ADDIS ABABA UNIVERSITY

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POPULATION STATUS AND HUMAN IMPACT ON BURCHELL'S ZEBRA (*Equus burchelli*, GRAY 1824) IN NECHISAR PLAINS, NECHISAR NATIONAL PARK, ETHIOPIA

BY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The population census of Burchell's zebra (Equus burchelli) and the human impact were carried out in Nechisar plains, Nechisar National Park, 515 km south of Addis Ababa from November 2001 to April 2002. Line transect count was used for population census. Social and physical surveys carried out on the range of Burchell's zebra population to find out human impact. The present population density estimate of Burchell's zebra in the Nechisar plains was found to be 16.6 ± 1.5/km^2. The population abundance of Burchell's zebra in the study area was found to be 4482 individuals. This estimate shows an increase in population trend compared to the previous one. During the wet season, 57.3% preferred the Nechisar open grassy plain. During the dry season, 53.5% preferred Hare hill plateau bushland. Grass and water availability was identified as the main factor influencing the movements and distribution of the Burchell's zebra population in Nechisar plains, especially during the dry season. Observation of feeding processes showed that they feed upon most common grasses available but appeared to have preference for particular six grass species. Their local distribution range was contracted during the wet season, 95.9% were observed inside the park. During the dry season, 76.2% were observed inside the park while 23.8% were observed outside the park boundary. Non-territorial nomadic Burchell's zebra live in social group. The average herd size of one-male harem and bachelor stallion herds was 10.8 and 6.4 individuals. The sex structure of Burchell's zebra population in the Nechisar plains was 34.8% adult male, 41.5% adult female and the rest 23.7% were unsexed immature young. The sex ratio of adult male to adult female was 1.0:1.19. The age structure of Burchell's zebra population in the Nechisar plains was 76.3% adult, 14.7% subadult, 5.2% juvenile and 3.8% foal. Predators of Burchell's zebra in the Nechisar plains are 28.6% lion (Panthera leo) and 6.5% spotted hyena (Crocuta crocuta), but the other causes of death, 14.5% old age and 49.4% unknown. Burchell's zebras are diurnal herbivores. During the dry season, two resting periods observed. The most important aspects of social behaviour communication were 38.8% visual, 24.2% olfactory, 18.8% tactile and 18.2% vocal (or auditory). Agonistic behaviour is observed during sexual display, danger and disputes. These were 53% submissive traits, 25% fighting, and 22% aggressive traits. Larger plain wild and domestic ungulates mix with Burchell's zebra in the Nechisar plains. These are 17.5% Grant's gazelle (G. granti), 4.8% Swayne's hartebeest (A. h. swayni), 1.6% Greater kudu (T. sterepsiceros), 11% cattle and 1.6% domestic goats. The socio-economic survey confirmed that 250 households settled at eight villages in the Nechisar plains comprising 1640 Guji Oromo people and 7080 livestock. The present study indicated that the Burchell's zebra population is at conservation risk because of the human impact that includes settlement encroachment, overgrazing, recent bush invasion and human disturbance. Developing community based wildlife conservation, improving the socio-economic standard and implementation of effective educational program to the local people can serve as a tool for the population management of the Burchell's zebra.

1. INTRODUCTION

Ethiopia has a unique diversity of wildlife. The diversity in the wildlife is chiefly because of the diverse habitat and climate, varying from desert to tropical forest and Afro-alpine habitats. The main areas of wildlife conservation are in the south and southwestern part of Ethiopia. The main Burchell's zebra populations at present are in Omo, Mago, Nechisar National Parks, and Yabelo Wildlife Sanctuary (Bolton, 1973). In East Africa, zebras are increasingly restricted to Parks, Sanctuaries and Game Reserves. The dependence of these species on water certainly puts limits to their ranges (Kingdon, 1979). In Africa, they are distributed across the Somali-Masai arid zone through the southern Savannah and marginally in the southwest arid zone, from southeastern Sudan to South Africa and Angola (Estes, 1997).

These protected areas were formerly administrated and managed properly, but during the last ten years, their integrity has become threatened due to poaching, encroachment of settlement and overgrazing by domestic animals (IUCN, 2000). National Parks and Wildlife Reserves have lacked sufficient trained staff, materials and resources to counter these threats. In the absence of adequate government funds, external support has been largely responsible for providing the resources to keep key protected areas at least moderately well staffed and managed. These problems are compounded by a general lack of public awareness on the value of the country's unique wildlife resources.

The word Zebra is derived from Portuguese *Zebro* that means wild donkey (East, 1995). A striped coat easily recognizes Burchell's zebra instantly (Kingdon, 1979). The Burchell's zebra (*Equus burchelli,* Gray 1824) popularly known as plain zebra or common zebra plays

an important role in maintaining the ecological balance in nature. Burchell's zebra have a unique set of behavioural, morphological and physiological characteristics, which allow them to exploit coarse grasses more effectively than other plain ungulates. They facilitate the use of coarse tall grasses by smaller plain ungulates such as Grant's gazelle (*Gazella granti*) (East, 1995; IUCN, 2000). The larger predators such as Lion (*Panthera leo*) usually kill old, weak and sick Burchell's zebra. They are gregarious animals frequenting on savanna grasslands as a result attract foreign tourists and local visitors. Among the wild species of equids, the Burchell's zebra have the greatest commercial value for the skin and meat. Unfortunately, the economic importance of the meat and skin production of Burchell's zebra has yet not been documented in detail. In Africa, large number of local people is poaching the Burchell's zebra in order to satisfy their meat demand (Duncan, 1992).

Nechisar plains support the country's largest concentration of Burchell's zebras (Kirubel Tesfaye, 1985). The estimate for the Nechisar National Park is around 3,000 (EWCO, 1995). Human impact in the park includes grazing of cattle by nomadic Guji and settled cultivation by the Kore together with rampant poaching (Kirubel Tesfaye, 1985). Bolton (1970) reported the degradation of the grass quality in the Nechisar plains through trampling by cattle causing habitat destruction. In 1980, the local people inside the park were forced out of the park by the previous military government. However, they returned back inside the park during the 1992 political change over in the country. This revenge activity has caused wide spread destruction both to the habitat and wildlife. The 1995 estimates of Burchell's zebra number by EWCO staff indicate substantial increase in the Nechisar National Park (IUCN, 2000). Despite these recorded increases, the level of protection and management at the park is relatively low due to encroachment of settlement (Schloeder, 1996).

The populations of Omo and Mago National Parks are at low levels compared to those recorded in 1986 - 90, well below the estimated 4,000 - 6,000 for those two national parks in the late 1970's (Lamprey, 1994). However, it is not clear to what extent the apparent population decline reflects movements of zebras in and out of the parks (Graham *et al.*, 1996). Lamprey (1994) and Graham *et al.* (1996) observed zebra herds on the adjacent Tama plains. These parks have received no effective protection since the mid-1970s, and heavily poached (Schloeder, 1996; Graham *et al.*, 1996).

Animals form a dynamic relationship with their environment that can be studied at two different levels of time and space (Norton-Griffiths, 1975; Inglis, 1976). The temporal and spatial variation in resource availability is a characteristic feature of many savanna ecosystem of Africa (Inglis, 1976; Kingdon, 1979). The seasonal variations in the availability of the required resources affect aspects of ungulate ecology such as its distribution, reproductive seasonality, habitat preference, and activity patterns (Kingdon, 1979; Sinclair, 1983; Duncan, 1985; Estes, 1997). Thus, the seasonal distribution of animals is linked with shifting distribution of critical resources (Inglis, 1976; Kingdon, 1979; Kirubel Tesfaye, 1985). Seasonal migration is a particularly successful strategy for coping with resources scarcity in the highly seasonal environments.

Non-migratory African herbivores satisfy their nutritional requirements in a limited home range by seasonally shifting between habitats within their limited ranges (Kingdon, 1979; Kirubel Tesfaye, 1985) and selecting varying plant species. 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 (Kirubel Tesfaye, 1985; East, 1995). Thus, natural populations are continuously declining in numbers due to the shrinkage of their natural habitats, and even some have become extinct (Smithers, 1983; Duncan, 1992). In this respect, the decline of large mammals is attributed to restriction to their ways of coping with seasonally changing habitats. The future of protected areas will depend on the development of conservation measures, which are appropriate to specific conservation areas (IUCN, 2000). Knowledge on the biology and ecology of wildlife is required for effective conservation and proper management activities (Sinclair and Norton-Griffiths, 1982). At present, the research information on its current population status and extent of human impact is not well identified. Therefore, it is crucial to study the population status and human pressure on the species.

The objectives of this study were to determine the current population status and human impact on the Burchell's zebra within Nechisar plains with the following specific objectives.

1. to determine current population density, abundance, trend, and habitat preference by using line transect random sampling method for population census.
2. to determine seasonal distribution, aspects of demographic composition and herd structure, daily activity pattern and behavioral traits by using silent detection field observation and line transect random sampling population census.
3. to identify the extent of human impact that affects the survival of Burchell's zebra by using social survey and field observations.

2. LITERATURE REVIEW

2.1 Evolutionary relationship and Taxonomy

The Burchell's zebra belongs to the Order *Perissodactyla*, Family *Equidae*, Genus *Equus* and

Species *burchelli*. There are three families of Perissodactyla: Tapirdae, Rhinocerotidae and Equidae. Two of the families, Rhinocerotidae and Equidae, are represented in tropical Africa. Zebras, asses and horses are members' of the Family Equidae. The evolutionary history of the equids has been documented in detail from their Eocene origins 55 million years ago, through the browsing *Miohippus* of Oligocene (Simpson, 1951; Kingdon, 1979). Subsequent fossils are found exclusively in North America until the Miocene when advanced equids began to invade other continents (Kingdon, 1979). The early equids were small browsing ungulates of forest habitats (Simpson, 1951; Kingdon, 1979). However, the extension of the grassland in the Miocene led to the evolution of new medium-sized cursorial grazer in North America. The family saw the Pliocene radiations to grazing equids, from *Merychihippus* in the Miocene to equids on the Pleistocene about 1.5 million years ago (Kingdon, 1979; Duncan, 1992).

The number of living Equid taxa is a matter of controversy. However, the Genus *Equus* includes six species and twenty-two subspecies. Three of these (*E. b. burchelli, E. b. hunippus* and *E. przewalikii*) are extinct (IUCN, 1990; Duncan, 1992). The three surviving species of zebras are: Mountain zebra (*Equus zebra*), Grevy's zebra (*Equus grevyi*) and Burchell's zebra (*Equus burchelli*) (Dorst, 1970; Kingdon, 1979; Duncan, 1992; Estes, 1997). Burchell's zebra show considerable geographical variations, resulting in the descriptions of a number of local races. The five extant subspecies of Burchell's zebra are: Grant's zebra (*E. b. boehmi*), Upper Zambezi zebra (*E. b. zambeziensis*), Crawshay's zebra (*E. b. crawshayi*), Chapman's zebra (*E. b. chapmani*) and Damara zebra (*E. b. antiquorum*) (Duncan, 1992; IUCN, 2000).

The shoulder height of Burchell's zebra measures: 120 - 140 cm; length of head and body: 217 - 246 cm, tail length: 47.0 - 56.5 cm and weight of adult male 250 kg, adult female 220 kg (Kingdon, 1979; Estes, 1997). Slight sexual dimorphism is seen between sexes. Males weigh more and adult stallions have well-developed canine teeth but not mares (Duncan, 1992). They are geographically very variable. The northernmost race *E. b. boehmi* is completely and boldly striped, decreasing towards the south. The southernmost races, *E. b. antiquorum* and *E. b. burchelli* have shadow stripes, with striped bellies and lower legs (Wolff, 1955; Dorst, 1970; Kingdon, 1979; Estes, 1997).

2.2 Distribution

Two species of wild asses are distributed in Asia, while three zebra and one wild ass species are confined to Africa. The wild horse is well adapted to temperate grasslands of northern hemisphere, but never penetrated the Sahara prior to domestication. The African wild ass is adapted to more conditions that are arid. The Somali ass exists as few scattered bands and still survives in the remotest reaches of Somalia and Ethiopia (Dorst, 1970; Kingdon, 1979; Estes, 1997). Among the three existing species of zebra, the Gravy's zebra (*Equus grevyi*) inhabits sub-desert steppe and arid bushland of Somalia, Kenya and Ethiopia (Dorst, 1970; Chris and Struat, 1997; Estes, 1997). The Mountain zebra (*Equus antiquorum*) inhabits dry stony mountains and hills of South Africa. Hartman's zebra ranges deep into the desert after the rains. Formerly, it was wide spread in the arid mountain ranges parallel to the coast from southern Angola to the Transvaal (Dorst, 1970; Estes, 1997). Burchell's zebra (*Equus burchelli*) is one of Africa's most adaptable and successful grazer. It utilizes a broad range of savannah habitats from tree less short grassland to tall grassland and open woodland (Dorst, 1970; Estes, 1997; Chris and Struat, 1997).

Plains zebras once ranged throughout eastern and southern Africa except in areas that lay within former forest belts, as in western and central Uganda (Kingdon, 1979). Then the range of plains zebra stops short of the Sahara and no zebras occur west of the Nile. In East Africa, zebras are increasingly restricted to Parks, Sanctuaries and Game Reserves. The dependence of these species on water certainly puts limits to its ranges (Kingdon, 1979). It is distributed across the Somali-Masai arid zone through the southern Savannah and marginally in the South West Arid Zone, from southeastern Sudan to South Africa and Angola (Estes, 1997). The 12 range countries of eastern and central Africa are Sudan, Ethiopia, Somalia, Uganda, Kenya, Rwanda, Tanzania, Angola, Zambia, Congo, Malawi and Mozambique; and the 5 range countries of southern Africa are Namibia, Botswana, Zimbabwe, South Africa and Swaziland (Appendix I).

2.3 Population size and trend

Five extant subspecies of Burchell's zebra were recognized (Duncan, 1992). The upper Zambezi zebra (*E. b. zambeziensis*) has suffered from over hunting in Angola and southern Congo. It survives in good number in western Zambia where the estimated 18,220 are substantially higher than reported by Duncan (1992). The Vast Kafue Park has the potential to support a large population of the subspecies in Zambia. The Crawshay's zebra (*E. b. crawshayi*) core populations are stable in the well-protected north and south Luangwa National Parks in Zambia (Appendix I). Significant population of this subspecies also occurs in protected areas of Malawi (Duncan, 1992).

The Chapman's zebra (*E. b. chapmani*) in Ngorogoro National Park in Tanzania suffered a catastrophic reduction during Mozambique's civil war. The Damara zebra (*E. b. antiquorum*)

occurs in substantial numbers in South Africa, northern Botswana and Namibia. The overall population trend of this subspecies is unclear, with numbers increasing in South Africa, decreasing in Botswana and greatly reduced in Namibia (Appendix I).

Among these subspecies, the Grant's zebra (*E. b. boehmi*) is the most abundant subspecies, with estimated total number of about half a million. This is mostly distributed in Tanzania and Kenya (Appendix I). The number of Grant's zebra has decreased in Uganda and Rwanda due to civil war, and may also be decreasing in Tanzania where excessive hunting for meat threatens the major population in the Serengeti National Park. Numbers appear to be stable in Kenya. Their population size and trend is unknown in Somalia and the Sudan.

Their population size in Ethiopia is estimated to be about 9000 (Yalden *et al.*, 1986). This figure then showed fast decline about 2000 (Duncan, 1992). The populations of Omo and Mago National Parks are at low levels compared to those recorded in 1986 - 90, well below the estimated 4,000-6,000 for those two national parks in the late 1970's (Lamprey, 1994) (Table 1). However, it is not clear to what extent the apparent population decline reflects movements of zebras in and out of the parks (Graham *et al.*, 1996). Zebra herds observed on the adjacent Tama plains by Lamprey (1994) and Graham *et al.* (1996). The latter observed no zebras within the Omo and Mago National Parks during the 1996 aerial survey. These parks have received no effective protection since the mid-1970s, and heavily poached (Graham *et al.*, 1996).

Table 1.Estimated population size and trend of the Burchell's zebra in Ethiopia

Area	Size in (km^2)	Year	Population	Trend	Source
Omo NP	4,033	1994	40	D	Aerial count (Lamprey, 1994)
Mago NP	2,098	1994	130	D	Aerial count (Lamprey, 1994)
Nechisar NP	514	1995	3,000	I	EWCO, 1995.
Yabelo WS	2,496	1995	2,840	S/I	Aerial survey (Thoules, 1995).
Total	9,141		6,000	S/D	

D: Decreasing, I: Increasing, S: Stable

The total number in these four protected areas was estimated to be about 2000 and decreasing (Duncan, 1992). Estimate by EWCO staff indicates substantial population increase at Yabelo. This is substantiated by the aerial survey results of Thoules (1995). Yabelo Wildlife Sanctuary has never received active protection and management. It was taken over for a livestock project in the late 1980s. In Nechisar National Park, road counts by Kirubel Tesfaye (1985) showed that the population size of Burchell's zebra was 6500 individuals/km^2. Since 1985, quantitative survey was not carried out in the Nechisar National Park. Nechisar National Park is affected by the encroachment of human settlement and livestock. Despite these recorded increases, the level of protection at Yabelo and Nechisar is relatively low.

