distinct areas. The drainage lines are the source of fresh grazing and water for almost all ungulates during the dry season (Kingdon, 1982). These dry season dispersal areas were in Ijara and Hulugho range units while Sangailu, Bura and Masalani ranges had small populations (Table 10). However during the wet season (late October through December), the densities of Hirola in the different range units were almost the reverses of the densities during the dry season. Bura, Masalani and Sangailu block units contained high population densities while the Ijara part of the range had low population density in the wet season (Fig. 8).

Figure 8. Hirola seasonal populations in the different range units

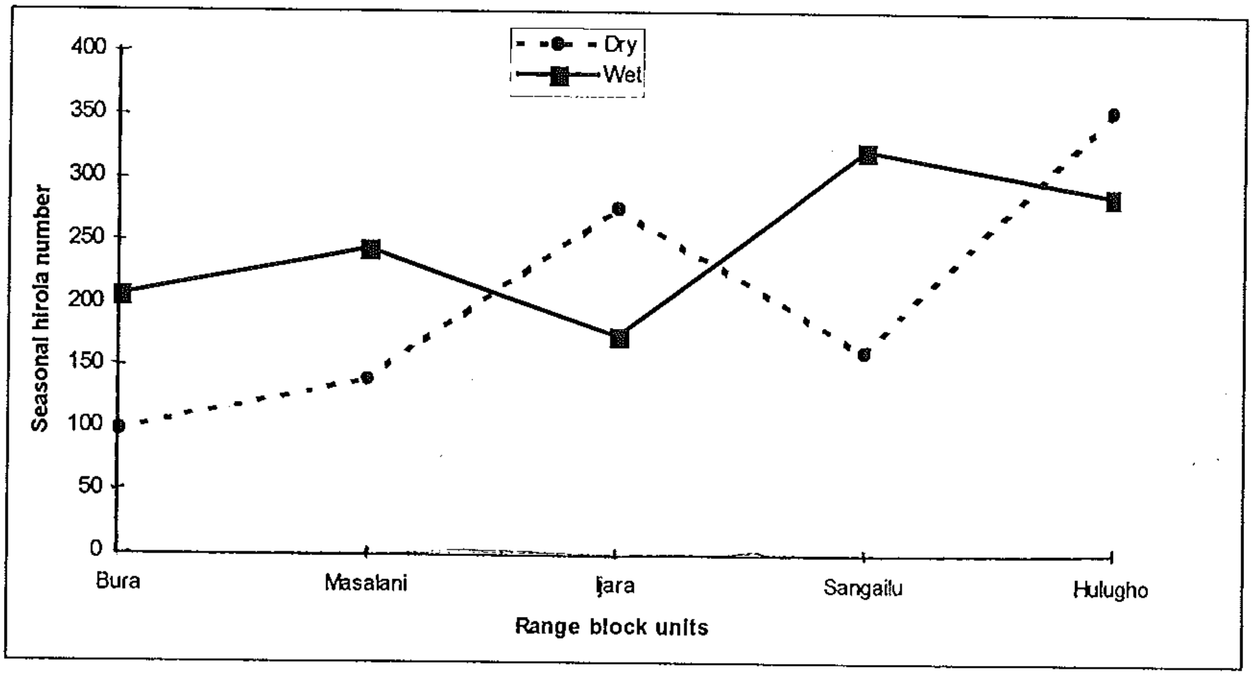


Table 11. Hirola observations in the range units and its seasonal changes compared with values expected if distribution were uniform (independent of season: Chi-square based on actual Hirola observations in the respective proportions of the range units).

	Dry season	Wet season	Cumulative
Calculated value	22.50	6.37	8.42
Tabulated	9.49	9.49	9.49
d.f.	4	4	4
P-value	< 0.05	> 0.05	>0.05

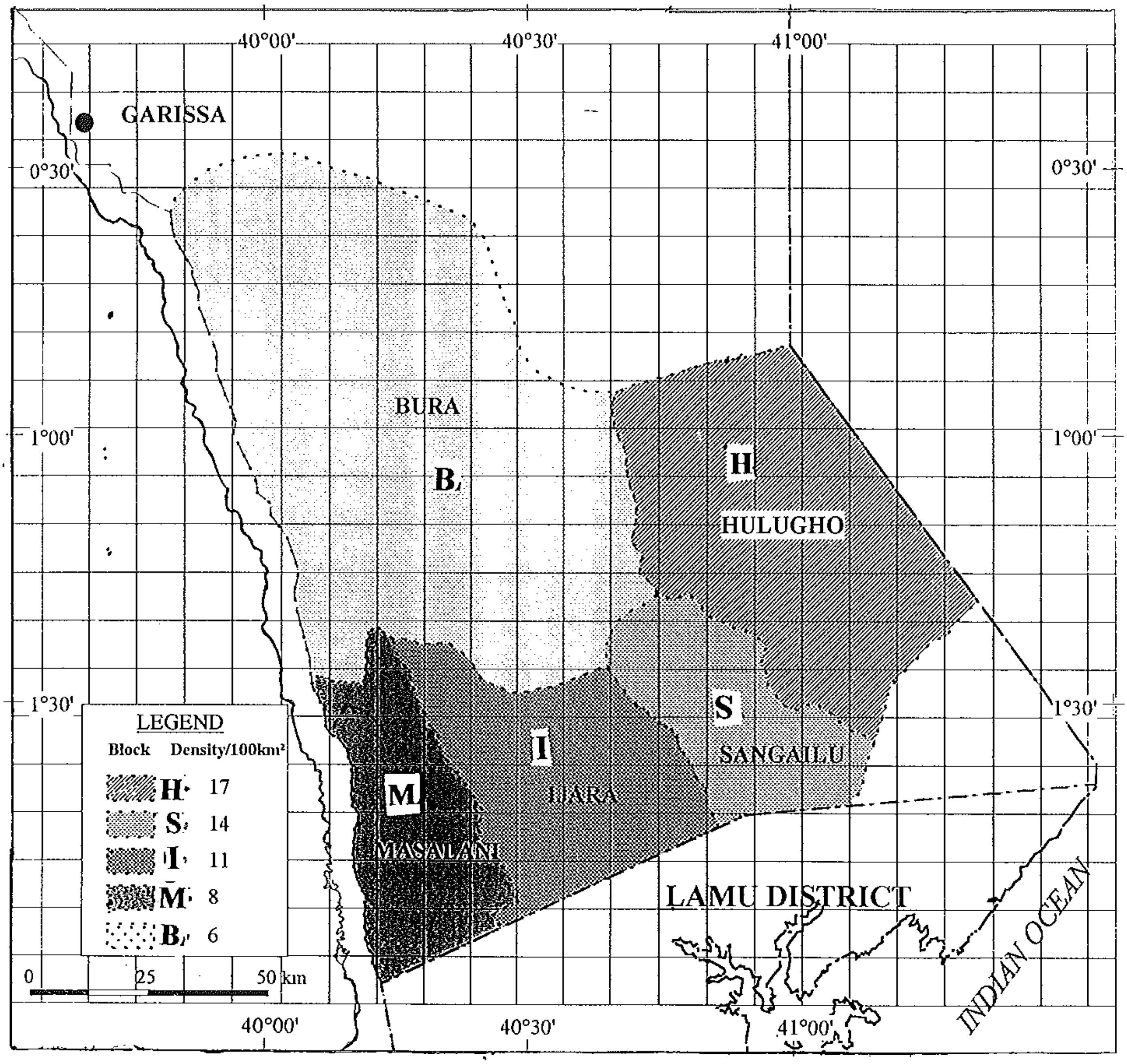
The deviations from an assumed uniform Hirola distribution in the different range units were significant during the dry season (Table 11). This indicated increased Hirola population in particular parts of the range. For instance, Hulugho range had 355 individuals observed in contrast with an expected 176 individuals relative to the proportion of the area. Conversely, 99 individuals were actually observed in Bura block although 250 individuals were expected. During the wet season, there was no significant deviation from the assumed uniform distribution in the range. This can also be observed from the increased sample standard error and variance that was obtained during the dry season. The lower standard error and variance observed in the wet season indicate an extent of uniform distribution compared to the dry season. These observations were consistent with Bunderson (1976).