2.4 Feeding habit

One of the African most adaptable and successful grazers, the plains zebra utilizes a broad range of savanna habitats from treeless short grassland to tall grassland and open woodland (Kingdon, 1979; Estes, 1997). It is equipped to deal both with long tough stems and the early stage of a flush. It is often the pioneer that leads the way into taller more wooded or wetter

pastures and prepares it for the wildebeests, gazelle and other associated antelopes (Estes, 1997). It is also among the most water-dependent of the plain ungulates (Duncan, 1992; Kingdon, 1979; Estes, 1997). They have to drink regularly once a day. Their digestive system is less efficient than the other ruminants. Plains zebra compensate this by grazing more day and night, including vegetation that is too fibrous and low in protein. The cellulose is broken down inside their large caecum. They have a fast rate of digestion and assimilation.

2.5 Economic and cultural value

Among the wild species, zebras have the greatest commercial value for their skin and meat. It is the future protein source of the world people in many African countries. Viewing and hunting for tourists and cultural values especially the horses and zebras symbolize beauty and freedom in many societies (Kingdom, 1979; Duncan, 1992).

2.6 Social organization and group composition

Plains zebras are non-territorial and nomadic. Their group consists of one-male harem and bachelor herds. Klingel (1969a) noted stable group structure in Ngorogoro. The figures were 7.05 animals for family groups or harem and 2.9 for the stallion groups. A one-male harem is a small permanent family group usually consisting of one male to six females and their offspring (Klingel, 1972). Average size for family group (one-male harem) was around 9 individuals and for bachelor stallion groups were 6 individuals in Nairobi National Park (Petersen and Casebeer, 1972). Kirubel Tesfaye (1985) described that Burchell's zebra to aggregate in a group of 100 individuals or more during the dry season. They were split into smaller units of 10 - 20 individuals during the wet season in Nechisar National Park.

Bachelor herd consists of 2 to 15 stallion zebras and they live in quite stable herds of stallion and subadult males. Bachelors are ready to form harems at 5 years and often leave their companion and wander alone in search of fillies on heat (Chris and Struat, 1997; Estes, 1997).

In Nechisar National Park, road count by Kirubel Tesfaye (1985) showed that the sex ratio of adult male to adult female was 1.0: 1.1. Adult to young ratio of Burchell's zebra was 1.00: 0. 04 during the wet season and 1.0: 0.1 during the dry season. In Nairobi National Park, adult male to adult female ratio was 1.0:1.2. The sex structure of the population was 32% male, 38% female and the rest 30% unsexed young. The ratio of adult to young was 1.00:0.04. The age structure of the population was 68.5% adult, 11.6% subadult, 16.9% juvenile and 2.9% foal.

2.7 Daily activity pattern and behavioural traits

The pattern of daily activity varies according to the nature of the habitat, food and weather conditions. In general, plains zebra spend most of the daylight grazing (Estes, 1997), in addition to dust bathing, rubbing, and drinking and resting period. However, to consume an adequate amount of herbage, they have to spend 60% of their time eating during day and night, under the best conditions, and over 80% under poor conditions. At night, they move very little unless disturbed by predators. Most rest and sleep lying down, apart from the group at least one animal per herd which stands alert guard (Estes, 1997).

If an ecosystem has unevenly distributed resources in both time and space, animals can exploit the range most effectively by being nomadic and continually adjusting their own density depending on the nature of their resources (Kingdom, 1979). This puts considerable

demand upon the social system. Great numbers will concentrate on local seasonal flushes and move together with or a head of herds of various other herbivores. As the grass is consumed, the zebras pass on the new pastures or scatter out into small family groups over much larger areas (Kingdon, 1979; Kirubel Tesfaye, 1985). Thus the density of zebra fluctuates seasonally and the total home range of a single-family group is subject to considerable variation according to the local ecological conditions.

2.8 Natality

Plains zebra have a single major birth peak during the rainy season and one foal is born each year after a gestation of about 375 days (Kingdon, 1979; Chris and Struat, 1997). In Nairobi National Park, foaling takes place throughout the year but peaked from January to March. Kirubel Tesfaye (1985) stated that Burchell's zebra produces young at any time of a year but peaked in April. The rate of foaling has thought to be closely correlated with rainfall and range conditions of the previous year (Kingdon, 1979). The fate of young animals will depend to a large extent on the rainfall pattern of the year. Klingel (1969b) stated that mares are fertile from the age of 30 months. Subadult recruited to the adult breeding pool was 9 - 16%. The age of juvenile was estimated to be 1-18 months with an average of 9 months. The average age of subadult was estimated to be two years.

2.9 Major threats

Kirubel Tesfaye (1985) identified that fire, poaching, overgrazing, cultivation; human disturbance and ticks (ecto-parasites) were the major threats on Nechisar National Park. Pastoralists generally tolerated zebras but this is not true for the farmers or settled ranchers. As settlement takes over more and more land, the mobile persistent plains zebras still find

their way back through all obstacles to graze and to drink. The conflict becomes progressively intensified because pioneer settlement and ranching schemes begin with a water source, and water is essential for plain zebra (Kingdon, 1979).

Apart from man, lion, hyena and wild dog are the three major predators of plain zebra (Kingdom, 1979; Estes, 1997). The Burchell's zebra's reaction to lion in their vicinity is generally to become very alert and stand in a semi-circle at 100 m. They usually stand 50 m apart from the lion. The whole herd cooperates to protect any threat. However, it is the stallion that actively defends his group and does not hesitate to attack hyena and wild dog (Estes, 1997).

Zebras suffer from several diseases including babeesia and anthrax. Parasites include several species of tapeworm, botflies, the lungworm (*Dictyocoulus sp.)*, the bloodworm (*Strongulus vulgaris*) roundworm and ecto-parasites (ticks) (Kingdon, 1979; Delany and Happold, 1979). Most of Africa's parks and reserves face increasing pressure from poaching, agricultural encroachment and livestock incursion, as human population densities increase on the surrounding land. As a result, the long-term future of many protected areas is not secured (IUCN, 2000).

3. STUDY AREA

3.1 Location and area size

The present study is carried out in the Nechisar plains at Nechisar National Park. The park supports the country's largest concentration of Burchell's zebra. It is located between latitudes 5^0 51' and 6^0 10'N, and longitudes of 37^0 32' and 37^0 48'E, 540 km, south of Addis Ababa

(Fig. 1). The South Nations, Nationalities and Peoples Regional Government administer it. The study area covers 270 km^2 of the Burchell's zebra range in NNP. It lies between the two Rift Valley Lakes, Abaya and Chamo (Bolton, 1970; Duckworth *et al.*, 1992).

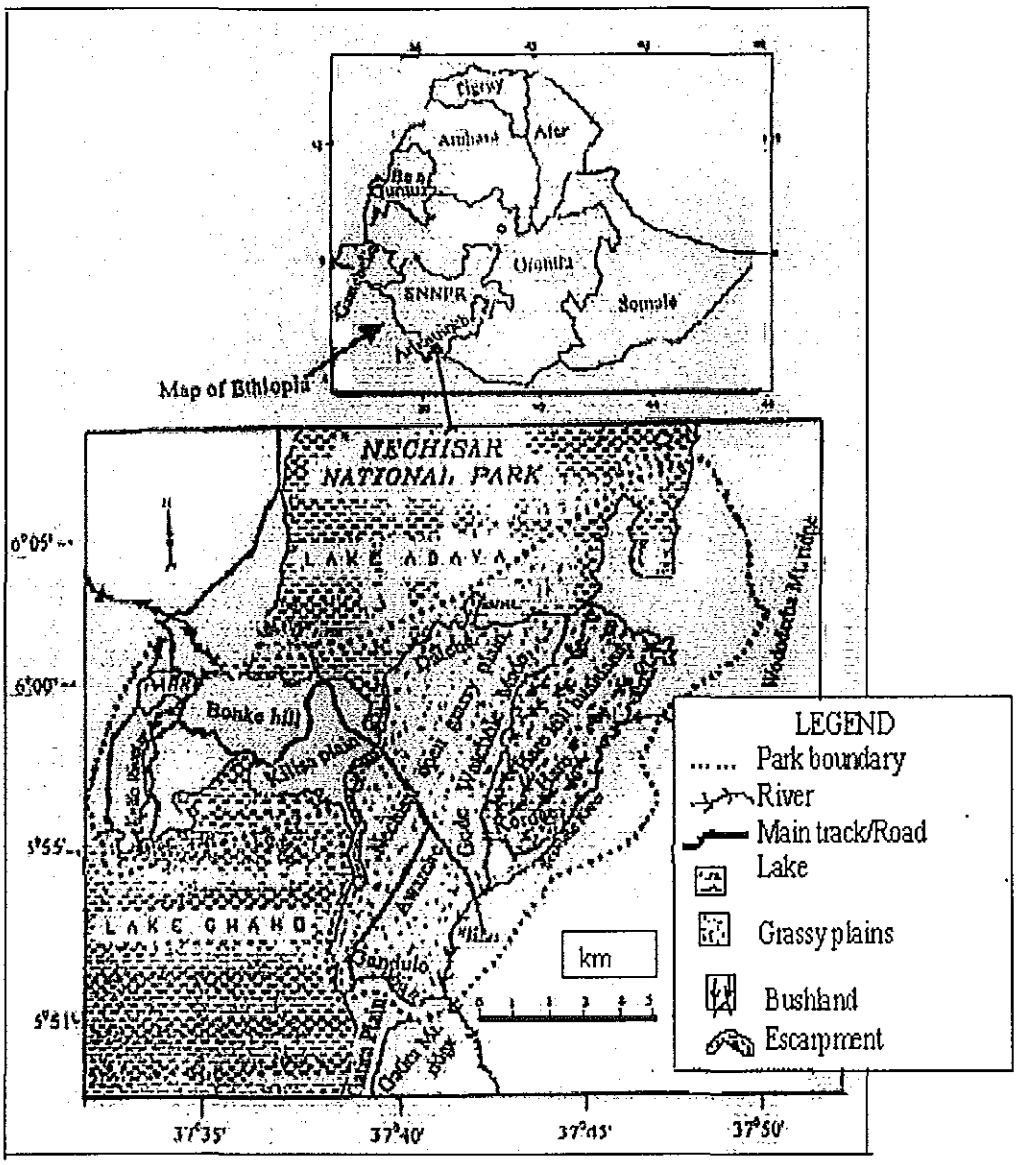

Figure 1. Location of the study area

3. 2 Topography and geology

The area has an altitude ranging between 1250 m and 1360 m. The soil of the Nechisar plains and surrounding bushlands is black cotton with high clay content. The rugged mountainous parts of the park have brown calcareous loam derived from volcanic rocks (Bolton, 1970). The soil ranges from patchy dark clay alluvial soils along the river basin to dominating dry cotton soil with poor drainage. During the rainy season, it becomes loose and sticky. Many parts of the Nechisar plains are mainly drainage basins. The river Sermale that runs along the eastern most corner of the range is one of the permanent sources of water in the area. The river has tremendous influence over the vegetation, settlement pattern and economic activities of the people within the Burchell's zebra range (Kirubel Tesfaye, 1985; Duckworth *et al.,* 1992).

The seasonal river basins, flood plains and valley bottoms are good providers of dry season grazing areas for domestic and wild herbivores (Kirubel Tesfaye, 1985). This area consists of mountain ridges, hills, Sermale River Valley and cultivated area with settlement east of the river. The presence of such topographic features and agricultural activity restricts easy seasonal mobility and distribution patterns of Burchell's zebra to the west of the Sermale River. The Sermale River flows in a southerly direction along the eastern most corner of the park form the Segen River and drains into Lake Turkana. The Mio River Valley water is dry at present.

The Nechisar plains are bounded in the north by Lake Abaya and in the south and southwest by Lake Chamo. These shallow fresh-water lakes are major sources of water for zebras and restrict their distribution and seasonal mobility towards these directions (Bolton, 1970).

3. 3 Climate

3.3.1 Rainfall

Kirubel Tesfaye (1985) summarized the rainfall and temperature data obtained from Arbaminch State Farm meteorological station. The station is about 5 km northwest of the park with similar altitude and undoubtedly experiences similar weather pattern. The mean annual rainfall the study area is between 800 and 1,000 mm. The annual distribution of rainfall pattern in the region is bimodal. The long rain occurs from March to May, and the short rain from September to November. The mean annual rainfall in the range measured over the last ten years (1992-2001) was found to be 895 mm. The peak mean monthly rainfall in April is 172 mm and it descends to 19.3 mm in December (Fig. 2). The present study period, wet season months are November, March and April and the dry season is from December to February. The peak mean monthly rainfall in April is 171.8 mm and this descends to 27.4 mm in February (Fig. 3). The rainfall in Nechisar plains for the last ten years was similar to the present study period, November 2001 to April 2002.

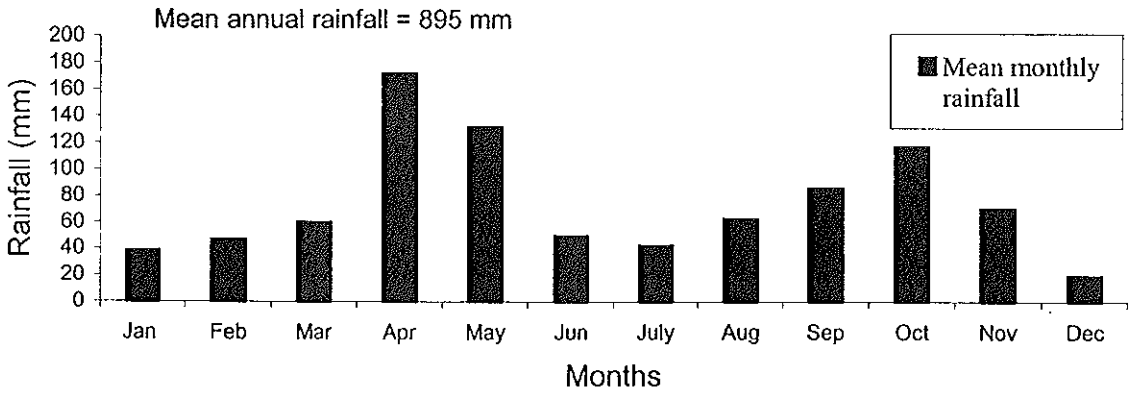

Figure 2. Mean monthly rainfall (mm) in Nechisar plains over 1992 – 2001 periods (**Source**: Arbaminch State Farm meteorological station, 2001)

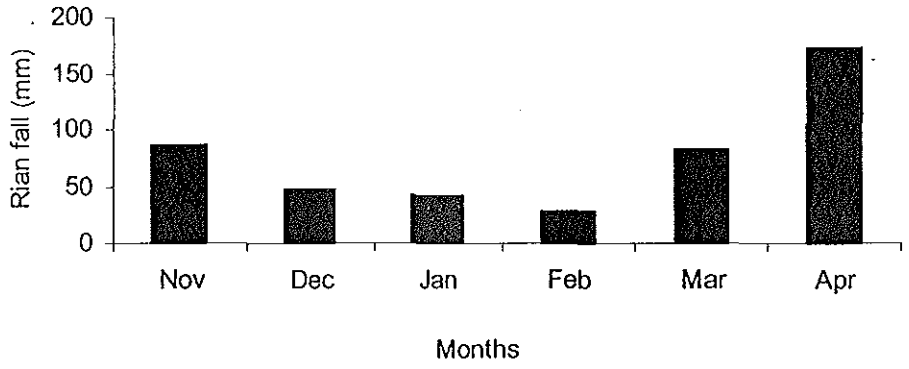

Figure 3. Monthly rainfall (mm) in Nechisar plains over the study period (**Source**: Arbaminch State Farm meteorological station, 2002)

3.3.2 Temperature

The mean annual maximum temperature is 32.2^{0}C and the minimum temperature is 17.4^{0}C. Temperature fluctuates seasonally; January to March is the hottest period with mean monthly maximum 33.1^{0}C in March. November to December is the coldest period with mean monthly minimum 15.3^{0}C in March. During the study period, February to March is the hottest period with the highest monthly maximum 34^{0}C in February. November to December is the coldest period with low minimum monthly temperature 14^{0}C in December. The temperature conditions experienced in Nechisar plains for the last ten years (Fig. 4) was similar to the present study period, November 2001 to April 2002 (Fig. 5).

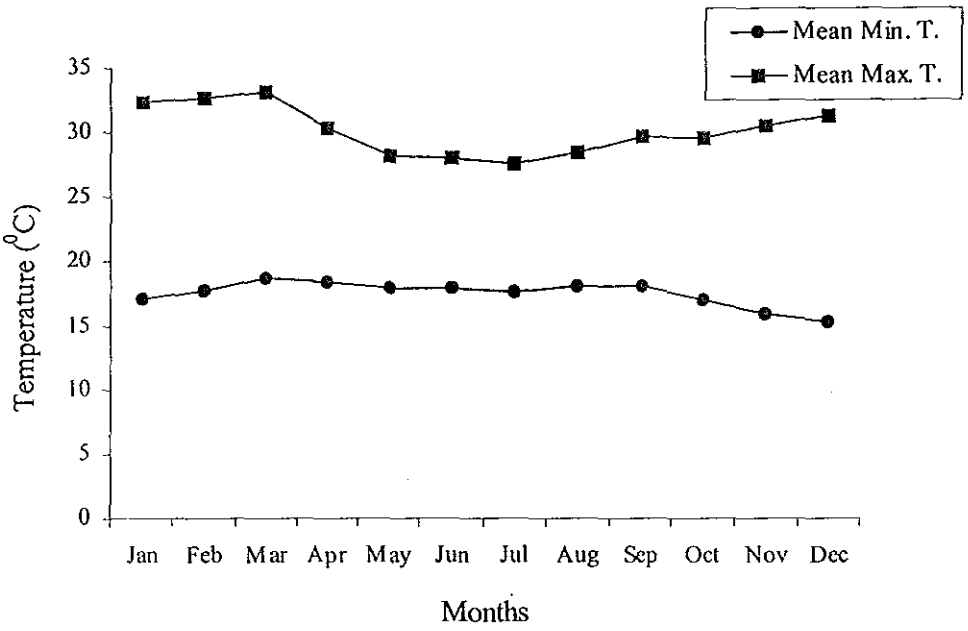

Figure 4. Mean monthly temperature (^{0}C) in Nechisar plains over 1992 – 2001 (**Source**: Arbaminch State Farm meteorological station, 2001)

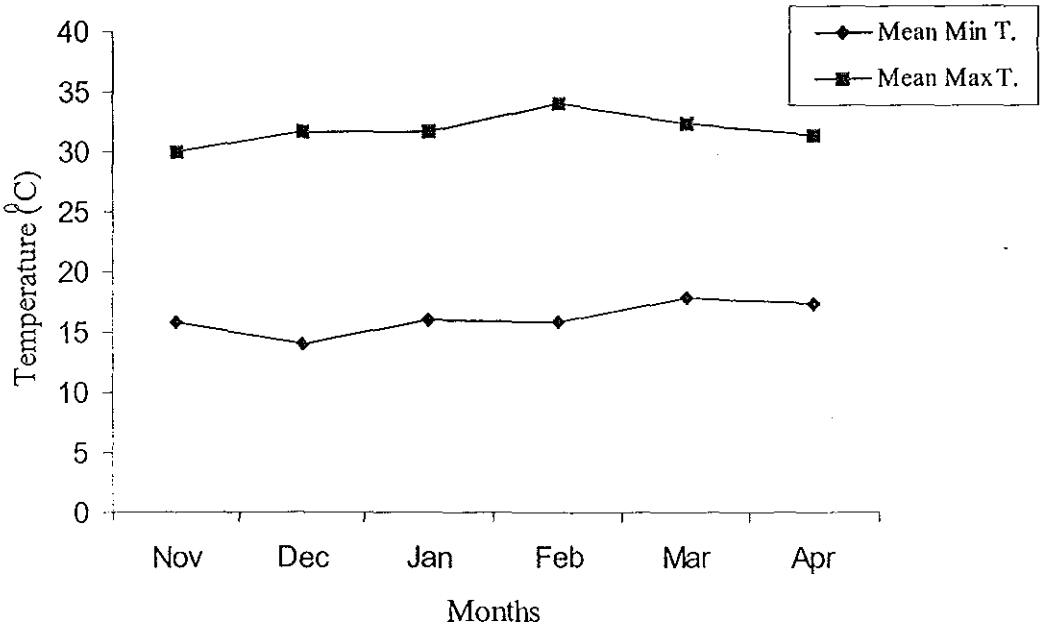

Figure 5. Monthly temperature (^{0}C) in Nechisar plains over the study period

3.4 Vegetation

Bolton (1970) described that the vegetation type of the study area as savannah grassland with scattered *Acacia-Commiphora* trees and bushes. The present study categorizes two main vegetation types: *Acacia-Commiphora* deciduous bushland and savannah grassland. Savannah grassland covers the Nechisar open grassy plain, a flat or undulating area of about 270 km^2. It extends from Degabule in the west to the Hare hills in the east, and from Datche in the north to the course of the dried up Mio River in the south (Kirubel Tesfaye, 1985; Duckworth *et al.*, 1992). There are few scattered trees and bushes that are invading the open grassy plain recently. The tree, shrub, herb and grass species that were observed in the Nechisar plains during the study period are shown in Appendix II.

The grass *Chrysopogon aucheri* occurs throughout the plains and is co-dominant with *chrysopogon sp.* in some areas. *Chloris roxburghiana, Cenchrus ciliaris* and *Ischaemum afrum* are abundant. *Lintonia nutans, Setaria sphacelata* and *Themeda triandra* are locally frequent. A good deal of *Heteropogon contortus* and *Bothryochloa radicans* also appears to favour the slopes. On the plateau of the Hare hills, *Lintonia nutans* and *Ischaemum afrum* are co-dominant but *Cenchrus ciliaris* and *Chrysopogon aucheri* are also frequent (Bolton, 1970; Kirubel Tesfaye, 1985; Duckworth *et al.*, 1992).

Bushland is the dominant vegetation of the park surrounding the Nechisar plains, covering most of the hills and gentler slopes with scattered shrubs and low bushy trees set in grassland. These occur on escarpments, steep rocky slopes and in gullies throughout the park as well as on the marginal vegetation zones of Lakes Abaya and Chamo, and as a large expanse east of Hitu. Areas of tall grasses between bushes are dominated by *Cenchrus ciliaris* at the Sermale

River areas. Duckworth *et al.* (1992) recorded herbs: *Justica flava* and *Ageratum canyzoide.* The bushland around Sermale River area is more open than around hot spring with large intervening area of tall grasses and dominant tree species. The tall species include: *Acacia tortilis, A. seyal, Combretum sp., Balanites aegyptica, Dichrostachys cinerea* and occasionally *A. nilotica* (Kirubel Tesfaye, 1985; Duckworth *et al.*, 1992).

3.5 The Mammalian fauna

As a result of its geographical isolation and wide variety of ecological units, the Nechisar plains harbour variety of mammalian species that contribute to the stability of the ecosystem. In addition to Burchell's zebra, the diurnal larger wild herbivores are endangered Swayne's hartebeest (*Alcelaphus buselaphus swayni*), Grant's gazelle (*Gazella granti*) and Greater kudu (*Tragelaphus strepsiceros*) (Kirubel Tesfaye, 1985; Duckworth *et al.*, 1992). In comparison to the other parts of Ethiopia, the faunal species in the Nechisar plains are abundant. Although the population status of the mammalian fauna in the area is not well known, it is presumed that buffalo has become locally lost and Swayne's hartebeest is critically endangered. The larger mammal species commonly found in and the vicinities of the Nechisar plains are shown in Appendix III.

3.6 Land use and human settlement

Nechisar National Park was proposed in 1967 and established in 1974. Boundary description was made in 1975 (Blower, 1967; Bolton, 1970). Initially, there were a number of small temporary encampments of cattle-owning Guji people around the Nechisar plains. No permanent habitations were seen. There were permanent villages on the hills to the east and

signs of cultivation could be seen on the slopes of Amaro Mountains. There are small villages on the land between the two lakes and on an island just north of the northern boundary. There is low human population density. Almost all the people are nomadic pastoralists who graze thousands of cattle on the plains (Blower, 1967; Bolton, 1970). During the past 50 years, there had been rapid developments in many of man's activities. These have profoundly changed the landscape and in doing so, greatly modified the habitats available to mammals (Delany and Happold, 1979). Recently due to urbanization and population increase, the large numbers of people have settled in the Nechisar plains to cultivate and graze their livestock. Most of the population of Africa is engaged directly or indirectly in agricultural activities of the small-scale peasant farmers and pastoralists who frequently engage themselves in traditional practices (Delany and Happold, 1979). Given the arid condition of the area, nomadic pastoralism is the major occupation and all other activities depend on livestock production. But they overlap two activities, the cultivation of the Sermale river floodplains and the herding of cattle on the central plain.

Kirubel Tesfaye (1985) counted 1689 heads of cattle and 188 herdsmen in the field. In 1996, the total projected number of cattle was 3,534 (Solomon Eshete, 1996). In 2001 the Nechisar National Park staff recorded 10,192 heads of cattle and 1,770 goats. Virtually, the Sermale riverine forest and ground water forest have been destroyed for cultivation and the entire area of Nechisar plains is grazed. The central plain is mainly used in the wet season and most cattle withdraw to surrounding bushlands of Hare hills and Sermale river Valley during the dry season. The subsequent competition between domestic and wild herbivores was intensive. Apart from cattle herding some households from all the Guji villages cultivate crops. Subsistence farming activities are presently concentrated along the Sermale River

Valley alluvial soil. The river is useful for irrigation when rainfall is minimal. Rain fed cultivation is also carried out in the area beyond the river. Ploughing is with oxen. The main subsistence crops grown include cereals like maize, sorghum and teff. The main crop is maize and sorghum. Other crops grown in the area are ensette (false banana) and fruit trees of mango, banana, papaya and citrus. Cash crops like coffee, chat and sugar cane are also grown. Most Guji households collect wild honey from natural or man-made beehives in the park. Fire is frequent and trees are destroyed as a result (Duckworth *et al.*, 1992; Solomon Eshete, 1996).

4. MATERIALS AND METHODS

4.1 Selection of sampling sites

Prior to the actual fieldwork, vehicle reconnaissance surveys were carried out in and around the Nechisar National Park. Prof. Afework Bekele, project advisor and Biologist Chemere Zewdie, NNP- administrator guided these surveys including Yisehak Doku, the project researcher; Girma Timer, the park biologist and Scout Jarso Guye, a guardsman. A network of 177 km of main and subsidiary tracks in the park covered most parts of the observation sites. Each monthly field observations in different nine sites consisted, first vehicle reconnaissance to determine the local distribution of Burchell's zebra inside and around the park, followed by walk on foot on the major routes of the animal and selected suitable vantage points to assess their droppings, foot prints and the animal itself. The local distribution pattern of the Burchell's zebra population was determined from the seasonal observations made in nine different sites during the study period.

Ecological features that limit the distribution of the Burchell's zebra such as vegetation cover, human settlement, livestock herds, water sources and land escarpments were observed by using binoculars (8x30 fields 7.5^0). The population to be sampled was clearly defined and its area delimited by referring 1:50,000-scale map of Nechisar National Park and using Global Positioning System (GPS) and compass with range (type 15) following the methods of Wilson *et al.* (1996) and Zelealem Tefera (2001).

Line transect sampling methods were employed for the estimation of the population density following the methods of Buckland *et al.* (1993) and Sutherland (1996). The line transects started from a random point, the location of which generated by the random number generator of Microsoft Excel™ on the map of the study area. The start points were then located using GPS and the transects were traversed on foot two days per week for three months during wet and dry seasons from November, 2001 to April, 2002. Surveys on the population size, structure, seasonal distribution, daily activity pattern and habitat preferences of Burchell's zebra conducted on the 6 sampling line transects were recorded on data sheet (Appendices II - IV).

4.2 Habitat types

The main study area based, on Nechisar plains, which support the highest concentration of the Burchell's zebra population. The area was spatially stratified into two main habitat types; the Nechisar open grassy plain and the surrounding Hare hill plateau bushland (Table 2).

Table 2. Habitat types and their boundary descriptions

Habitat type	Boundary descriptions	Altitude (m a.l.s.)	Ecological features	
			Hills	Villages
Open grassy plain	North: Lake Abaya East: Hare hill ridges & Sermale Valley Riverine forest South: Mio river valley West: land bridge between Lake Chomo and Abaya	1250-1280	Degabule Badagedela Handerko Kalo-korke Datche Kaliya	Gandulo Awarche Gode Watchole Mado Datche
Bushland	North: Lake Abaya East: Sermale Valley Riverine forest South: main track from HQ to Amaro District. West: Nechisar open grass plains	1350-1360	Hare Hitu Haroresa	Kordae Hare

A total of 6 sampling transect lines at distances of 24 km were marked in the study area by using GPS (Global Positioning System). All line transects have equal length of 4 km and the same direction towards northeast (Table 3). The total area of Nechisar plains is 270 km^2. The Nechisar open grassy plain habitat accounted for 74% of the total area. Hare hill plateau bush land habitat accounted for 26% of the total area. The area proportion of these two main habitats was 1:0.35. The relative pattern of habitat preference of the animals was derived from the number of animals observed in the main two habitat types.

Table 3. Locations, number of sampling transect lines and estimated area sizes

Habitat	Area size (km^2)	No. of sampling line transects	Line transects number.	Location
Nechisar open grassy plain	200	4	T_1	$5^0$53'00"- $5^0$55'16"N $37^0$38'40"-$37^0$39'00"E
			T_2	$5^0$55'16"- $5^0$57'32"N $37^0$39'00"-$37^0$39'20"E
			T_3	$5^0$57'32"-$5^0$59'48"N $37^0$41'00"-$37^0$41'20"E
			T_4	$5^0$59'48"-$6^0$02'04"N $37^0$41'30"-$37^0$42'10E
Hare-hills plateau Bushland	70	2	T_5	$5^0$56'10"-$5^0$58'26"N $37^0$43'00"-$37^0$43'20"E
			T_6	$5^0$58'26"-$6^0$00'42''N $37^0$43'20"-$37^0$43"40"E
Total	270	6		

4.3 Population estimation

4.3.1 Population density estimate

The density of Burchell's zebra population in the Nechisar National Park was estimated using the line transects DISTANCE-sampling method (Buckland *et al.*, 1993; Sutherland, 1996; Wilson *et al.*, 1996).

$D = n\, f(0)\, S/2L$ Where: D: population density
n: number of zebra herds observed (sample size)
f(0): the probability density function of distances from the line, evaluated at zero distance
L: total length of line transects
S: mean group size in the population

Intensive ground survey was carried out on foot along allocated line transects to estimate the Burchell's zebra population density and abundance. Population census was carried out early in the morning 0600 to 1130 hr and late afternoon 1530 to 1800 hr twice a week. Population census was conducted for three months during the wet season (November, 2001 and March to April, 2002) and during the dry season (December, 2001 and January to February, 2002). The start and end point of each transect was located using the GPS and were traversed on foot systematically in northeast direction with the help of compass at the speed of 4 km per hour. Whenever the animals were observed, the sight distances from the line transect, the sight angle, observable coordinate activities, the presence of other large mammal species in the vicinity and habitat types were also recorded (Appendix IV). Sight distance and angle from the line transect was determined by visual estimation using compass. Silent detection was practiced to minimize population disturbance as described by Wilson *et al.* (1996). Repeated counting of the same individuals or clusters was avoided using easily recognizable features such as cluster size, harem composition and distinct individuals with body deformities such as tail lost, ear cut, etc (Wilson *et al.*, 1996).

The data were analyzed by using Buckland *et al.* (1993) DISTANCE analysis method and computer program *SPSS 10.0 window (1999) analysis* for estimation of population density. Buckland *et al.* (1993) recommend that for DISTANCE analysis the number of sighting should be > 60 for more reliable density estimate. The sight frequencies of Burchell's zebra during line transect sampling was low in Hare hill bushland, so all the Burchell's zebra sightings were pooled together to produce an over all density estimate for the whole study area. Thus, the perpendicular distance (x_i) taken from each line transect to the geometric center of the groups were recorded. The sample size (n_i) represented a number of groups

observed during the population census. The sample size (n_i) was independent of perpendicular distance (x_i) and a mean herd size (s_i) is used an estimator of the average group size.