Since forage resources were uniformly available, the animals were scattered in the range without concentrations to particular range units. The scattered distribution of herbivores were observed particularly when the rain was evenly distributed (Western, 1976). The uneven distribution of Hirola during the wet season is possibly due to the Hirola retreating from the wooded habitats and waterlogged areas to better-drained and higher grounds. In addition, the presence of livestock could as well displace the Hirola from some parts of the areas.

Constant search for green forages is the primary proximate cause of most ungulate movements (Jarman *et al*, 1971; Pennycuick, 1975). This is the case when they rely mainly on the margins of watercourses and understories of wooded habitats containing remnant forage, as is observed for the Hirola. However, in the local areas where livestock and human interference were high, the question of better food resources was not the primary issue since wild herbivores were easily displaced even from better pastures.

The distributions of pastoral livestock were largely determined by the spatial and temporal patterns of rainfall in the range. Usually, rainfall in the Hirola range is very unevenly distributed and livestock populations were invariably found in the areas with good pastures. The Pastoralists in the range move seasonally with their livestock herds between wet and dry season ranges. This is common in many grassland ecosystems in Africa (Fryxell *et al*, 1985). Such traditional livestock husbandry is presumably designed to maximise secondary production and therefore mimic the evolved behaviour of natural populations (Fryxell *et al*, 1985). Thus the presence of pastoralists livestock in the range affects the Hirola distributions and mostly pushed into resource marginal areas.

Figure 9. Distribution of the Hirola in the different range block units



3.3.2. Seasonal movement patterns

The seasonal patterns of Hirola distributions in the range were complex. Its distribution depended upon the timing and extent of rainfall as well as the distribution of domestic animals and human densities. The seasonal movements of the Hirola in response to the altering range conditions seemed to be restricted by the pastoralist livestock, which also maximise seasonally changing range productivity. Hirola did not show distinct migrations as normally observed in wildebeest and zebra (Pennycuick, 1975; Inglis; 1976; Watson, 1976). This could be confirmed since the Hirola does not form large groups during the dry season as observed in migratory ungulates. However, Hirola showed short range seasonal movements in search of green forage within its natural range, commonly observed in many non-migratory ungulates. During the dry season food resources remain only in ephemeral areas, hence Hirola tend to aggregate around these isolated resource areas. With the arrival of rains, these groups break up into small units and disperse randomly throughout the range. Many ungulates were reported to drift down to low-lying areas especially after the rains are over and gather in great numbers as the pastures shrink under the influence fire, drought and overgrazing (Kingdon, 1982).

Due to the effects of El-nino weather phenomenon, forages were relatively available in the natural depressions throughout the dry season. Probably as a result of this, the Hirola population did not exhibit organised and distinct movement patterns but rather more subtle local movements within the range. This was observed from the presence of the Hirola in all the range units during dry season. The movements of the species tended to be localised and possibly never migrated across the border into the neighboring Somalia range and vice versa. Such local movements within the range were perhaps to make use of the heterogeneous vegetation communities.

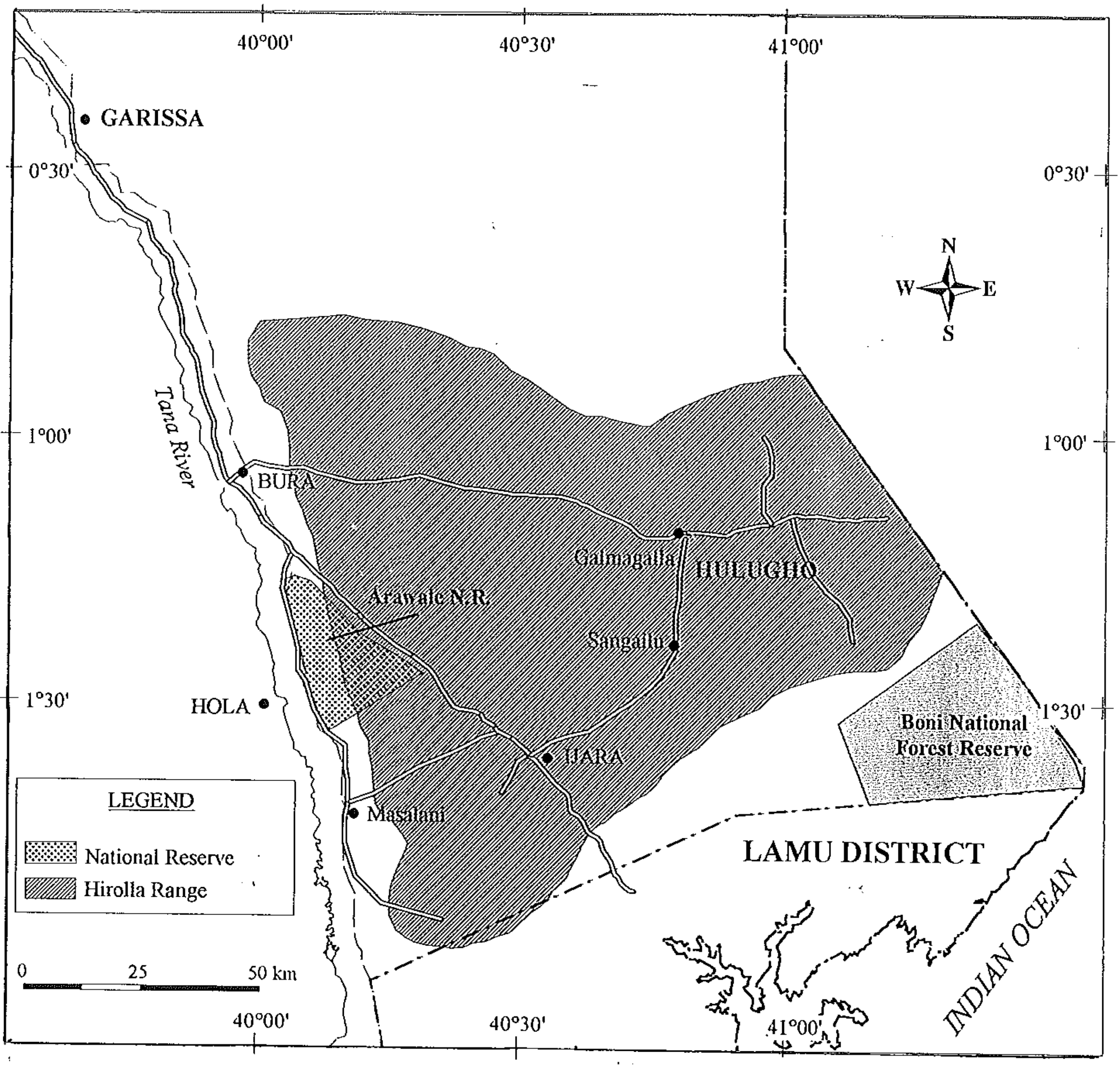
Bunderson (1976) reported that Hirola had spread distribution in the range during the wet season but portrayed clumped distributions especially in the vicinities of Tana River and Galma-Galla during the dry season. The present observations seemed to agree with this report, although the clumping nature of the Hirola near the River was not evident. However, high Hirola populations were found in the areas south and west of Ijara range unit. Similarly, the Galma-Galla area of Hulugho range unit had increased Hirola numbers. These areas were probably its dry season concentration areas since most pastoralist livestock leave these areas to occupy the flood plain areas and along the River Tana. Parts of Bura and Sangailu areas had high density of pastoralist livestock since these areas were also occupied as dry season fallback grazing areas. The distribution of the Hirola appeared to be affected by the livestock and human densities and the seasonal weather. Weather is the primary proximate cause of distribution patterns in most of large mammals (Leuthold *et al*, 1976; Pennycuick, 1975; Kutilek, 1979).