4.3.2 Population size estimate

Population density and population size are interrelated population parameters. Hence population size was found by multiplying the population density with total area of the Nechisar plains following Buckland *et al.* (1993) and Wilson *et al.* (1996). Based on the total area of the Nechisar plains (270 km^2) the population abundance of Burchell's zebra in Nechisar plains was calculated from their population density estimate.

$$N = D \times A$$

Where, N: Total population size
D: Population density
A: Total size of the study area

4.4 Habitat preference

Seasonal habitat selection of the Burchell's zebra was determined from the two range habitats. These habitats were deduced from the categories of vegetation types (Wilson *et al.*, 1996; Sutherland, 1996) that had the highest frequency of Burchell's zebra population. The numbers of Burchell's zebra sighted in two different main habitat types during the presumed active feeding periods between 0600 h to 1130 h and 1530 h to 1800 h were also used to predict habitat preference. The average number of Burchell's zebra observed in two habitat types was compared in respect to vegetation cover and types in the study area (Appendix II). Data were analyzed using descriptive statistics and compared using Chi-square test in computer program *SPSS 10.0 for windows (1999).*

4.5 Seasonal distribution

The seasonal distribution pattern of the Burchell's zebra population was determined from the seasonal observation made on 6 line transects of the two main habitats. A seasonal change of the Burchell's zebra population was monitored on monthly basis in each habitat. The Burchell's zebra harem sightings made in the different habitats was recorded in population census data sheet (Appendix IV) to obtain the seasonal distribution of the species. The variations of Burchell's zebra numbers in the habitat were used to predict the seasonal distribution of the species in the Nechisàr plains. Ranging patterns were also determined from the observed distributions (Petersen and Casebeer, 1972; Kingdon, 1979; Delany and Happold, 1979).

4.6 Population structure

Population structure is an important prerequisite for assessing the direction of change of natural population (Senzota, 1988). The various aspects of social organization such as group sizes, age and sex composition, and carcasses were recorded (Appendix IV and VI) in order to monitor the influence of seasons on the Burchell's zebra group composition (Klingel, 1969b; Petersen and Casebeer, 1972; Kirubel Tesfaye, 1985; Wilson *et al.*, 1996; Estes, 1997). The reproductive potential of Burchell's zebra was also determined from the demographic structures of groups. Whenever a group was sighted, records were made on the age class and sex of the individuals. These were achieved by use of a pair of binocular (8x30 Field 7.5^0) and observing the relative body for approximate age-classes and the external genital for sex determination of adult males and females. Sex characteristics and age estimate used for field identification (Klingel, 1966) is shown in Appendix VII.

Birth was assumed whenever an adult female was seen in the company of a foal or juvenile. During the population census, death was recorded when the carcass of a missing individual observed. All skulls from zebra carcasses collected were investigated to classify sex and age groups of dead animals following the method of Petersen and Casebeer (1972). Juvenile and foal skulls are entirely consumed by larger predator. Hence, the juvenile and foal observed in the family group during the first survey and lost during the next survey are recorded as dead animals. The adult stallion skull has larger canine teeth while subadult possesses smaller skull without canine teeth. The canine teeth lost, damaged adult skulls were grouped under unknown column. The information on the approximate demographic composition and structure such as the age classes and sex ratio was used to predict the general trend of the Burchell's zebra population as to whether it is declining, increasing or stable.

4.7 Daily activity pattern and behavioural traits

General observations of both individuals and herd daily activity pattern were investigated by selecting one-male harem and a bachelor stallion herd of Burchell's zebra in the Nechisar plains from 0600 h to 2000 h during wet and dry reasons. The harem was followed on foot using silent detection aided with binoculars. All identifiable daily activity rhythms and behavioral traits were recorded on behavioural data sheet Appendix V. Wilson *et al.* (1996) and Sutherland (1996) stated silent detection method is used for daily activity observation of the Burchell's zebra.

4.8 Human impact

Physical and social surveys were conducted to identify the extent and frequency of human activities on the study area. Total count on number of houses, villages' domestic animals and water catchments was carried out. Ground surveys revealed woodcutting for construction and fuel, man-made beehives for honey collection, foot passengers and car travelers usually during the weekdays followed the methods of Wilson *et al.* (1996) and Zelealem Tefera (2001).

Pre-set questionnaires and individual interviews of local people were used to identify the nature and extent of traditional use value and background history of Burchell's zebra. Also investigate attitudes of local communities toward wildlife conservation. In this study, the participants for the group discussion were defined as key informants. Most of the participants were elderly people with good knowledge of wildlife and local histories. The key informant interviews were conducted with a written checklist of open-ended questions shown in Appendix VIII.

A total of 124 informants including both sexes and young from eight Guji Oromo villages participated in this interview. To find out how the local people perceives the wildlife in the study area, a dummy of the respondents with minus sign (–) if the response was negative, zero (0) if the response was benign neglect and plus sign (+) if the response was positive was taken as dependent variable as described by Jerrold (1984). Data were analyzed using descriptive statistics and responses were compared using Chi-square test in computer program *SPSS 10.0 for windows (1999).*

5. RESULTS

5.1 Population estimation

Burchell's zebra live in family groups of one-male harem or a bachelor stallion herd. A total of 64 herds of Burchell's zebra were observed during the wet season and 61 herds during the dry season. There was no significant variation between the dry and wet season sample sizes ($P > 0.05$). The mean group size (s) was found to be 9.15 and 7.8 individuals during the wet and dry seasons respectively. There was no significant variation in the mean group size between the wet and dry seasons ($P > 0.01$). A total 586 individual zebras ($n = 64$) were counted during the wet season and 477 individual zebras ($n = 61$) during the dry season (Table 4). There is no significant variation between the number of individual zebras in wet and dry seasons ($P > 0.05$). An average number of 532 individual zebras ($n = 63$) were counted in the Nechisar plains resulting in an average herd size of 8.5 individuals (Table 4).

Table 4. Number of herds, herd size and individual Burchell's zebra counted on each sampled line transect during the wet and dry seasons.

Line transect	Season						Average		
	Wet			Dry					
	n_i	Mean number of individuals	s_i	n_i	Mean number of individuals	si	n_i	Mean number of individuals	s_i
T_1	13	117	9.0	10	81	8.1	12	99	8.6
T_2	12	113	9.4	11	84	7.6	12	99	8.6
T_3	13	117	9.0	10	83	8.3	12	100	8.7
T_4	14	127	9.1	12	92	7.7	13	110	8.4
T_5	7	69	9.8	10	76	7.6	9	72	8.6
T_6	5	43	8.6	8	61	7.6	7	52	8.0
Total	64	586	54.9	61	477	46.9	63	532	50.9

n_i: cluster size (number of zebra herd observed), si: mean number of group size,

5.1.1 Population density estimate

Population density of Burchell's zebra in the Nechisar plains using DISTANCE analysis method was 18.3 ±0.8 /km^2 and 15.0±1.2/km^2 during the wet and dry seasons, respectively (Table 5). There was no significant difference between the wet and dry seasons ($P > 0.05$). Thus, the population density in Nechisar plains was estimated to be 16.6±1.5 individuals/km^2 during the study period.

Table 5. Population density of Burchell's zebra during the wet and dry seasons

Season	Population density (individual zebras/km^2)	Standard deviation
Wet	18.3	± 0.8
Dry	15.0	±1.2
Average	16.6	±1.5

5.1.2 Population size estimate

Based on the population density estimate (Table 5), the population size was found to be 4940 and 4050 individuals during the wet and dry seasons with 95% confidence interval of [4725 - 5757] and [3726 - 4373] at 5 degree of freedom. The Burchell's zebra population size estimate showed a significant variation seasonally ($P < 0.05$). The total population size estimate calculated from the mean population density estimate was 4482 individuals with 95% confidence interval of [4077 - 4887] at 1 degree of freedom. This population estimate was rounded to 4500 (Table 6).

Table 6.Estimated population size and trend of the Burchell's zebra in Nechisar NP.

Year	Population size	Trend	Sources
1966	200	Increasing	Blower, 1967
1970	400	Increasing	Bolton, 1970
1985	6500	Increasing	Road count (Kirubel Tesfaye, 1985)
1995	< 3000	Decreasing	(EWCO, 1995).
2002	4500	Increasing	Line transect count (the present study result)

5.2 Habitat preference and feeding habit

5.2.1 Habitat preference

Out of a total of 1063 counted individuals, 813 (n = 95) accounted for 52% of the total observations counted in the Nechisar open grassy plain. The rest 250 individuals (n = 30) accounted for 48% of the total observations counted in Hare hill plateau bushland (Table 7). There was no significant difference in the two main habitats ($P > 0.05$). During the wet season, Nechisar open grass plain habitat accounted for 53.3% and Hare hill plateau bushland habitat accounted for 42.7% of the total sight frequencies of Burchell's zebra (n = 64). During the dry season, Nechisar open grassy plain habitat accounted for 46.5% while Hare hill plateau bushland habitat accounted for 53.5% of the total sight frequencies of the Burchell's zebra (n = 61) (Table 7). The Burchell's zebra habitat preference significantly depended on seasonal variation ($P < 0.05$).

Table 7. Sight frequency of herds and individual Burchell's zebras in the two main habitats.

The numbers shown in the parentheses are percentages.

Habitat type	Season				Average	
	Wet		Dry			
	n_i	Number of Individuals observed.	n_i	Number of Individuals observed.	n_i	Number of Individuals observed.
Open grassy plain	52	474 (57.3)	43	339 (46.5)	47.5	407(52.0)
Bushland	12	112 (42.7)	18	138 (53.5)	15.0	125 (48.0)
Total	64	586	61	477	62.5	532

n_i: number of herds observed (cluster size)

5.2.2 Feeding habits

Burchell's zebra preferred grass species (Table 8). Out of a total of 368 behavioural observations, 148 spent on foraging activities. There was no seasonal difference in the percentage frequency of grass species consumption between the dry and wet seasons (χ^2 = 0.108, df = 1, P > 0.05). The sighting frequency percentage of these grass species were 33.8% *Themeda triandra*, 23.0% *Lintonia nutans*, 13.5% *Setaria sphacelata*, 12.8% *Ischaemum afrum*, 8.8% *Chrysopogon aucheri* and 8.1% *Cenchrus ciliaris*. Burchell's zebra showed significant variation in the consumption of grass species (χ^2 = 46.067, df = 5, P < 0.05). The two grass species *Themeda triandra* and *Lintonia nutans* were the most preferred diet accounting for 56.8% of the total sight frequency of grass intake. *Chrysopogon aucheri* and *Cenchrus ciliaris* were the least preferred grass species in the diet Burchell's zebra. They account for 16.9% of the total sight frequencies.

Table 8. Sighting frequency percentage of grass species consumed by Burchell's zebra

Grass species	Sighting frequency	Percentage %
Themeda triandra	50	33.8
Lintonia nutans	34	23.0
Setaria sphacelata	20	13.5
Ischaemum afrum	19	12.8
Chrysopogon aucheri	13	8.8
Cenchrus ciliaris	12	8.1
Total	148	100.0

5.3 Distribution

The local distribution of Burchell's zebra is mostly in savanna open grassland. Their distribution is primarily determined by the availability of grass and water. They are non-territorial nomadic animals, which move to habitats where better grasses and water are available. During the wet season, out of a total of 314 observations, 95.9% of sight frequency (n = 301) of the animals, droppings and footprints was inside the park while 11.1% (n = 13) was outside the park in the Gatira plain and Mountain range south of the park boundary. The Nechisar open grassy plain accounted for 73.7% while Hare hill plateau bushland accounted for 20.6% of the total percentage sight frequency of direct and indirect observations inside the park (Table 9). The relative distribution of Burchell's zebra outside the park is insignificant during the wet season ($\chi^2 = 3.940$, df = 1, $P > 0.05$). Their relative distribution is significantly abundant in the Nechisar open grassy plain and Hare hill plateau bushland during the wet season ($\chi^2 = 12.3$, df = 1, $P < 0.05$). During the dry season, out of a total of 447 observations, 76.2% of sight frequencies (n = 343) of the animals, droppings and

footprints were inside the park while 23.8% (n = 104) outside the park. Among these observations, 42.9% (n = 193) was in the Nechisar open grassy plain and 21.3% (n = 96) was in the Hare hill bushlands inside the park (Table 10). Their relative distribution ranges show significant variation seasonally inside and outside the park ($\chi^2 = 0.334$, df = 6, $P < 0.05$). During the dry season, their local distribution range extends southward to the Gatira plains and mountain ranges, eastward to the Wododerba ridges outside the park. During the wet season the distribution range was contracted into Gatira plain outside the park boundary.

Table 9. Observation sites, habitat types and number of sight frequency inside and around Nechisar NP. during the wet season

Observation site	Habitat type	Number and percentage of sight frequencies					
		Direct obser.	Indirect observation				
		No. of zebra herds	Sight frequency of Droppings per zebra			No. of foot Prints/ zebra	%
			Fresh	Decay	Total		
Inside the park							
Bonke hill escarpment	bushland	-	-	-	-	-	-
Kilisa plain	bushland	-	-	5	5	-	1.6
Nechisar plain	grassland	40	50	42	92	99	73.7
Hare hill plateau	bushland	10	15	20	35	20	20.6
Gerbe Mt. ridge	bushland	-	-	-	-	-	-
Sermale River Valley	Cultivated	-	-	-	-	-	-
	Sum	50	65	67	132	119	96.0
Outside the park							
Wododerba Mt. ridge	bushland	-	-	-	-	-	-
Gatira plain	grassland	-	-	8	8	-	2.5
Gatira Mt. ridge	bushland	-	-	5	5	-	1.5
	Sum	-	-	13	13	-	4.0

Table 10. Observation sites, habitat types and number of sight frequencies inside and around Nechisar National Park during the dry season.

Observation site	Habitat type	Number and percentage of sight frequencies					
		No. of zebra herds	Sight frequency of Droppings per zebra			No. of foot Prints	%
			Fresh	Decay	Total		
Inside the park							
Bonke hill escarpment	bushland	-	-	-	-	-	-
Kilisa plain	bushland	2	4	6	10	5	3.8
Nechisar plain	grassland	25	35	50	85	83	42.9
Hare hill plateau	bushland	15	25	18	43	38	21.3
Gerbe Mt. ridge	bushland	-	-	-	-	-	-
Sermale River Valley	Cultivat.	2	4	3	7	28	8.2
	Sum	44	68	77	145	154	76.2
Outside the park							
Wododerba Mt. ridge	bushland	1	3	2	5	6	2.7
Gatira plain	grassland	10	18	10	28	25	14.0
Gatira Mt. ridge	bushland	2	6	8	14	16	7.1
	Sum	13	27	20	47	47	23.8

5.3.1 Seasonal distribution

The highest density of Burchell's zebra population (19/km^2) was observed in Nechisar open grassy plain during the wet season as shown in Table 11. The highest density of Burchell's zebra (10.4/km^2) was observed in Hare hill plateau bushland during the dry season.

Table 11. Number of Burchell's zebra observed in both habitats during the wet and dry seasons

Habitat	Vegetation type	Density (per 6 km^2)	
		Wet season	Dry season
Nechisar plain	Open grassy plain	19.0	17.0
Hare hill plateau	Bushland	9.4	10.4

5.4 Population structure

A total of 3190 observed individuals were categorized into three sex and four age-class lists as shown in Table 12. They live in social groups of one-male harem or bachelor stallion herd. The group of 3 to 28 individuals consisted in one-male harem (family group). The bachelor stallion herd size ranged between 2 to 17 individuals. The one-male harem herd is composed of mares, subadults, foals and a dominant stallion.

Table 12. Number, structure and composition of the Burchell's zebra population. Numbers in parentheses are percentages.

Month and year	n_i	x	Sex and age structure categories					Sex ratio	Age ratio
			AM	AF	SA	Juv	Fo	AM: AF	Ad: Yg
Nov 2001	64	540	190(35.2)	220(40.8)	78(14.4)	28(5.2)	24(4.4)	1:1.16	1:0.32
Dec 2001	62	529	183(34.6)	218(41.2)	80(15.1)	30(5.7)	18(3.4)	1:1.19	1:0.32
Jan 002	61	461	158(34.3)	190(41.2)	77(16.7)	23(5.0)	13(2.8)	1:1.20	1:0.33
Feb 2002	60	441	153(34.7)	184(41.7)	75(17.0)	20(4.5)	9(2.1)	1:1.20	1:0.31
Mar 2002	63	582	209(35.9)	252(43.3)	71(12.2)	30(5.2)	20(3.4)	1:1.21	1:0.26
Apr 2002	65	637	220(34.8)	264(41.4)	85(13.3)	35(5.5)	33(5.3)	1:1.20	1:0.32
Total	375	3190	1113	1328	466	166	117		
Average	63	532	185	221	78	28	20	1:1.19	1:0.31
%			(34.8)	(41.5)	(14.7)	(5.2)	(3.8)		

AM: Adult male, AF: Adult female, SA: Subadult, Juv: Juvenile, Fo: Foal, Ad: Adult = n (AM+AF), Yg: Young = n (SA+Ju+Fo.), n: herd size (number of zebra herds observed), x: mean number of individual zebra

5.4.1 Sex structure

Out of a total of 3190 observed individuals, 34.8% was males 41.5% was females and 23.5%

was unsexed immature young (subadults juveniles and foals). The ratio of male to female was 1.0:1.19 ($P > 0.05$). The sex ratio of Burchell's zebra was female biased (Figure 6).