3.3.3. Distribution trend

During the present study, Hirola was observed north of Bura areas both during dry and wet seasons for the first time. Probably, the Hirola might have been forced to extend its ranges northwards to avoid disturbances (Fig. 10). The natural ranges of the Hirola constituted the areas to east of Tana River between Bura block to the north and Masalani block to the south as also observed in Bunderson (1976). Early records have shown that the historical ranges did not changed significantly despite the indications of decline in the species' abundance (Watson *et al*, 1973; Bunderson, 1976, 1977 and DRSRS 1977-1993). However, Bunderson, (1976) observed an extension of its range to the southern parts during the wet season when food and resources were plenty although this was not recorded in northern part of the range.

An overlap in the distribution of livestock, human settlements and the Hirola population distribution was reported in Ottichilo *et al*, (1995). But this was not observed during this study, as the species may have been displaced from the areas inhabited by human beings. The recent drastic population declines was attributed to the contraction of the species' natural range (Wargute *et al*, 1993; Ottichilo *et al*, 1995) and the resultant displacements of the wild herbivores from most of their important habitat zones. According to the local informants, the recent heavy floods caused by the El-nino induced rains forced many ungulates such as buffalo, gazelles and topi to leave the boggy soils in the floodplains in order to occupy high grounds in the northern part of the range. When the floods were over, most of these species remained in their new areas that still had large pools of water and green forages.

Figure 10. Current Hirola range in southern Garissa



3.4. GROUP COMPOSITION

3.4.1. Demographic structure

The compositions of the Hirola herds based on the total numbers sighted during the survey were categorised according to sex and age classes (Table 12). Hirola individuals formed social groups of nursery and bachelor herds. The nursery herds are comprised of females, young, yearlings, and a dominant male which are usually almost stable numbers ranging between 5 and 17 individuals. The bachelor herds are mainly sub-adults (males and females) and subordinate adult males that stay in large group (ranging between 2 and 24 individuals) but very unstable. The structure of the Hirola herds varied in the different social classes and seasons. Mixed aggregation of bachelor and nursery herds numbering up to 72 animals have been reported particularly at the start of the wet season when isolated rain showers produced patches of green forages (Bunderson, 1981). A variety of benefits accrue to group-living individuals and, hence lead to group formation, for instance reduced predation risk (Harvey *et al*, 1978).

72.4% of all the Hirola observed were comprised of adults while 27.6% were immature individuals (unsexed calves and yearlings). Among the adult individuals, female constituted 40.3% while adult males totalled to 32.1% of the mean population observed during the study period. The percentages of sex and age distributions of the Hirola population in the natural ranges closely agree with the observations of the translocated Tsavo sub-population (Adanje, in prep.). The sex ratio of adult Hirola was female biased. Chi-square goodness of fit showed a significant difference in the sex ratio of Hirola population.

Table 12. Structure and composition of the Hirola population

	Adult Female	Adult Males	Young* Indiv.	Total	Age ratio Ad/Yg	Sex ratio F/M
Dry	423	322	285	1030	2.6:1	1.5:1
Wet	489	405	340	1234	2.6:1	1.2:1
Average	456	363	313	1132	2.6:1	1.2:1
(%)	40.3	32.1	27.6	100.0		

Young *: Yearlings + calves; Indivi. (Individuals);. Ad (Adults); Yg (young)

This confirms that there is no reason for assuming an equal adult sex ratio in species that practice polygamy mating system where sex ratio is expected to be biased towards females. Nonetheless, there are factors that contribute to the low male individuals in the Hirola population. Tentative explanation of male mortality in many African antelopes, is that bachelor males are distributed in often less favourable habitats (Jarman, 1973; Spinage, 1982). While nursery herds are free to seek the best grazing areas in their home range, the bachelor herds of the Hirola remain in the peripheral resource area hence subordinate males become weak and eventually susceptible to starvation. In addition, it may perhaps be due to the male's nature and propensity of forming small groups which enhances their vulnerability to predations (Jarman, 1973). The tendency to form small groups makes it difficult to detect the approach of dangers. Poaching also affects adult males more than females since they are chosen for their large size. These factors may have caused the small proportion of adult males observed in the Hirola population.

The fairly high proportion of young animals indicated a healthy and increasing population. An increase of the calves numbers recorded during the wet season observation suggested that more neonates were born in the early wet period which confirms the observations by Andanje (in prep.). Calves of most antelopes are usually hidden among the dense tall grasses and under the bushes until they can fully follow the parent herd (Kingdon, 1982). As a result, the numbers of neonates could be underestimated although they are quite vulnerable to predation at this stage. During the censuses, the Hirola neonates were mostly observed in the company of at least 5 adult individuals. According to anti-predator hypothesis (Hamilton, 1971; Harvey *et al*, 1978) individuals reduce the chances of being predated on by associating with the others to increase vigilance.

Since wooded habitats impaired group cohesion and cause the disintegration of large groups (Jarman, 1974), the Hirola group sizes were smaller in denser vegetation covers that restricted visibility but were larger in open grassland habitats. Other than the habitat influence, most *Alcelaphinae* form large aggregation during the dry seasons under the influence of fire and isolated rain showers (Gosling, 1969; Kingdon, 1982). In the case of the Hirola, group aggregations occurred along watercourses during the dry season. In such concentration, the Hirola group sizes increased but were unstable. The sub-adult individuals were observed to move freely between bachelor and nursery groups. However, the aggregation phase of the Hirola groups may be a prelude for establishing a position of dominance and take-over of potential male competitors In low-density areas, the Hirola groups were relatively small and stable. Groups that have large number of individuals, particularly potentially breeding females and males, split into smaller groups. Large group sizes of any species could be indicator of better habitat qualities (Stelfox *et al*, 1987).

Similarly, various intrinsic factors such as the difference in breeding ability (Ochiago, 1993) and genetic variability (Lande *et al*, 1987) affect the demographic composition and structures of species. These factors may help to determine the intrinsic birth rates and the initial numbers of potential breeders in the Hirola groups. For instance, there may be a threshold number of adults in a group below which the survival of the calves or reproduction is uncertain (Lande *et al*, 1987). During dry periods and calving seasons, female herds move into better pasture areas or thicker vegetation types, which may influence population dispersal patterns (Kingdon, 1982). However, unlike other alcelaphines, Hirola males do not become solitary or territorial without breeding females. The mature males are either dominant that accompany nursery female herds or are subordinate that associate with bachelor herd.

3.4.2. Demography of the selected groups

10 Hirola herds were selected on the basis of ease access to their areas and acceptance to the observers. These were monitored for 2 months of the study period to detect group dynamic processes such as births, deaths and migrations. The groups selected varied in numbers as well as age and sex compositions. The groups initially had a total of 87 individuals with group sizes ranging between 6 and 11 individuals and a mean of 8.7 (Table 13). Adult individuals were 56.3% of the overall while the sub-adults constituted 27.6% of the selected groups (Fig. 11). The frequency distributions of different age-sex classes were all skewed to adults particularly females. The total females comprised 49.4%, while males and unsexed calves were 34.5% and 16.1% respectively (Fig. 12). This probably indicates potentially breeding females.

Table 13. Demographic composition of 10 selected groups

		ADULT		SUB-ADULT		
GROUP	Group size	Male	Female	Male	Female	Calf
I	6	2	3	-	-	1
II	6	1	2	-	1	2
III	7	1	4	2	-	-
IV	8	1	3	1	1	2
V	9	2	4	1	2	-
VI	9	1	5	-	-	3
VII	9	1	4	-	1	3
VIII	11	5	1	3	2	-
IX	11	1	5	2	-	3
X	11	3	-	3	5	-
TOTAL :	87	18	31	12	12	14
Mean:	8.7	1.8	3.1	1.2	1.5	1.4
S.D:	1.9	1.3	1.7	1.2	1.5	0.8

Figure 11. Age structure of the selected groups

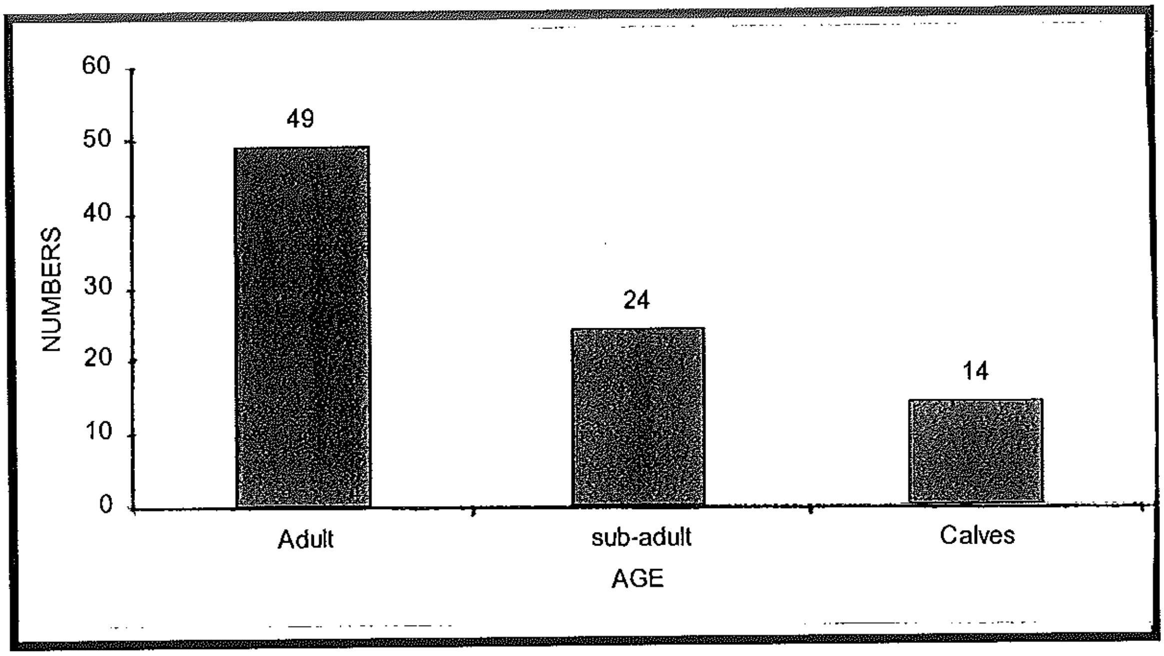
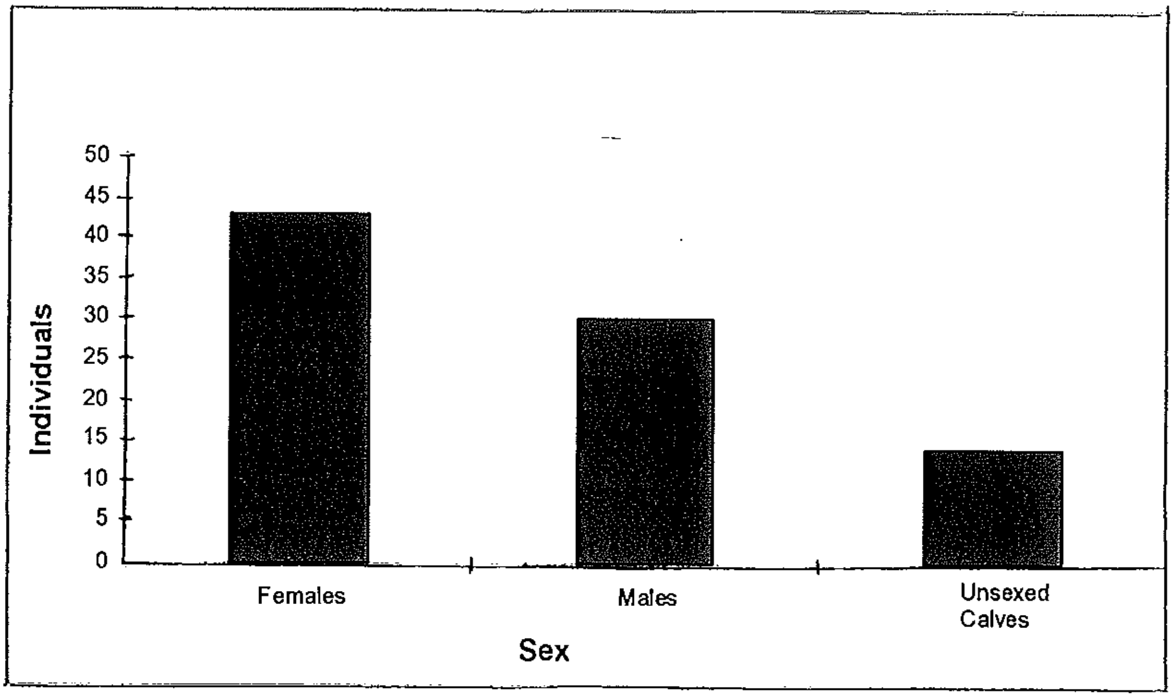


Figure 12. Sex structure of the selected groups



3.4.4. Changes of group composition

Over the period of study, there were 4 deaths (two unsexed calves, one adult male and a newly borne calf) and 6 births among the 10 sampled groups. Jackals and hyaena were presumed to have taken the two calves in the lie out places and the other calf was found by shepherd boys and carried to their homesteads but died before it was returned. Hunters most likely killed the adult male since its fresh skull was discovered. There were 4 individuals (2 sub-adults, a female and an adult male) that left their respective groups (group IX and X) and were later found to have established their own group. No immigrations into the groups were recorded in all the 10 selected groups. The overall change due to births, deaths, and emigrations in the selected groups was about 2.3% (Table 14). However, the numbers of these selected groups have actually increased by 2.3% individuals within the study period.