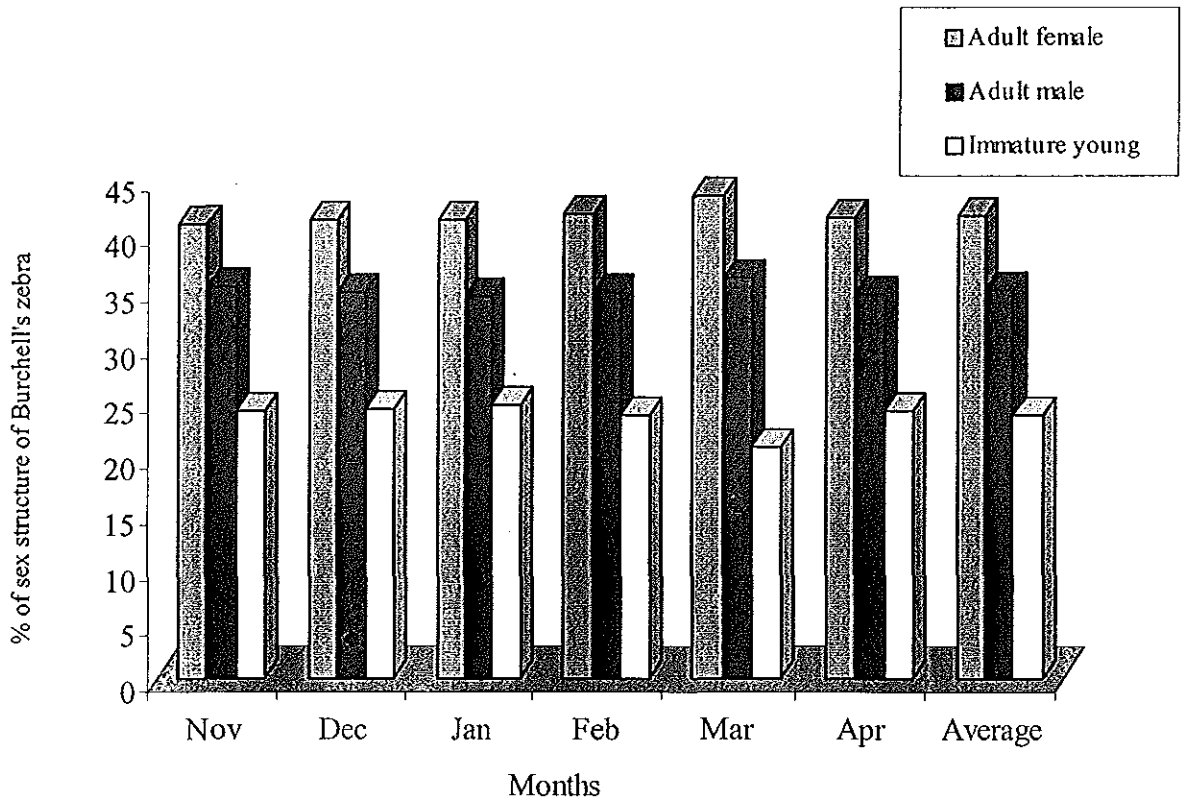

Figure 6. Sex structure of Burchell's zebra in the Nechisar plains over the study periods

5.4.2 Age structure

Adult Burchell's zebras accounted for 76.5% of the total population observation. Subadults comprised 14.7% and the juveniles and foals were 5.2% and 3.7%, respectively (Figure 7). Age ratio of adult to young was found to be 1.0: 0.31.

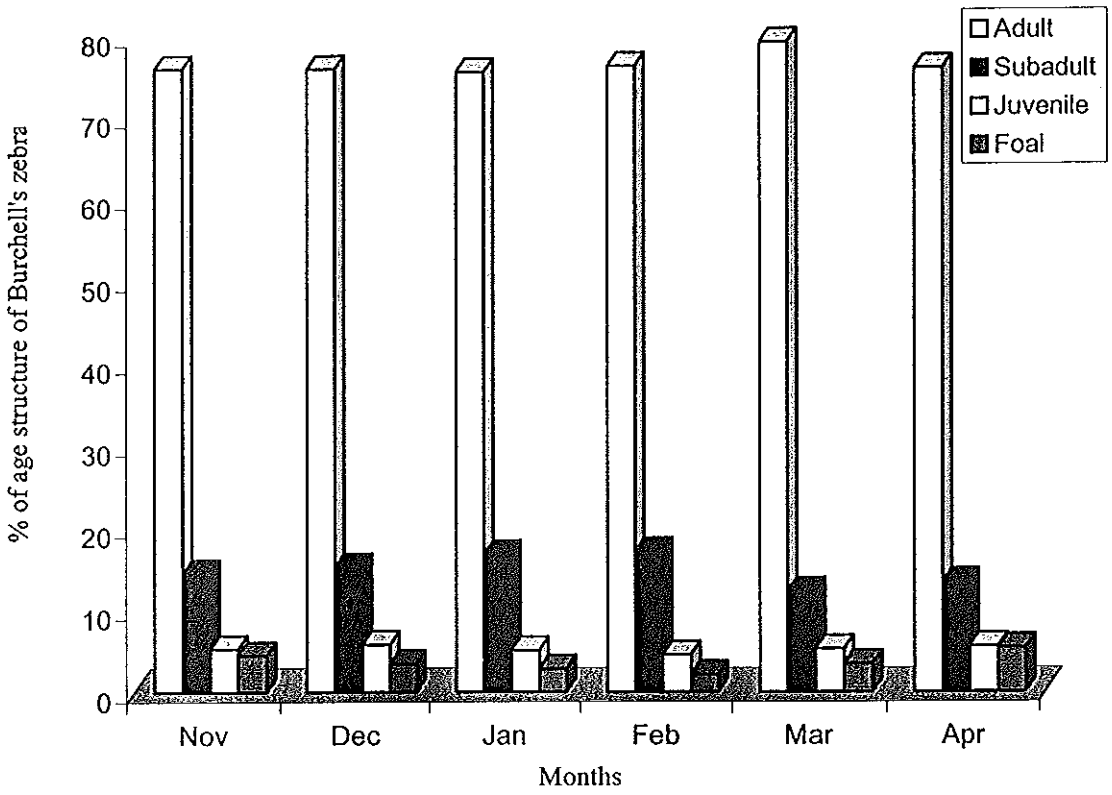

Figure 7. Age structure of Burchell's zebra in the Nechisar plains (2001-2002)

The seasonal population composition of Burchell's zebra in Nechisar plains is summarized in Table 13. During the wet season, the sex structure of Burchell's zebra population was 35.2% male, 41.8% female and 23.0% unsexed young. During the dry season, the sex structure of the species was: 34.6% male, 41.3% female and 24.1 unsexed young. The sex ratio of male to female was 1.0:1.19 (Table 13).

During the wet season, 77% of the population was adult while 23% consisted of immature individuals. During the dry season, 75% of the animal observed was adult while 24% unsexed young. The age ratio of adult to young was 1.00:0.30 and 1.00:0.32 during the wet and dry

seasons, respectively (Table 13). The percentage of age distribution showed seasonal variation ($P < 0.05$). Juveniles accounted for 13.3% during the wet season and 16.4% during the dry season. The newborn foals accounted for 4.4% during the wet season and 2.7% during the dry season. Juvenile and newborn foal showed a significant variation seasonally.

Table 13. Population structure of Burchell's zebra was observed in the Nechisar plains. Percentage is shown in parentheses.

Season	n_i	Sex and age structure categories					Total	Sex ratio	Age ratio
		AM	AF	SA	Juv	Fo		AM: AF	Ad: Yg
Wet	64	206(35.2)	245(41.8)	78(13.3)	31(5.3)	26(4.4)	586	1:1.19	1:0.30
Dry	61	165(34.6)	197(41.3)	78(16.4)	24(5.0)	13(2.7)	477	1:1.19	1:0.32

AM: Adult male, AF: Adult female, SA: Subadult, Juv: Juvenile, Fo: Foal, Ad: Adult = n (AM+AF), Yg: Young = n (SA+Juv+Fo), n_i: number of herd (sample size).

5.4.3 Group composition

The group composition of family group (one-male harem) and bachelor stallion group is shown in Table 14. Burchell's zebra formed fairly stable groups throughout the year. Out of a total of 63 observed family groups, one-male harem herd accounted for 35.1%. The mean one-male harem or family group size was 10.8 individuals. The mean bachelor stallion herd size was 6.4 individuals (Table 14). There was significant difference in-group size of one-male harem herd and bachelor stallion herd ($P < 0.001$). The sex composition of a one male-harem ($n = 220$) was: 13.1% adult male, 56.1% adult females and 38.8% unsexed immature young (subadult, juvenile and foal). In the age distribution of a one-male harem (or family group), adults over 30 months accounted for 69.2 while young formed 30.8%. The age structure of family group was: 69.2% adult, 19.6% subadult, 6.5% juvenile and 4.7% foal (Table 14).

Table 14. Group composition of Burchell's zebra in the Nechisar plains

Month	n_i	No. of stallion herd	Stallion herd size	No. of family group	Family group herd size	Sex & age structure per family group				
						AM	AF	SA	Juv.	Fo.
Nov	59	22	6.0	37	10.4	1.4	5.7	2.0	0.7	0.6
Dec	56	21	6.7	35	10.8	1.1	6.1	2.1	0.8	0.5
Jan	50	20	6.0	30	11.0	1.1	6.2	2.5	0.7	0.4
Feb	49	21	5.8	28	11.0	1.0	6.4	2.6	0.7	0.3
Mar	62	20	6.5	42	10.6	1.8	6.0	1.6	0.7	0.5
Apr	64	16	7.5	48	10.8	1.9	5.5	2.0	0.7	0.7
Total	340	120	38.5	220	64.6	8	36	13	4	3
Aver.	57	20	6.4	37	10.8	1.4	6.0	2.1	0.7	0.5
%		35.1		64.9						

n_i: Sample size, AM: Adult stallion, AF: Adult mare, SA: Subadult, Juv: Juvenile, Fo: Foal,

5.4.4 Natality

Over the study period, 117 foals were observed following their mothers (Table 15). Among these 65.8% was during the wet season and 34.2% was during the dry season. Among 112 pregnant mares, 70.5% was observed during the wet season while 29.5% during the dry season. The highest percentage, 70.5% of pregnant mares and 65.8% foals were observed during the wet season. Foaling took place throughout the study period but peaked in April (Fig. 8). The highest number of foals coincides with the maximum rainfall in April (Fig. 9).

Table 15. Number of oestrous fillies, pregnant and nursing mare with foal. Percentage is shown in parentheses.

Season	Month	No. of oestrous fillies	No. of pregnant mares	No. of nursing Mare with foal
Wet	November	8(21.0)	10(8.9)	24(20.5)
	March	18(47.4)	23(20.5)	20(17.1)
	April	10(26.3)	46(41.1)	33(28.2)
	Sum	36	79	77
Dry	December	2(5.3)	5(4.5)	18(15.4)
	January	-	10(8.9)	13(11.1)
	February	-	18(16.1)	9(7.7)
	Sum	2	33	40
	Total	38	112	117

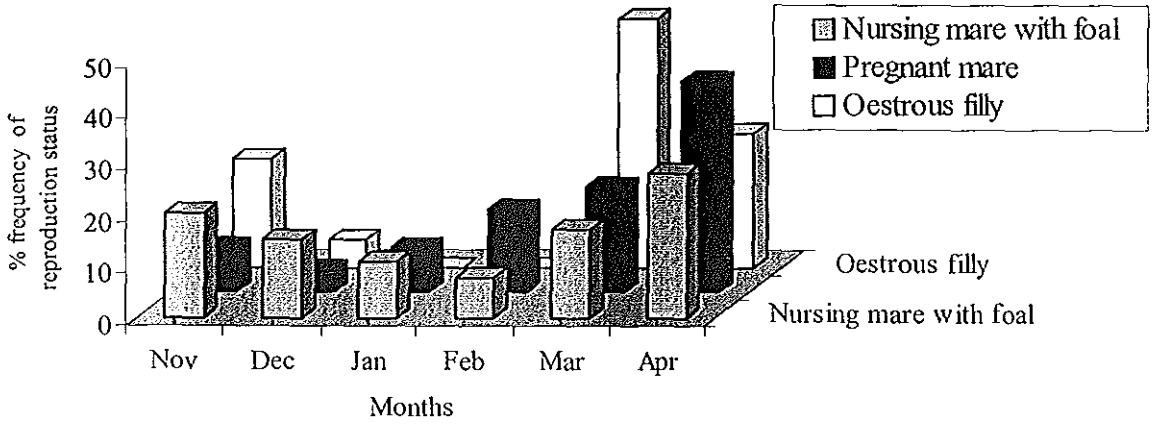

Figure 8. Percentage frequencies of oestrous fillies, pregnant and nursing mare with foal

5.4.5 Mortality

Out of a total of 77 zebras died during the study period causes of death comprised 49.4%, unknown, 35.1% predation and 14.5% old age (Table 16). The main decimating factors of Burchell's zebra in the Nechisar plains were found to be predation and old age. Lion and spotted hyena were the two main predators of Burchell's zebra. Lion killed 28.6% (n = 22) and the spotted hyenas killed 6.5% (n = 5) (Table 16).

Table 16. Number of deceased Burchell's zebra and the main causes. Percentage is shown in parentheses.

Predator		Natural		
Killed by lion	Killed by spotted hyena	(Old age)	Unknown	Total
22 (28.6%)	5 (6.5%)	12 (14.5%)	38 (49.4%)	77

During the study period, 59 skulls were collected and grouped under different age and sex classes (Table 17). Adult males accounted for 18% while adult females accounted for 23% of the total unidentified adult skulls. The skulls of subadults accounted for 13.0% while the juveniles and foals accounted for 9.1% and 14.3%, of populations. Proportion of male and female skulls indicated a sex ratio of 1:1.29. The difference was not significant ($\chi^2 = 14.836$, df = 1, $P > 0.05$) animals. Percentage of mortality estimate for juvenile and foal was 30.4% and 55.8% while the average mortality percentage estimate for adult was 13.8% of the proportion of total population.

Table 17. Sex and age categories of skulls collected and distributed. Percentage is shown in parentheses.

Season	Month	Sex and age categories of dead Burchell's zebra						Total
		No. of collected skulls				No. of young lost		
		AM	AF	SA	UA	Juv.	Fo.	
Wet	Nov	1(11.1)	2(22.2)	2(22.2)	2(22.2)	1(11.1)	1(11.1)	9
	Mar	2(15.4)	3(23.1)	2(15.4)	3(23.1)	1(7.6)	2(15.4)	13
	Apr	3(17.6)	4(23.5)	2(11.8)	4(23.5)	1(6.0)	3(17.6)	17
	Sum	6	9	6	9	3	6	39
Dry	Dec	3(21.4)	3(21.4)	1(7.2)	3(21.4)	1(7.2)	3(21.4)	14
	Jan	2(16.6)	3(25.2)	2(16.6)	2(16,6)	2(16.6)	1(8.4)	12
	Feb	3(25.0)	3(25.0)	1(8.3)	3(25.0)	1(83.)	1(8.3)	12
	Sum	8	9	4	8	4	5	38
Total		14	18	10	17	7	11	77
%		(18.2)	(23.4)	(13.0)	(22.0)	(9.1)	(14.3)	

AM: Adult male, AF: Adult female, SA: Subadult, UA: Unknown adult, Juv: Juvenile, Fo: Foal

5.5 Daily activity pattern and general behavioural traits

5.5.1 Daily activity pattern

A total of 117 daily active period observations were recorded. 96.5% of the active periods ranged from 0600 h to 1800 h. Occasionally, a few 3.5% individuals were observed grazing and drinking before midnight. 89% became more active in the morning between 0700 and 1100 hr, and 86.5% in the afternoon between 1500 and 1800 hr during the dry season. 96.5% rested between 2000 and 0600 hr during the night at their bedding sites. They rested during

sunny days under shades the trees and bushes between 1300 to 1430 hr (Fig. 10).