A varying group dynamics and bondage were observed among the Hirola social classes. Strong bond existed among the nursery herds as observed in most ungulates (Estes, 1974). Adult females could leave the group only when calving or visiting the calf lying out in the vicinity of the group. Dominant adult males were always present as they maintained a close association with the nursery herds. This enabled the adult male to easily detect an approaching enemy. It was also observed that the Hirola sub-adults of both sexes have very loose connection with both bachelor and nursery herds. Weakening and dissolution of the mother-young bondage in antelopes after the birth of a subsequent offspring or as a result of sub-adults being harassed by adults (Leuthold, 1973) was also observed in the Hirola.

Table 14. Demographic changes in the selected groups

Group	Initial Size	EVENTS Birth	Death	Emigration	Present Size	Changes (%)
I	6	-	-	-	6	0
II	6	-	-	-	6	0
III	7	2	-	-	9	+ 2.3
IV	8	-	1	-	7	– 1.1
V	9	1	-	-	10	+ 1.1
VI	9	-	1	-	8	– 1.1
VII	9	-	-	-	9	0
VIII	11	2	1	-	12	+ 1.1
IX	11	1	1	3	8	– 3.4
X	11	-	-	1	10	– 1.1
TOTAL:	87	6	4	4	85	– 2.3%
Mean:	8.7	0.6	0.4	0.4	8.5	
SD:	1.9	0.8	0.5	1.0	1.9	

3.4.4. Daily activity rhythms and General behavioural traits

General observations on both individuals and groups activities were made during the study. The basic patterns of daily activity of Hirola are shown by both of the social categories. Most activity patterns in a group were coordinated with little activity overlap, necessary to retain herd cohesion. Basic group activities in most antelopes change seasonally (Jarman and Jarman, 1973). For instance the feeding activity is minimal during the dry season where a decrease in food availability with a decrease in feeding times was observed. Hirola groups were observed to be most active during morning hours and evening towards most part of the night depending on the season. The morning feeding activity normally peaks up between 0730 h and 1030 h, but longer hours during the dry season when for the rest of the day they remained inactive and resting under the shades. Two resting periods were displayed during the day corresponding to early morning and throughout mid day hours. As the wet season approached, other activities such as feeding, play fighting, rutting and territorial markings were the major daily activities. The dominant territorial males were observed to kneel down to slash the short vegetation with the horns while rubbing the scents, scratch the ground and urinate on the spot. These are some of the territory marking observed in most ungulates (Kingdon, 1982).

The Hirola groups selected open spaces in the low vegetation areas to sleep in the night between their feeding intervals. Individuals remained extremely watchful even when lying down. Individuals would face in different directions making it difficult for any enemy to approach without being seen. Sight is very important for the Hirola and probably the most efficient means of protecting themselves from predators. When approached by observers, the individuals escaped in the same route for about 250 meters, and watch back from the best available open grounds. The dominant male and females with calves appeared to take turn in leading and directing the daily activities of the group.

Like most hider species, Hirola females isolate from the group during calving and mostly remain in the vicinity within the sight of their offspring. The female may soon rejoined its herd in the vicinity, leaving the calf hidden in the bushes, a phenomenon common in most ungulates (Eates, 1974; Kingdon, 1982). When alarmed, the mother moves in the direction of her calf, which runs ahead of the herd. If followed persistently, the adult individuals would dash into different routes leaving the calves behind. However, the calf follows its alarmed parent even when it is unaware of the cause of the alarm. On few occasions, Hirola groups were found close to domestic animals, during early morning observations. This was probably for protection strategies against predation where the groups emerge from their day covers around the evenings and spend close to livestock homesteads in the night. At dusk, before cattle moved out of the kraal (*"boma"*), the Hirola were observed to disappear into their covers away from human and livestock disturbances. A situation where the Hirola were seen to take refuge towards people and domestic animals was sighted when they were attacked by pack of wild dogs.

3.5. Mammal fauna

In addition to Hirola, the range contains unique mammal fauna, which contribute to the ecosystem stability. In comparison to other parts of Kenya, the faunal species in the areas can be considered particularly abundant. Although the status of the mammal fauna in the area is not presently well known, it is presumed that their numbers have declined in the same way that Hirola population did. The large mammal species that were observed in considerable numbers during the study are shown in Appendix 4. Most of these mammals are commonly found in the vicinities of the river Tana ecosystem.

The Tana River riparian forest is a major faunal boundary for mammalian communities in northern Kenya (Marsh, 1976). The unique relict habitats represented by the gallery forests embody the last refuges for the endangered Tana River Crested Mangabey

(*Cercocebus galeritus galeritus)*, Tana River Red Colobus (*Colobus badius rufomitratus*), and De winton long-eared bat (*Laephotis wintoni)*. The statuses of these riparian bound species are presently threatened since their forest habitats are continuously declining. Tana GEF (Global Environmental Facility) project, funded by the World Bank has just been initiated for the long-term monitoring and protection of the Tana River basin ecosystem and its biodiversity.

The Hirola groups showed a tendency of associating with few large herbivores although it avoided domestic animals. Table 15 shows the percentage of association with particular species relative to the total Hirola observations. It appears that Hirola associate with Beisa oryx more than any other wild herbivore. This probably explains that the two species are not ecological competitors and probably show different feeding strategies. Wildebeests (*Connochaetes taurinus*) and Grants' zebra (*Equus burchelli*) have been reported to utilise the same ecological zones without competition for forage resources, thus closely associate with each other (Jarman *et al*, 1979).

Elephants (*Loxodont africana*), rhinos (*Diceros bicornis*) and leopards (*Panthera pardus*) that were once abundant in the area have vanished completely as a result of intensive poaching supported by market demands for their product (Leaky, 1988). The disappearance of elephants was thought to have resulted in the increase of wooded habitats in the area and this has contributed to the decline of plain games (Ottichilo *et al*, 1995). The absence of browser species and the domination of grazers, mainly cattle in the

Hirola range were disastrous. Experts have often pointed out that grazers alone severely diminish productivity and exacerbate range deterioration (Pratt *et al*, 1977).

Table 15. Observed Hirola association with other animal species

Species associated	Percent association
Alone	41
Beisa oryx (*Oryx beisa beisa)*	19
Zebra (*Equus burchelli)*	13
Grants' gazelle (*Gazella granti)*	12
Ostrich (*Ostrithius camellus)*	6
Giraffe (*Giraffa camelopedalis* and	
Gerenuk (*Litrocranus walleri*),	4
Topi (*D. l. jimela)*	3
Domestic animals (Cattle)	2

4.0. CONSERVATION AND MANAGEMENT OF THE HIROLA

4.1. Conservation measures

The law in Kenya adequately protects Hirola, but the problem is its implementation (Chris, 1996). Its conservation has been precarious for the last 25 years especially after the irrigation schemes and livestock development industry were established within its range. Arawale National Reserve was created in 1974 to ensure long-term survival of the species (Bunderson, 1976). However, the reserve has apparently failed to protect the species and it is no longer a preferred habitat for the animals (Wargute *et al*, 1993). Complete protection of the Hirola in its natural range became hard given the insecurity situation and the animals' high mobility habits (Western, in press). However, management priority is usually given to high tourists' potential protected areas, for the purpose of higher economic returns. Given the remoteness of the Hirola range where development has been minimal coupled with insecurity situation, management in the Hirola Arawale National Reserve remains insufficient. Presently, the Hirola competes with humans, domestic and other wild herbivores for the available resources and exists without any other land reserved for its protection.