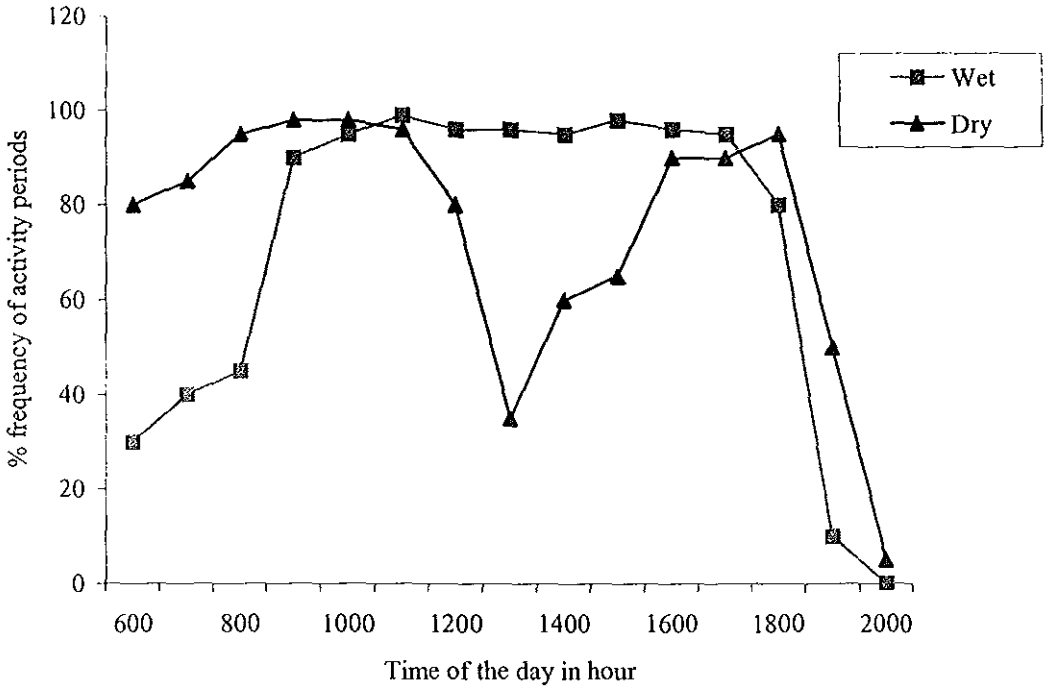

Figure 9. Percentage frequencies of daily activity periods during the wet and dry seasons

On warm and dry days, 80% of the herds pass the night together and activity commences at dawn led by the dominant adult stallion. Once they reach pasture field, their group then divides into the family groups. Bachelor stallion herds move independently and begin grazing. 75% of the herd begins to move to water sources at 1100 hr. 65% seek shade and rest most frequently around noon between 1200 and 1430 hr after drinking water. During late afternoon, 75% of Burchell's zebra begin move together back to the short grassland (Fig. 11). This is the period when social activities reach a peak (dust bathing, rolling and fighting) (Wilson *et al.* 1996).

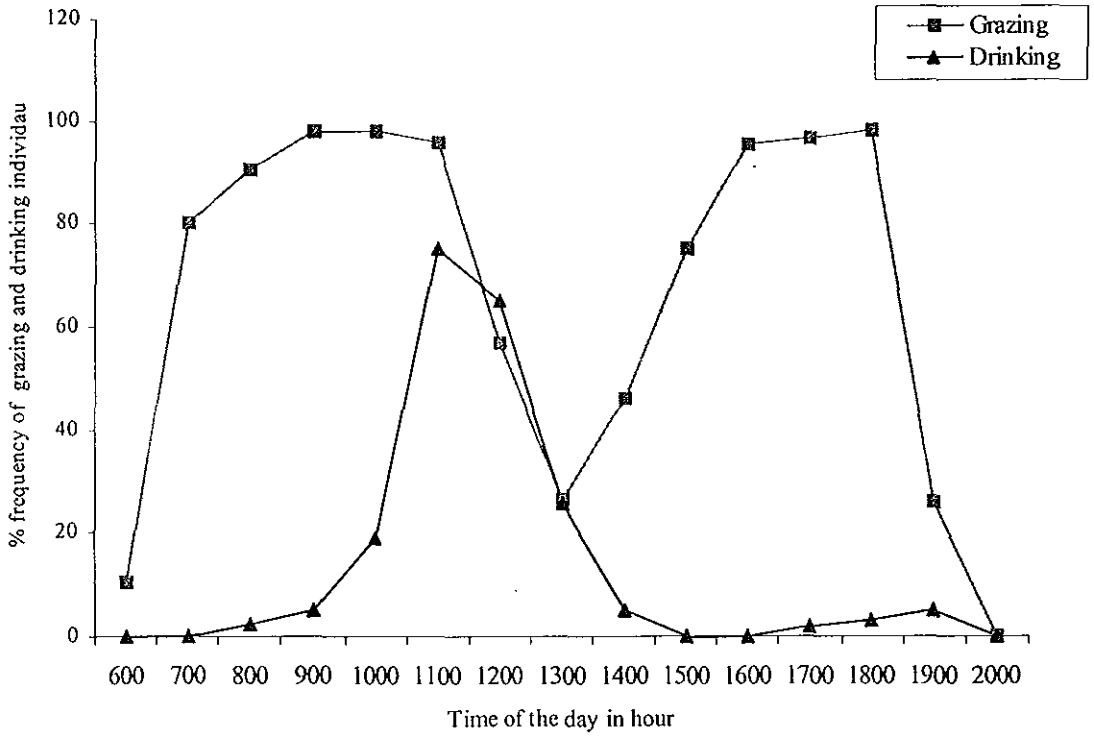

Figure 10. Percentage frequencies of daily grazing and drinking periods of Burchell's zebra during the dry season.

96.5% of Burchell's zebra's activity periods ranged from 0900 to 1700 hr during the dry season (Fig. 12). No zebra was observed during the night unless disturbed by hunting lions or hyenas. In cold, rainy days, 60% of Burchell's zebra become active after 0730 hr. They graze throughout the day in the wet season before returning to night bedding places (Fig. 12). Daily activity periods of Burchell's zebra show significant variation between the dry and wet seasons. Percentage frequency of grazing and drinking periods vary significantly between seasons of wet and dry ($\chi^2 = 9.467$, df = 1, $P < 0.05$). In Nechisar plains, 95% of Burchell's zebra begin to move to their bedding ground at 1800 h during the wet season and 1830 h during the dry season. Their bedding sites on Nechisar plains near settlements (56.6%), Hare hill plateau (30.4%) and Degabule ridge (13%).

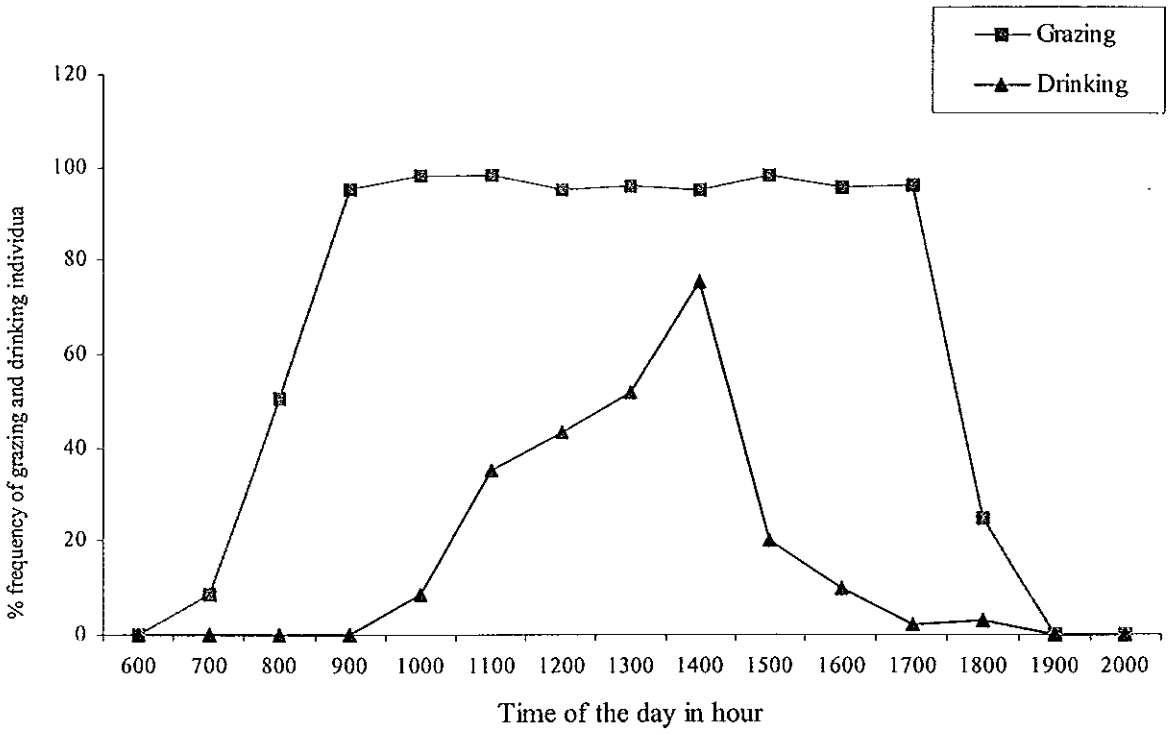

Figure 11. Percentage frequencies of daily grazing and drinking periods of Burchell's zebra during the wet season.

5.5.2 Communication

Out of a total 330 observation, the four major behavioral characters of communication were visual (38.8%) that includes ear positions, facial expressions, general body posture, olfactory (24.2%) that includes urine smelling, faecal smelling, naso-nasal and naso-genital contact of greeting challenge; tactile (18.8%) that included social grooming, standing head resigning in pair and greeting rituals and vocal or auditory (18.2%) that included alarm call of a loud snort, quite snort gasp of worming a short squall during play fights, a drawn-out squeal (Table 18). All but visual communication was the most frequent and intensified social behavior in Burchell's zebra population ($\chi^2 = 4.562$, df = 3, $P < 0.05$).

Table 18. Sight frequency and percentage of communication types of Burchell's zebra

Type of communication	Behaviour	Types of information conveyed	Sighting frequency per day	(%)
Olfactory	Urine smelling faecal smelling naso-genital contact	Reproductive situation identification and greeting ritual.	80	24.2
Vocal or auditory	Vocal sound	Alarm, warning and attack contact call	60	18.2
Visual	Facial expression ear position, head and tail position body strip	Emotion, threat and sexual display.	128	38.8
Tactile	Social groom Greeting ritual Sniffing and Rubbing	Social bond, group member identification	62	18.8
Total			330	100

5.5.3 Agonistic behavior

Agonistic behavior is not obvious in the species. But it happens when a bachelor stallion attempts to form its own family group (harem) and abducts filly from her herd. Then he must fend rival stallions every time fill comes into heat. The observed agonistic trait during the study period is listed in Table 19. Out of the total 981 agonistic behavioural traits observed 53% was submissive traits, 25% was fighting traits and 22% was aggressive traits. Aggressive displays were most frequently observed when a bachelor stallion attempts to form new harem, top ranked mare and mare with newborn foal. Submissive displays were most frequently observed on defeated subordinate stallions, lower rank mares and subadults.

Table 19. Percentage sighting frequencies of agonistic behavioral traits of Burchell's zebra

	Displays	Sighting frequency per day	(%)
Agonistic trait	Erect postures, raised head with pricked ears and arched tail	86	39.8
	High stepping gait	20	9.3
	Teeth bared and ears laid back	50	23.1
	A loud snort	60	27.8
	Sum	216	22.0
Submissive behaviour	Lowered neck with extended tail and ears laid lack	120	23.1
	Grooming initiatives	100	19.2
	Chewing lip movements	80	15.4
	Kicking hind feet	150	28.8
	Coarse gasp and run away	70	13.5
	Sum	520	53.0
Fighting	Biting with teeth	80	32.7
	Rearing and striking with forefeet	60	24.5
	Kicking with hind feet	105	42.8
	Sum	245	25.0
Total		981	100.0

5.5.4 Interspecific interactions

Mammals observed during the study period are shown in Appendix VI. Burchell's zebra group shows a tendency of association with few large herbivores and domestic animals. Frequency of association of Burchell's zebra with other herbivores is given on Table 20. The percentage sight frequency of Burchell's zebra herd alone accounted for 63.5%, Grant's gazelle 17.5%, Swayne's hartebeest 4.8%, Greater kudu 1.6%, domestic cattle 11.0% and goats 1.6%. Burchell's zebra associated with Grant's gazelle more than any other wild herbivores.

Table 20. Relative abundance and percentage sight frequency of Burchell's zebra interaction with other large mammal species.

Mammalian species	Relative abundance to present Burchell's zebra population size estimate	Sighting frequency	%
Burchell's zebra (*E. burchelli*)	0.72	40	63.5
Grant's gazelle (*G. granti*)	0.17	11	17.5
Swayne's hartebeest (*A. h. swayni*)	0.02	3	4.8
Greater kudu (*T. strepsiceros*)	0.004	1	1.6
Cattle (domestic)	1.65	17	11.0
Goat (domestic)	0.13	1	1.6
Total		63	100

5.6 Human impact

5.6.1 Settlement encroachment and its effect on the Burchell's zebra

The socio-ecological survey confirmed that Guji Oromo tribes settled in eight villages of Nechisar plains (Table 21). There are six villages in the Nechisar open grassy plain habitat and two villages in the Hare hill plateau bushland. Out of the 124 households sampled, 84.7% were observed in the open grassy plain while 15.3% in the bushland. The distribution of settlements is significantly different in these two main habitats ($\chi^2 = 14.942$, df = 1, $p < 0.05$). The 250 households in these two main habitats comprised 1640 Guji Oromo people. Percentage composition of sex showed that 47% (770) male and 53% (870) female. A sex ratio of

male to female was found to be 1:1.3. The average household family size was 6.5 per household.

Table 21. Population size of eight villages of Guji Oromo settlement in the Nechisar plains

Villages	Number of households	Number of households sampled	Family size	Number of people	Sex ratio
					Male: Female
Gandullo	40	20	7.6	304	1:1.2
Awarche	24	12	4.5	108	1:1.1
Gode	44	22	7.3	321	1:1.1
Watchole	42	21	7.5	351	1:1.2
Mado	25	12	6.3	158	1:1.1
Datche	37	18	5.7	211	1:1.2
Hare	10	5	4.6	46	1:1.0
Kordae	28	14	6.3	177	1:0.9
Total	250	124	6.5	1640	1:1.3

A total of 7587 heads of cattle and goats was identified from 124 household interviews. Cattle accounted for 93.3% and goats 6.7% (Table 22). However, using line transact sampling the count was 7385 heads of cattle and 574 goats. There was a significant variation between the two methods ($\chi^2 = 6.431$, df = 1, $P < 0.05$). The average number of cattle and goats, per household was found to be 28.3 and 2.03, respectively (Table 22).

Table 22. Number of livestock counted in the eight Guji Oromo villages of Nechisar Plains

Village	Number of households	Number of households sampled	Number of cattle	Average size of cattle per household	Number of goats	Average number of goats, per household
Gandullo	40	20	1280	32.0	60	1.5
Awarche	24	12	600	25.0	43	1.8
Gode	44	22	1320	30.0	88	2.0
Watchole	42	21	1239	29.5	59	1.4
Mado	25	12	650	26.0	30	1.2
Datche	37	18	1065	28.8	89	2.4
Hare	10	5	310	31.0	35	3.5
Kordae	28	14	616	22.0	113	4.0
Total	250	124	7080		507	

5.6.2 Resource utilization and human disturbance

Livestock overgrazing with thatching (grass cutting); wood collection for fuel and construction; and wild honey collection that influenced the ecology of Burchell's zebra is shown on Table 23. Herdsmen and Thatcher observed in the Nechisar plains were 260 per day. Out of 250 households in the Nechisar plains, 236 individuals were observed while collecting firewood and cutting trees daily.

Table 23. Natural resources used in the Nechisar community and their effect

Population status of Burchell's zebra

Important resource utilization activities	No. of people observed per day	No. of livestock observed per day	No. of vehic observed pe day
Grazing and thatching grasses	236	7587	-
Cutting and collecting wood for fuel	260	-	-
Wild-honey collecting	15	-	-
Sum	511	7587	-
Access to Arbaminch	65	3	5
Bole soil licking	14	500	-
Fishermen	12	-	-
Sum	91	503	5
Total	602	8090	5

Most Guji Oromo households collect wild-honey from natural or man-m wild-honey collectors were observed daily (Table 23). Beehives on bran acacia tree were observed in the Kordae village during this study period bark of big trees to prevent honey badger climbing up, to eat honey. As acacia trees are found dry surrounding the Nechisar plains. During the the movement of Burchell's zebra to Sermale River to drink water is during the dry season. At the same time, the frequent use of fire disturbance. Deliberate fire burns about three quarters of the park. T induce fresh grass and remove ticks.

The main track from Arbaminch town to Amaro district passes through the center of Nechisar plains. This causes great disturbance to the plain ungulates especially for the water dependent Burchell's zebra. The foot passes also cause great disturbance. On average 65 foot-passengers, 5 vehicles and 3 pack animals were counted daily on the main tracks during the dry season (Table 23). This disturbs tourists and encourages the illegal fishermen by providing transportation facilities. It also disrupts the movement of Burchell's zebra from Nechisar plains across the main track or road to Sermale River. The herdsmen also take 500 heads of livestock to bole soil (salt lick), thereby disrupting zebra movements.

5.6.3 Habitat destruction

The major components of habitat destruction in the study area are shown on Table 24. Among the five main factors that degraded the Nechisar plains grass quality, 69.2% is recent bush encroachments, 21.2% is forest fire and 9.5% is overgrazing and trampling. During the last thirty years, 33.6% of suitable grassland for Burchell's zebra has been reduced.

Table 24. Estimated area of habitat degraded and causes of destruction in Nechisar plains

Village	Recent bush encroachment area in hectare	Current burnt area in hectare	Trampled bare ground In hectare	Livestock fence in hectare	Flood catchments in hectare	Sum	%
Gandullo	200.0	-	300.0	0.12	0.04	500.2	5.58
Awarche	100.0	-	205.0	0.08	0.03	305.1	3.41
Gode	0.5	-	100.2	0.03	0.03	100.8	1.13
Watchole	0.3	1900.0	100.1	0.08	0.05	2000.2	22.33
Mado	0.1	-	50.01	0.06	0.04	50.3	0.56
Datche	200.0	-	100.002	0.09	0.02	300.1	3.35
Hare	5200.0	-	0.001	0.02	0.01	5200.0	58.06
Kordae	500.0	-	0.005	0.05	0.01	500.0	5.58
Total	6200.9	1900.0	855.318	0.53	0.23	8956.7	
%	69.231	21.210	9.550	0.006	0.003		

5.6.4 Attitude of the Guji Oromo pastoralists

5.6.4.1 Knowledge of wildlife species

Out of a total of 124 participants, only 16.8% named 1-10 species of wildlife, 40.0% named 10-15 species and 43.2% named > 15 species of wildlife. Knowledge of wildlife in the area differed between village residents of eight Guji Oromo people ($\chi^2 = 12.752$, df = 7, $P < 0.05$). Residents of Hare village (60%), and Watchole (54.5%) knew more wildlife species than respondents from other village dwellers (Table 25).

Table 25. Number of wildlife species named by the respondents in eight Guji Oromo villages in the Nechisar plains.

Village	n	1-10 species (%)	10-15 species (%)	> 15 species (%)
Gandullo	20	25.0	40.0	35.0
Awarche	12	16.7	50.0	33.3
Gode	22	9.1	40.9	50.0
Watchole	22	9.1	36.4	54.5
Mado	12	25.0	50.0	25.0
Datche	18	27.0	33.3	38.9
Hare	5	20.0	20.0	60.0
Kordae	14	7.1	42.9	50.0
Total	124	21	49	54
%		16.8	40.0	43.2

n: number of individual respondents

The age of respondents was important in determining the knowledge of wildlife ($\chi^2 = 8.269$, df = 3, $P < 0.001$). Older respondents (age > 40 years) knew more wildlife species than the young (15 - 20 years). Sex was important in determining the knowledge of wildlife ($\chi^2 = 3.625$, df = 1, $P < 0.05$). Male respondents named more species (81.7%) than females (19.3%). Those who had lived in the area for more than 30 years named more species ($\chi^2 = 6.236$, df = 1, $P < 0.05$) than those who have lived there for short periods. Those who have completed elementary level education and participated in wildlife conservation workshops and seminar named more species than the others ($\chi^2 = 12.332$, df = 1, $P < 0.05$).

5.6.4.2 Views on trends of wildlife population

Out of a total of 124 participants, 11.3% respondents acknowledged the increase in wildlife of Nechisar plains, while 73.3% respondents suggested decrease in wildlife. A few (8.1%)

respondents believed that there was no change in the number wildlife (Table 26). There was a marked difference ($\chi^2 = 6.2$, df = 7, $P < 0.05$) in views among the different village residents. Most of the residents from Gandullo (85.0%), Gode (77.3%) and Watchole (76.2%) suggested that wildlife is decreasing. In contrast, few respondents from Gandullo (5.0%) thought wildlife is decreasing. There was significant difference on the trend of wildlife population between the sexes ($\chi^2 = 3.6$, df = 1, $P < 0.05$). 52.9% of the males and 19.8% of the females acknowledged that wildlife was decreasing. There was no difference among categories of age ($\chi^2 = 12.0$, df = 4, $P > 0.05$), and duration of residence ($\chi^2 = 7.8$, df = 3, $P > 0.05$).

Table 26. Views on trends of wildlife population size among eight Guji Oromo villages.

Villages	n	Increasing (%)	Decreasing (%)	No change (%)	No opinion (%)
Gandullo	20	5.0	85.0	5.0	5.0
Awarche	2	16.7	66.7	8.3	8.3
Gode	22	9.1	77.3	4.5	9.1
Watchole	21	9.5	76.2	9.5	4.8
Mado	12	8.3	66.7	16.5	8.3
Datche	18	16.6	66.7	5.6	11.1
Have	5	20.0	60.0	20.0	-
Kordae	14	14.3	71.5	7.1	7.1
Total	124	14	91	10	9
%		11.3	73.3	8.1	7.3

n: number of individual respondents

5.6.4.3 Views on trends of Burchell's zebra population

From a total of 124 participants, 87.9% assumed that Burchell's zebra population is increasing. Only 4.0% of the respondents thought that the population is decreasing. The reasons for the decline are habitat destruction, bush encroachment, direct shoot, poaching, predators, parasites and water poisoning (Figure 13). There is no significant difference

among the different age groups (χ^2 = 0.33, df = 4, P > 0.05), sexes (χ^2 = 0.33, df = 1, P > 0.05) and duration of residence in the area (χ^2 = 11.23, df = 3, P > 0.05) on status determination (Table 27).

Table 27. Views on trend of Burchell's zebra population size in the eight Guji Oromo villages respondents.

Village	n	Increasing (%)	Decreasing (%)	No opinion (%)
Gandullo	20	90.0	5.0	5.0
Awarche	12	92.0	-	8.0
Gode	22	86.4	4.5	9.5
Watchole	21	90.4	4.8	4.8
Mado	12	83.4	8.3	8.3
Datche	18	94.4	-	5.6
Hare	5	80.0	-	20.0
Kordae	14	78.6	7.1	14.3
Total	124	109	5	10
%		87.9	4.0	8.1

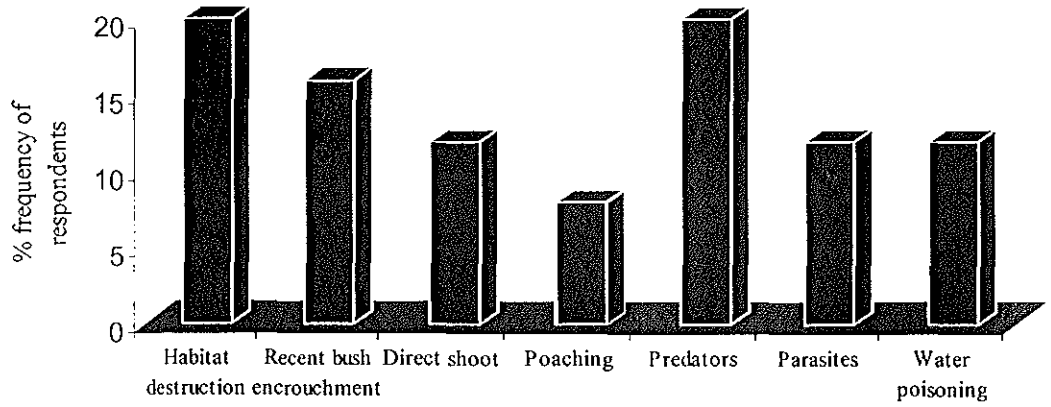

Figure 12. Factors confirmed by respondents as major threats of Burchell's zebra

5.6.4.4 Local people attitude towards wildlife

Out of the 124 participants, 42.4% respondents had no problem with wildlife, but 53.6% considered them nuisance and had a negative attitude towards the wildlife. However, views on the problems with wildlife differed among village residents ($\chi^2 = 9.491$, df = 7, $P < 0.05$) (Table 28).

Table 28. Views on wildlife in eight Guji Oromo Villages

Villages	n	Nuisance (%)	No problem (%)
Gandullo	20	75.0	25.0
Awarche	12	41.7	58.3
Gode	22	45.5	54.5
Watchole	21	38.1	61.9
Mado	12	50.0	50.0
Datche	18	66.7	33.3
Hare	5	80.0	20.0
Kordae	14	78.6	21.4
Total	124	71	53
%		53.6	42.4

n: number of individual respondents

The age of respondents was important in determining views on problems caused by wildlife ($\chi^2 = 8.246$, df = 4, $P < 0.05$). Young respondents (< 20 years of age) had a positive attitude towards wildlife than the older ones. The sex of respondents was also an important determinant of views ($\chi^2 = 0.333$, df = 1, $P < 0.05$), with more females (75%) showing a negative attitude than males (56.6%). There was a significant difference ($\chi^2 = 14.029$, df = 4, $P < 0.05$) on the length of residence and education on their attitudes towards wildlife. The old resident in the area and educated people had a better positive attitude than others.

Out of the 71 respondents considered as wildlife a nuisance 16.9% confirmed that carnivores such as lions, spotted hyena, leopard; jackal and wolf attack them and their livestock (Fig. 14), 14.1% noticed that herbivores like warthog, bush pig, porcupine & baboon destroy their crops. 12.7% acknowledged that Burchell's zebra, Grant's gazelle, Swayne's hartebeest and Greater kudu compete for grazing land. 5.6% knew anopheles mosquitoes, tsetse flies and ticks as the disease vectors for cattle and man. 21.1% fear of displacement from their local places. 19.7% blamed wildlife as obstacle for their social status improvements, and 9.9% assumed that they contaminate drinking water.

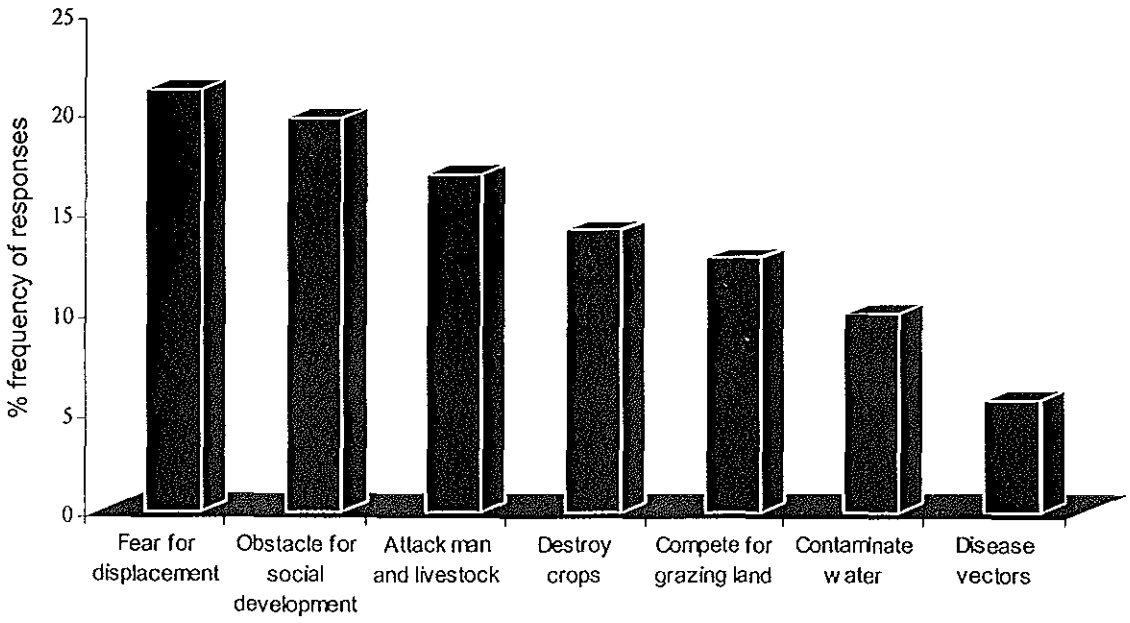

Figure 13. Views of the local people on the wildlife in the Nechisar plains

Out of the 19 respondents considered Burchell's zebra as a nuisance species (74.8%) of the respondents considered that zebra have no use value whatsoever and did not think it is worth

conserving them, and (13.3%) responded they are fierce to domestic animals. They chase and kill newly born livestock and dogs. The rest (12 9%) responded they compete with cattle for grazing land (Fig. 15).

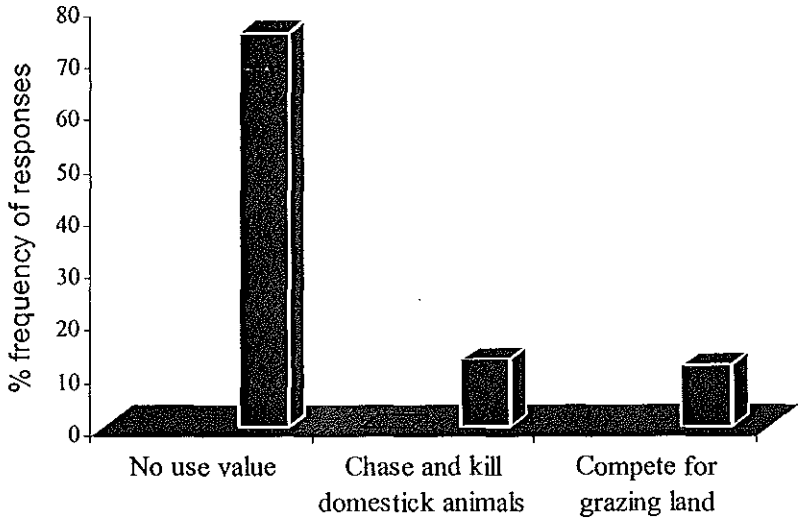

Figure 14. Reasons for considering Burchell's zebra as a nuisance species

5.6.4.5 Support for wildlife conservation

Out of a total of 124 participants, 33.6% supported wildlife conservation programmes while 66.4% opposed wildlife conservation (Table 29). However, there was a significant difference on the support for conservation among village residents ($\chi^2 = 10.537$, df = 7, $P < 0.05$). Most respondents from Gode (54.5%) and Hare (40%) supported wildlife conservation. However, villagers of Datche (83.3%) and Kordae (78.6%) opposed wildlife conservation (Table 29).

Table 29. Views of respondents to the wildlife conservation among the eight villages of Guji Oromo people.

Village	n	Support wildlife conservation (%)	Oppose wild life conservation (%)
Gandullo	20	40.0	60.0
Awarche	12	33.3	66.7
Gode	22	54.5	45.5
Watch ole	22	31.8	68.2
Mado	12	25.0	75.0
Datche	18	16.7	83.3
Hare	5	40.0	60.0
Kordae	14	21.4	78.6
Total	125	42	83
%		33.6	66.4

n: number of individual respondents

Views on support for wildlife conservation are similar between sexes ($\chi^2 = 1.537$, df = 1, P > 0.05) and among age of respondents ($\chi^2 = 4.152$, df = 4, P > 0.05). However, view on the support for wildlife conservation significantly differed based on duration of residence and education in the Nechisar plains ($\chi^2 = 13\ 468$, df = 7, P< 0.05). 33.6% of the respondents supported wildlife conservation (Table 29). Among these, 23.8% responded to generate income from tourism, 19.0% to fulfill government regulation, 16.7% for job opportunity; 14.3% for future meat supply; 9.5 % for cultural value; 9.5% for medical value; and 7.2% for scenic beauty (Fig. 16).

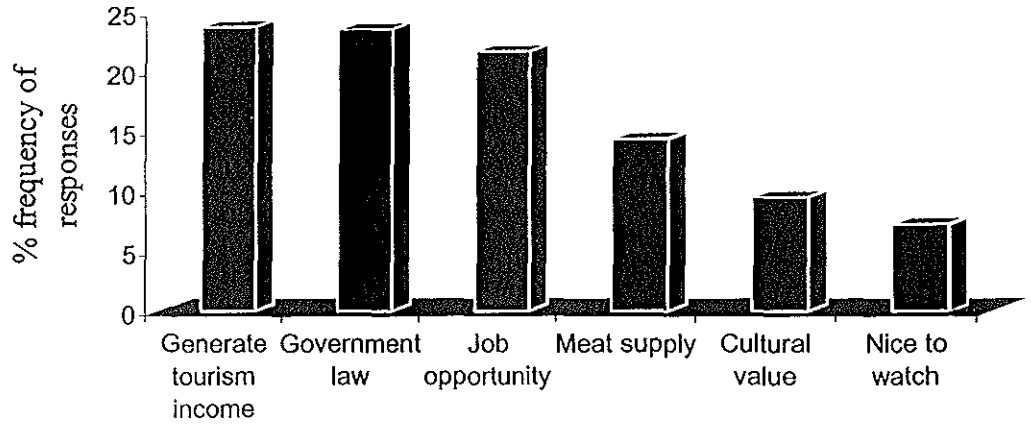

Figure 15. Reasons for supporting wildlife conservation

5.6.4.6 Support for the Burchell's zebra population conservation`

Support for the Burchell's zebra population management was fairly similar among the eight Guji Oromo Villages in the Nechisar plains ($\chi^2 = 6.000$, df = 7, $P > 0.05$) (Table 30). Out of these respondents (46.8%) confirmed the species has been neglected, 37.9% considered as a good species and 15.3% considered as a nuisance species.