The decline of the Hirola populations since 1970s was as a result lack of effective conservation measure, even though security problems of the areas was the reason for the ineffective protection. Due to the declining numbers of the Hirola in the natural habitats, *ex situ* conservation measures were considered. A small sub-population of the Hirola was introduced into Tsavo East National Park in 1996 in addition to the 1963 translocated individuals. This was an attempt to extend its distribution to other ecologically suitable habitats to ensure the continued survival of the Hirola. Despite the poor herd structure and small genetic pool, the translocated sub-population survived well in the new environment, although high calf mortality has been a drawback (Andanje, in prep.)

4.1.1. Factors affecting the status of Hirola

Discussions with the local people during the study found some preliminary evidences that might have caused the decline of Hirola population. The responses were rated in a descending intensity as hunting, bush encroachment, habitat destruction, predation, human disturbances, drought and diseases. These factors were also mentioned by other workers (Wargute *et al*, 1993; Ottichilo *et al*, 1995). Controlling these factors is the primary management strategies that would ensure the long-term survival of the Hirola and maintenance of its natural habitats.

4.1.1.1. Hunting

The main cause of Hirola decline was the incessant hunting by people with firearms. Although there is legal provision to prohibit poaching, the existing protective measures inside and outside the Arawale National Reserve are almost totally ineffective. The level of banditry and the proliferation of automatic weapons in the areas thwarted anti-poaching efforts in the 1980's that exterminated elephants and rhinos (Western, in press). The communities at riverside and those at border areas frequented hunting activities. They periodically travel for long distances in a hunting expedition. Hunters without firearms have invented an efficient hunting technique of blinding the animals with strong light in the night and kill them easily (Ugas, pers. comm.). During aggregations around restricted food resources, the Hirola is again easily hunted.

Recent investigations have found that bushmeat consumption is common, especially in the refugee camps located in Kenya (Sirat, Pers. comm.). Although hunting of wild animals has been widespread in other parts of Kenya, presently the situation has been contained due to improved public awareness and the general anti-poaching campaigns in protected areas. Community sensitisation and dissemination of information on the status of the Hirola and the establishment of regular patrol system in the area can be useful in preventing the sporadic poaching activities in the area.

4.1.1.2. Bush encroachment

The proportion of wood cover is increasing in the Hirola ranges, continuously reducing the grassland habitats (Table 3). According to the local people, open plains have turned to bushlands, also observed by other workers (Ottichilo *et al* 1995; Wargute *et al*, 1993). The encroachment of *Acacia* woodland upon open grassland was evident in Arawale National Reserve where regeneration of woody species increased the woodland habitats. This reduced the range areas available to the Hirola, which mostly avoid dense wooded habitats.

The roles of elephants and fires in limiting tree regeneration are probably important in maintaining the open grassland habitats was documented by Yoaciel *et al* (1982) in Rwenzori National Park and Western (1984) in Serengeti National Park. Elephants help in opening up of dense habitats and turned woodlands into grasslands. The absence of elephants in the range and the rare occurrence of fires led to the increase in *Acacia* regeneration in the Rwenzori National Park (Yoaciel *at al*, 1981). Bush encroachment associated with the loss of large mammals from the ecosystem and the seasonal flooding regimes were observed in the Hirola ranges. Similar phenomenon of bush encroachment has been reported in many savanna ecosystems, threatening the existence of grassland species due to the continued contraction of their ranges (Yoaciel *et al*, 1981).

Bush encroachment could result from the lack of browsing pressure on the shrubs and tree seedling layers to prevent the regeneration of tree species (woodlands) and leading to the replacement of grass species. Under-use and probably series of years of high rainfall in the areas have caused an overall increase in shrubs and tree densities and changed species composition in the Hirola ranges. Densely wooded habitats did not favour most grazer species such as Hirola but other browsing species such as Greater kudu and the Gerenuk, which seem to be successful in numbers within the range. As long as grassland areas continue to be encroached by wood species, the Hirola populations will decrease and probably remain only in small insular open areas. Action to retard wood regeneration by use of rotational fires should be implemented in parts of Arawale National Reserve. The future of the Hirola in the range depends primarily on the reduction of woody vegetation cover.

4.1.1.3. Habitat destruction

The habitat destruction results from the expansion of farmlands and the overgrazing by pastoralist livestock in most of the dry season wet grazing areas. Farming activities also reported by Ochiago (1991) still continues and is carried out in a wasteful and destructive method of shifting cultivation, which lead to continuous removal of vegetation cover along the Tana River. Cultivation of crops take up the dry season grazing areas and wetlands reducing areas available for grazing activities. This caused increased grazing pressure, which results frequent burning by pastoralists, partly to secure new forage for livestock and to remove dense standing biomass, especially when grasses and other plants are dry.

Although fire could be useful in pasture regeneration, wild animals require escape routes and adequate vegetation cover for protection. Wood cover is particularly beneficial to Hirola as shelter and protection, especially during the calving season and shading during the hot season. Therefore, the maintenance of habitats with relatively good vegetation cover is critically important for survival of the Hirola in the ranges. Overgrazing and frequent range fires have been reported to favour the growth of unpalatable plant species that are unattractive to both domestic and wild herbivores (Pratt *et al*, 1966).

4.1.1.4. Predation

Predation by large carnivores affects the status of the Hirola and other wild herbivores in the areas. Although such predation effects on the Hirola is not well known yet, field observations and reports by the local people confirmed predation incidences. The major natural enemies of the Hirola were observed to be African wild dog (*Lycaon pictus*) and lion (*Panthera leo*). Hunting packs of wild dogs are most widespread predators of both wild and domestic animals in the area. Serval cat (*Felis serval*), Jackals (*Canis aurius*) and hyaena (*Crocuta spp.*) take the calves in their lie-outs. The carnivore predation is also a problem to the pastoralists in the area.

4.1.1.5. Human disturbances

The continued expansion of settlements and human activities in the area cause great disturbances to wild animals. The wild herbivores are displaced from wet grazing areas by the pastoralists' livestock and do not gain access to waterholes. Armed bandits who periodically intrude into the area and the presence of heavy military patrol cause further disturbances (Bille, pers. comm.). Similarly, herdsboys scare away the Hirola and other wild herbivores mostly for fear of disease transmission and pests to their livestock. Although the pastoralists are relatively tolerant to the Hirola and other wild animal herbivores in the area, harmonious co-existence can be achieved through conservation outreach programmes. Such programmes could be executed through both formal and informal means by conducting village meetings, visiting local schools, livestock watering points and the use of rangers in the area.

4.1.2. Hirola Task Force

The precarious situation of the Hirola required a renewed action especially after the reports by KWS (1995) gave an alarming estimate of about 300 Hirola individuals. In an attempt to rescue the species from a possible extinction, Hirola Task Force was formed to steer an emergency conservation measure for the Hirola. Due to security reasons in the Hirola ranges, the Task Force recommended an *ex situ* protection for the species through the establishment of sub-population in other well protected areas (Andanje, in prep.).

In the execution of this short-term plan, a second Hirola population was introduced into the Tsavo East National Park to boost the genetic pool of the earlier translocated sub-population. Post release monitoring reports showed that the animals have low population growth potential in their new habitat (Andanje, in prep.). Relocation of species to new environment is bad conservation; rather basic conservation must remain the maintenance of the natural habitats with all its species. The desired long-term objective of *in situ*

Hirola conservation is yet to be achieved. Although the Task Force recommended an improved protection for the Hirola in its natural home ranges, conservation activities generally remain minimal in the eastern bank of the river Tana that corresponds to the Hirola ranges.

4.1.3. Community conservation

Wild animals play an important role in the lives of rural people as socio-cultural symbols and contributor in the maintenance of biosphere and ecosystem stability (FAO, 1995). There has always been special relationship between the local people and their immediate nature, which are usually ignored by decision-makers and even scientists. The outcome is the destruction of both species and their natural habitats. To cultivate goodwill among the local community towards conservation efforts, it requires identifying, understanding and appreciating the roles of the community, based on their socio-economic and cultural realities. Such participatory approaches have been lacking in the Hirola conservation efforts.

Conservation efforts for Hirola need to involve the local people, mainly the pastoralists in taking joint responsibility in managing their natural resources. Such joint ventures enhance the conservation of species and its ecosystems and minimise threats. Such community conservation has succeeded in many parts of Africa, for instance, in Zimbabwe, Nambia, Zambia, Tanzania, to mention a few. However, this depends on the understanding the local history, local technologies, food security, infrastructure, physical characteristics of the area and the trends of social reforms (FAO, 1995).

Hirola co-existed with the pastoralists, livestock in the range for thousands of years. Discussions with local elders revealed that pastoral community possesses somewhat cultural attachments ("*Barka*") with the Hirola and identify it with good conditions of their livestock populations. Bunderson (1976) reported that the Hirola and pastoralists livestock in the range are both subject to the environmental stress and their co-existence produced a balanced equilibrium between the domestic and wild herbivores. The pastoralists in the area are inextricably linked and reasonably tolerant of the Hirola. They consider the wild herbivores in the locality as some kinds of remote sensing mechanisms used to understand the pasture conditions, weather changes, disease and intensity of tick infestation and predation in the range. However as the pastoralists continue to be exposed to modern lifestyles, these preservative cultures erode more and more.

The fact that the local communities are concerned with the Hirola conservation was also clearly observed during its translocation when the locals protested against the plan although the support and participation was misconceived (Hyder, in press). Presently the community members have organised and formed Hirola conservation group whose objectives are to protect and keep surveillance of all wild animals in the local areas and more so for the threatened Hirola. Harroru Community Hirola Conservation Group (HCHCG) is a community-based organisation (CBO) which has been in the forefront in organising community forums and conservation outreach campaigns. The group which comprise local leaders, youth, and elders and contact groups, aim to sensitise and educate the people in the area on the harmonious co-existence and protection of wild animals in the range. The local people especially the pastoralists are knowledgeable about the Hirola and its ecology, which can be useful in participatory conservation efforts.

Programmes that relate development to conservation are needed so that the communities appreciate conservation efforts. Poverty alleviation projects that would improve the health services both for the humans and domestic animals, water supply and income generating activities (bee keeping, subsistence farming, small-scale enterprise etc.) would promote conservation activities in the Hirola range. To these initiatives, the HCHCG received support from UNDP- GEF/SGP towards social mobilisation and surveillance of the Hirola populations in the range.

5.0. CONCLUSIONS

The trends of Hirola populations have been so irregular that specific conclusion might not be possible. Even then, the underlying trend is that the Hirola populations have declined rapidly in much of its range since the 1970's as indicated in its earlier accounts (Wargute *et al*, 1993; Agatsiva, 1995). The current Hirola population is estimated to be about 1416 Hirola individuals. Comparing with the previous population estimates this number is not alarmingly too low. Although its populations have decreased far much in the past two decades, the Hirola population seems to have stabilised between 1000 and 2000 individuals since 1985, also reported by many authors (Figure 5). The relatively high percentage of juveniles and breeding females suggested that the present Hirola population might be increasing, probably as a result of decline in domestic animals in the areas and better moisture regimes in the past years.

The study showed that seasonal variation in the quality and abundance of forage affect the habitat preference of the Hirola as also reported for most savannah ungulates in Dunham *et al* (1982), Fryxell (1987), and Duncan (1985). The Hirola however, showed marked preferences for the less wooded vegetation and relative avoidance of the densely wooded habitats, both being marked during the wet season. Shifting between vegetation types and selecting range of plant species seasonally was observed in Hirola. These results are consistently observed in most ungulates in resource scarcity and seasonally changing ecosystems in Africa (Kutilek, 1979).

The distribution patterns of the Hirola could be explained mainly in terms of its seasonally changing habitat conditions also reported for many other ungulates by Western (1975) and Jarman e*t al*, (1972). As a result of rainfall seasonality in the range, green grass and surface water supplies vary considerably both in distribution and abundance. In this study, it was observed that during the wet season, the resources are abundant throughout the range, thus the Hirola population showed scattered distribution, also reported by Bunderson (1976). However, during the dry season, the required resources are isolated and restricted largely to ephemeral wet grazing areas along watercourses and valley bottoms. The Hirola populations build up in such areas as Galma-Galla areas during the dry season (Table 4). This confirmed an earlier observation by Bunderson (1976) that Galma-Galla areas of Hulugho range was an important dry season habitat for the Hirola. However, Bunderson (1976), reported major wet and dry season concentration areas near the Tana River between Masalani and Bura particularly during the dry season. Such Hirola concentration in these areas was not observed during both dry and wet seasons of the study. The expanding human settlements and the seasonal grazing pattern of pastoral livestock probably displaced the Hirola population from these dry season key habitats. The observed distribution of the Hirola and livestock differed with earlier reports by Wargute *et al* (1993) and Ottichilo *et al* (1995) that the two populations showed a degree of overlapping distributions.

The demographic compositions of the Hirola population were adult female biased (Table 12). The high proportion of immature individuals in the population indicated an increased percentage of potentially breeding females, which are determinants of population growth. Seasonal changes in the group sizes are also found in other species, usually during migration or seasonal concentrations on localised food resources. The Hirola group sizes and compositions seem to be consistent with both food dispersal (Jarman, 1974) and anti-predator (Hamilton, 1971; Harvey *et al*, 1978) hypotheses. Conversely, during the wet season the Hirola groups had relatively fewer individuals in each group. The Hirola herds with fewer members seemed to have high bondage and close social grouping as it is found in most antelopes (Jarman, 1974; Leuthold, 1977).

6.0. RECOMMENDATIONS

By virtue of its low numbers and restricted distribution compounded by the continued lack of effective protection, the Hirola is extremely endangered in its natural habitats. Therefore, regular population monitoring is needed. More comprehensive studies are needed to find out the limiting factors and determine evidences of exogenous processes regulating the Hirola population. An assessment of niche overlap between the Hirola and domestic livestock in the range would help to understand the intensity of competition for resources. The effect of the expanding human settlements on the movement and distribution of the Hirola should be established. An inventory of plant species consumed by the species both during the dry and wet seasons is essential. These would help in the formulation of appropriate conservation measures for the Hirola.

The continued existence of the Hirola in its natural ranges depends upon the accordance of effective protection of the Hirola and proper management of the Arawale National Reserve. Although Arawale reserve is apparently unsuitable for the Hirola, its rehabilitation through improved management programs such as the control of bush encroachment, security and exclusion of human activities would attract the Hirola populations back into the reserve. Since the reserve represents only about 4% of the Hirola natural ranges its extension to the east and south should be explored together with the local communities. Village Scouts who would be responsible for reporting on poaching activities and to keep track and record of all wildlife in the areas could be recruited. Well-equipped ranger posts are required to monitor hunting activities in the eastern bank of the River Tana specifically at Mansabubu, Galmagalla and Ijara. The control of firearms to stop opportunistic poaching would be an effective conservation measure for Hirola and other wild animals that occur in the northern region of Kenya. Otherwise the Hirola ranges have good potential for the long-term survival of significant wildlife population if security problems can only be overcome.

Effective conservation measure should be carried out through an extension work to create public awareness among the local community. The aim should be to promote a situation where Hirola conservation forms part of a multiple land use systems. The local people should be educated on the importance of conservation so that they appreciate the benefits of nature conservation. It is important to combine the best of the indigenous knowledge and modern conservation systems to develop a deeper understanding of the species and their ecosystems. Such participatory activities on the protection of Hirola would succeed with minimal provision of socio-economic incentives, where development and poverty alleviation activities could be related to biodiversity conservation. Local communities should be encouraged in regards to conservation issues through the support for community initiated projects. Such support to the local people in areas without immediate financial gains from conservation would enable the local people to appreciate and work together with conservation agents. Hirola Management Committee (HMC) should realise the efforts of local people and involve them in decision making as well as to seek their opinions in Hirola conservation in the natural ranges.

7.0. APPLICATION OF THE OUTPUT

The study achieved an insight into the current population status of the Hirola, its habitat requirements and seasonal distribution patterns. This study contributes to the continuous flow of data and the monitoring process of the Hirola population trend. Effective conservation of local biological resources that occurs in unprotected areas could only be achieved through the implementation of such field-based data. The results would help the local community and wildlife authority to plan a meaningful management and protective measures for the Hirola and its ecosystem.

Through repeated field visits during the study, the researcher and the local people have learnt more about the Hirola ecology, the relation between Hirola and the pastoral livestock and more importantly the need to involve the community on the issues of conservation. The people become better informed about the plight of the threatened wild animals in the areas and conservation measures would easily form part of the multiple land use system in the area.

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Appendix 1. Survey data entry form

Season (Dry/Wet)......... **Range block unit...........**
Month of season................ **Sample Quadrat number........**
Period of season (Early/Mid/Late)........ --

Date	**Time**	**Quadrat Number**	**Group size**	**A/M**	**A/F**	**S/A**	**Calves**	**Coord. Activity**	**Habitat Type**	**Other Species**

Key: A/M – Adult male; A/F – Adult female; S/A – Sub-adult

Total Animals sighted

Adult Sex ratio:-

Age ratio:-

Total of other species:-

Comment:

Appendix 2. Seasonal observations of the Hirola in the 20 sample quadrats of the range blocks

	Sample Quadrat	Dry season	Wet season	Average
1	Nanighi	32	91	61.5
2	Bura	23	39	31
3	Masanbubu	27	34	30.5
4	Garasweino	17	42	29.5
5	Masalani	23	50	36.5
6	Korissa	19	48	33.5
7	Hara	20	35	27.5
8	Kotile	30	40	35
9	Gababa	47	71	59
10	Jalish	127	70	98.5
11	Gerille	60	47	53.5
12	Warsame	89	57	73
13	Sangailu	33	73	53
14	Getilun	41	82	61.5
15	Handaro	14	40	27
16	Wakab Harey	53	62	57.5
17	Mata Arba	20	86	53
18	Galma-Galla	129	107	118
19	Doy	109	77	93
20	Gubis	117	83	100
	Total	1030	1234	1132
	Sample mean	51.5	61.7	56.6
	Sample variance	1576.9	461.7	752.2
	Sample standard error	39.7	21.5	27.4
	POPULATION ESTIMATE	1288	1543	1416
	POPULATION VARIANCE	9860.5	2885.6	4701.1
	POPULATION STD. ERROR	99.3	53.7	68.5
	95% CONFIDENCE LIMIT	208	112	143

Appendix 3. Common grasses, trees, shrubs and herb species found in the Hirola range

Grass species	*Panicum maximum*	*Boscia spp*
Aristida adensionis	*Sporobolus brockmanii*	*Calypterotheca spp*
Cenchrus ciliaris	*Sporobolus pyramidalis*	*Combretum spp.*
Cenchrus ciliaris	*Tetrapogon tenellus.*	*Commiphora spp*
Chrolis barbata	**Herbs**	*Cordia spp*
Chrolis roxburgiana	*Becium spp*	*Diospyrus spp*
Cynodon dactylon	*Commelina africana*	*Dobera glabra*
Cyperus chordorrhizus	*Commelina bengalensis*	*Figus populifolia*
Dactyloctenium spp	*Commelina erectus*	*Grewia spp*
Digitaria macroblephora	*Indigofera intricata*	*Lanea spp*
Digitaria milanjiana	*Portulaca oleraceae*	*Lannea alata*
Digitaria rivae	*Tephrosia subtriglora*	*Mimusops obtusifolia*
Digitaria spp	**Trees and Shrubs**	*Phyllanthus somalensis*
Echinocloa spp	*Acacia mellifera*	*Salvadora persica*
Enteropogon	*Acacia nilotica*	*Sesmothamnus rivae*
schimperaus,	*Acacia ruficiens*	*Terminalia spp*
Latipes senegalensis	*Acacia senegal,*	*Veronia spp*
Panicum infestum	*Acacia tortilis*	*Xeromphis spp*

Appendix 4. List of large mammal fauna observed in the study area

African civet *Vivera civetta*
African wilddog *Lycoan pictus*
Beisa oryx *Oryx beisa beisa*
Buffalo *Syncerus cafer*
Bushbabies *Galago spp.*
Bushbuck *Tragelaphus scriptus*
Caracal *Felis caracal*
Cheetah *Acinonyx jubatus*
Common zebra *Equus burchelli*
Genets *Genetta spp.*
Gerenuk *Litocranius walleri*
Giraffe *Giraffa camelopedalis*
Grant's gazelle *Gazella granti*
Greater kudu *Tragelaphus strepsiceros*
Grey duiker *Cephalophus grimmia*
Guenther's dikdik *Rhynchotragus guentheri*
Harvey's duiker *Cephalophus callipygus*
Hippopotamus *Hippopotamus amphibians*
Black-backed Jackal *Canis mesomelas.*
Kirk's dikdik *Rhynchotragus kirkii*
Lesser kudu *Tragelaphus imberbis*
Lion *Panthera leo*
Olive baboon *Papio anubis*
Ratel *Mellivora capensis*
Serval cat *Felis serval*
Spotted hyaena *Crocuta crocuta*
Stripped hyaena *Hyaena hyaena*
Syke's monkey *Cercopithecus mitis albotorquatus*
Tana river Crested mangabey *Cercocebus galeritus galeritus*
Tana river Red colobus *Colobus badius rufomitratus*
Topi *Damaliscus lunatus jimela*
Vervet monkey *Cercopithecus aethiops*

Warthog *Phacocoerus aethiopicus*
Waterbuck*Kobus ellipsiprymnus*
Wild cat *Felis silvestris*