There was a significant difference among different age categories for grouping them as a good or bad species ($\chi^2 = 3.558$, df = 4, $P < 0.05$). Most old people (> 60 years of age) considered the Burchell's zebra as a good species while some respondents (15-20 years of age) considered as nuisance. Educated people and long-lived residents showed positive attitude to the Burchell's zebra population ($\chi^2 = 0.835$, df = 1, $P > 0.05$). Potential for tourism, cultural value, and prey for lions are the positive attitudes (Fig. 17).

Table 30. The attitude of villagers' towards Burchell's zebra in the Nechisar plains

Village	n	Good species (%)	Nuisance species (%)	Benign neglect (%)
Gandullo	20	30.0	10.0	60.0
Awarche	12	33.3	16.7	50.0
Gode	22	36.4	18.2	45.4
Watchole	21	38.1	14.3	47.6
Mado	12	41.7	8.3	50.0
Datche	18	33.3	22.2	44.5
Hare	5	40.0	20.0	40.0
Kordae	14	57.1	14.3	28.6
Total	124	47	19	58
%		37.9	15.3	46.8

n: number of individual respondents

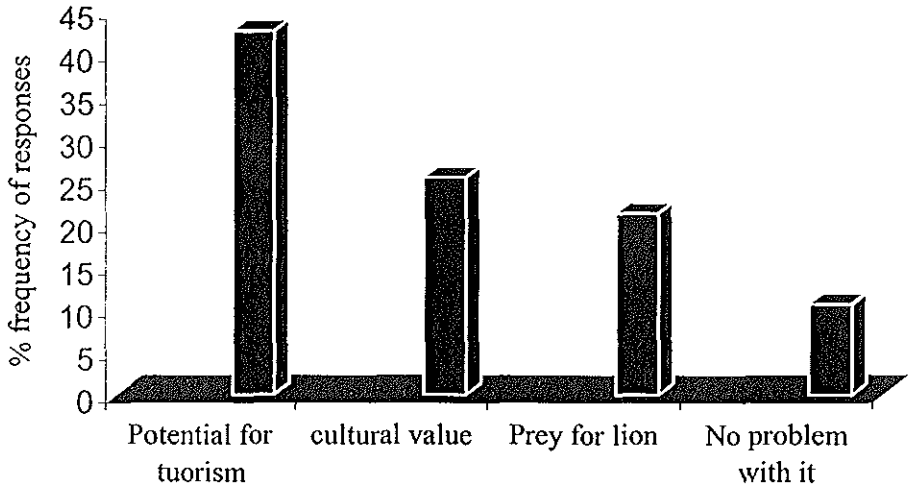

Figure 16. Reasons for considering Burchell's zebra as a good species

6. DISCUSSION

6.1 Population status

The population density of Burchell's zebra in the Nechisar plains using DISTANCE analysis was estimated to be 18.3 ± 0.81/km^2 and 15.0 ± 1.2 /km^2 during wet and dry seasons. The mean population density of the Burchell's zebra in the Nechisar plains was found to be 16.6 ± 1.5/ km^2. The slight variation between the two seasonal population density estimates was caused by the seasonal resource requirements of the species in different habitats which in turn influences the group size and detection probability. Kirubel Tesfaye (1985) made the first population density estimate of Burchell's zebra in the Nechisar plains. This population density estimate for the wet and dry seasons was 13.4/km^2 and 34.9/km^2. The average population density of the species was 24.2 individuals /km^2. He used road-counting method of fixed sighting distances during the wet season and variable sighting distances during the dry season population census. The use of different methods might have been the source of variation.

During the present study period, the mean population size estimate of Burchell's zebra in the Nechisar plains was found to be 4482 individuals with 95% confidence interval [4077 - 4887]. This suggests that the true total population size of Burchell's zebra is estimated to be around 4500 individuals. The wet season population census obtained larger number of Burchell's zebra compared to the dry season. Such high estimate of the population size during the wet season was attributed to the more animal visibility as suggested by Harvey and Greenwood (1978). Furthermore, a quick growth of short green grasses and flood plains

attract many plain zebra into central open grassy plain during the wet season. They were concentrated on local green flushes, spent more time in moving and grazing together in the open grassy plain area. Similarly, the moderate temperature and cloudy weather conditions tended to cause the animal to be more active. During the dry season, the short grasses in the flood plains dry up, and the productivity of the plain drops. This causes the Burchell's zebra to move to the surrounding bushland to look for food source and rest under shades of trees and bushes. The animals also become less active which reduces the probability of observation.

High proportion of the female and immature young individuals observed during the study period shows that the Burchell's zebra population is increasing. Most of the respondents, 87.9% was opinioned that the Burchell's zebra population is increasing. Blower (1967) and Bolton (1970) gave estimation of the Burchell's zebra to be 200 and 400. After the establishment of NNP, Burchell's zebra population size was increasing rapidly up to 1992. As a result of revenge by the local people during the fall of the military regime, a large number of Burchell's zebra was killed in 1992. As a result, the population size declined rapidly between 1992 and 1995. The Burchell's zebra population could be recovering due to the application of strict wildlife management regulation that has been practiced by local people and as result of regular patrolling of NNP scouts.

The distribution and abundance of many species are influenced by the spatial arrangement of suitable habitats across a given landscape. The habitat requirement of Burchell's zebra was closely associated to availability of water and edible grasses. The relative patterns of habitat preferences corresponded with the number of animals observed in two different habitats. Out

of a total of 1063 observed Burchell's zebra (n = 125), 52% were found in the Nechisar open grassy plain. The proportion of seasonal habitat use is associated with the sight frequencies of the Burchell's zebra in different habitat types. They usually prefer open grassy plain areas where grass is abundant and water is available. During the wet season, 57.3% of the total sight frequencies (n = 64) preferred open grass plain. During the dry season, 53.5% of the total sight frequencies (n = 61) preferred Hare hill plateau bushland. This sight frequency alteration showed that habitat preference of the Burchell's zebra copes with the change in seasonal resource conditions as described by Delany and Happold (1979).

Minimum deviation was observed during the dry season compared to the wet season. The plain zebra utilize both habitats during the dry season. They intensify their relative preference in the open grassy plain areas at the beginning of the rainy season. The pattern of vegetation use changed as the dry season approached. The Burchell's zebra population concentrated towards the area with scattered trees and bushes nearby River Sermale and Lakes (Chamo and Abaya). These bushes are important as dry season refuges. They also contained tall grasses and provide shade. However, Burchell's zebra prefer less dense trees and bushes. Basically, positive relationship was observed in the feeding habit and habitat preference of Burchell's zebra. They usually prefer open grassy plains of savanna grassland. This was possibly due to the effect of vegetation cover on the visibility and detection of predators or other rivals of the same species as described by Harvey and Greenwood (1978).

Dorst (1970) stated that Burchell's zebra are mainly grazers but occasionally browse on leaves and scrubs when resource is scarce. Lamprey (1963) estimated that 92.5% the food of the zebra was grass, 5.4% was herb and 2% was shrub. In the Nechisar plains, grass

comprises all the diet during the wet and dry seasons. They have never been observed browsing herbs and shrubs.

Vesey-Fitzgerold (1965) noted that *Sporobulus sp.* and *Vossia sp.* are preferable grass species of Burchell's' zebra in the Rungwa Valley, Tanzania. Casebeer and Koss (1970) found that the Burchell's zebra diet approximate to the availability of actual grasses. But the dominant fire climax grass, *Themeda triandra* figured very high in their stomach samples in Ngorogoro. During the study period, observations on the grass types and feeding rate showed that the Burchell's zebra feed upon most common grasses available. But, they preferred grass species such as *Themeda triandra, Lintonia nutans, Setaria sphacelata, Ischaemum afrum, Chrysopogon aucheri* and *Cenchrus ciliaris*. Feeding observations during the study period indicated that *Themeda traidra* was the most preferred grass species, followed by *Lintonia nutans* and *Setaria sphacelata* as described by Casebeer and Koss (1970).

The distribution of Burchell's zebra is primarily determined by the availability of grass and water in the savanna grassland as described by Duncan (1992) and Estes (1997). Bolton (1970) reported Nechisar plains as home for Burchell's zebra and some individuals were also observed on the Gatira plains. The present study showed that 95.9% of the Burchell's zebra occurred inside the park. But few (4.1%) were observed outside the park in the Gatira plain and Gatira mountain ranges south of the park boundary during the wet season as described by Bolton (1970). During the dry season, their local distribution range becomes wide, 76.2% inside the park and 23.8 % outside the park boundary as reported result by Kirubel Tesfaye (1985). The population was dispersed to search better pasture and water sources from the central open grass plain to surrounding bushlands. Inside the park they extend their range to the west into Kilisa plain. Outside the park their distribution range extended eastward to the

Wododerba hill ranges and southwards to the Gatira plain, and Gatira mountain ranges.

Burchell's zebra population showed relative seasonal change in distribution both spatially and temporally. The seasonal distribution of the species significantly varied in the different parts of the study area. The highest density of the species was particularly observed in Nechisar open grassy plain (16.5/km^2) during the wet season. Hare hill plateau bushland had the highest population density (13.1/km^2) during the dry season. Their seasonal distribution was correlated with the availability and abundance of green grasses and flood plain. During the dry season (December to February), they disperse to surrounding bushland of Hare hill plateau, Degabule escarpments, Haroresa ridges and Hitu bushland. However, in December the first rainy season ends, grasses dry out and flood in the water catchments dry up. The nomadic pastoralists in the Nechisar plain move to the Sermale River Valley and Hare hill plateau bushland with their livestock. By the late dry season, overgrazing reduces the grass quality and ecto-parasites (tick) invade the open grassy plains. The Burchell's zebra then move to the surrounding bushland where tall grasses, shade trees and bushes frequent. Grant's gazelle and Swayne's hartebeest with smaller population and body size have partly switched from poor quality dry grass to high protein browse as described by Delany and Happold (1979).

During the wet season (November, March and April), they move to the central open grassy plain, contracting the distribution range, thereby increasing in population density in the central plain. Pastoralists also follow with their livestock. In the Nechisar plains, herds of zebra, Swayne's hartebeest, Grant's gazelle, cattle and goat congregate to graze on the new green grasses.

The structure of the Burchell's zebra herds and group sizes varied in different social classes and seasons. Kirubel Tesfaye (1985) described that mixed aggregation of one-male harem and bachelor stallion herds' coalition number up to 100 individuals per group during the dry season and this group splits into units of 10 - 20 individuals during the wet season in the Nechisar plains. In present study, it was observed that non-territorial nomadic Burchell's zebra live in social groups of one-male harem and bachelor stallion herd as described by Klingel (1969a) and Estes (1997). The one-male harem herds are composed of a dominant stallion, mares, subadults, juveniles and foals which are usually stable numbers ranging between 3 and 28 individuals as described by Petersen and Casebeer (1972) in the Athi Kapiti plains, Nairobi. The bachelor stallion herds are mainly subadults and subordinate adult males. Their group size ranged between 2 and 17 individuals but unstable as described by Petersen and Casebeer (1972) and Estes (1997).

In the Nechisar plains, the average group size of one-male harem and bachelor stallion herds was 10.8 (10.4 - 11) and 6.4 (5.8 - 7.5) individuals. Petersen and Casebeer (1972) reported an average herd size per family group and bachelor herd were 9.0 and 6.0 individuals in the Athi Kapiti plains, Nairobi. Klingel (1969a) also noted stable group structure numbers (7.05 per family group and 2.9 per bachelor herd) in the Ngorogoro crater, Tanzania. Varieties of benefits accrue to group living individuals and, hence lead to group formation. For example, reduced predation risk is a major advantage of it (Harvey and Greenwood, 1978). In Burchell's zebra, whole herd members cooperate to protect any threat increase group size and reduce predation risk as described by Estes (1997). During the present study, the dominant and subordinate stallions were observed to defend against predators, cooperatively.

Estes (1997) has noted that at least one member of a resting herd remains standing and alert; a herd member that fails to react to alarm snorts is urged to rise by a nudge. The present study has observed that grouped preys often detect an approaching predator sooner than solitary individuals. This occurs even though each individual in a group usually spends less time in vigilance behaviour and can allocate more time to other activities. Earlier detection increases the likelihood of escape. This advantage may be particularly practiced in larger group members giving alarm signals when a predator is sighted. Jarman, (1974) stated that wooded habitat impairs group cohesion and cause the disintegration of large groups. The group size of Burchell's zebra is smaller in bushland, but larger in open grassland habitat. During the present study period, in addition to the habitat, water sources also influenced their group size during the dry season.

Petersen and Casebeer (1972) stated that sex structure of Burchell's zebra in the Athi Kapiti plains, Nairobi, was 32% adult male, 38% adult female and the rest 30% unsexed young. Sex ratio was 1:1.2 adult male to adult female. In the Nechisar National Park, road count by Kirubel Tesfaye (1985) showed that the sex ratio of adult males to adult females was 1.0: 1.1 In the preset study, the sex structure of Burchell's zebra population in the Nechisar plains was 34.8% adult male 41.5% adult female and the rest 23.7% were unsexed immature young (Subadult, juvenile and foal). The sex ratio of adult male to adult female was 1.0:1.19 is similar to Petersen and Casebeer (1972) Athi Kapiti plains, Nairobi.

The sex ratio of Burchell's zebra population was female biased. This confirms that there is no reason for assuming an equal adult sex ratio in species that practices polygamy. Nonetheless, one of the factors that contribute to the less number of male individuals is its anti-predator

behaviour. As stated by Estes (1997), they usually stand staring at the predator except when being chased. The dominant adult stallion actively defends his harem and goes looking for missing mares or young that probably is exposed to the hunting lion. Jarman (1974) mentioned that the smaller groups reduce the vigilance over predators and enhance their vulnerability to predation. These are the main factors for the small proportion of males observed on the Burchell's population in the Nechisar plains.

In the Nairobi National Park, the ratio of adults to young was 1.00:0.04. The age structure of the population was: 68.5% adult, 11.6% subadult, 16.9% juvenile and 2.9% foal. Kirubel Tesfaye (1985) showed that the age ratio of adult to young zebra was 1.00: 0. 04 during the wet season and 1.0: 0.1 during the dry season. In the present study, the age structure of the population was 76.3% adult, 14.7% subadult, 5.2% Juvenile and 3.8% foal. Adult to young ratio was 1.0:0.31. A female biased sex ratio and the fairly high proportion of young animals indicate a healthy and increasing population. The plain productivity is determined by the amount and duration of rainfall. The two breeding seasons of Burchell's zebra coincide with two alternative wet seasons.

Natality of the Burchell's zebra is one of the most important characteristics of a population observed in the Nechisar plains. Foaling takes place throughout the year but peaked in April. Kirubel Tesfaye (1985) also reported that peak birth rate of Burchell's zebra in the Nechisar plains was in April. This peak birth rate of Burchell's zebra coincides with the maximum monthly rainfall 172 mm in April. The breeding season commences in March and peak in April. Hence it is expected that peak birth rate probably occur in October with maximum monthly rainfall of 117 mm. At the end of the first wet season in November (2001), high

number of foals was recorded. This highest percentage of birth in the wet season is to ensure maximum opportunity of the survival of young.

Happold and Delany (1979) reported that defense rarely occurs unless the prey is at least three times heavier than the predators. The adult average body weight of Burchell's zebra ranges from 220 - 250 kg. Kruuk (1972) has mentioned the average weight of a lion ranges from 110 - 180 kg and the average body weight of a spotted hyena ranges from 45 - 60 kg. When the enemy approaches, a herd that has a young foal, adult stallions actively defend. They stand in semi-circle and stay close together instead of running away. Most of the time, spotted hyenas scavenge on the Burchell's zebra carcass killed by lions. A clan of spotted hyena attack old, sick and solitary zebras. The smaller sized carnivores such as leopard, cheetah and hunting dogs were never observed while attacking Burchell's zebra in the Nechisar plains during the present study. During the present study, the main decimating factors that cause death of Burchell's zebra in the Nechisar plains were predation and old age. The two main predators of Burchell's zebra are lion and spotted hyena coupled with ecto-parasite ticks and assumptions of algal bloom in Lake Chamo as described by Klingel (1969b).

Jarman and Maari (1973) stated that basic group activities in most antelopes change seasonally. Burchell's zebra herds were observed to be most active throughout the daytime during the wet season. During the dry season, they become more active early in the morning between 0730 and 1000 hr and in the late afternoon between 1500 and 1830 hr. Burchell's zebra usually prefer open space on the top of hills as their night bedding site. This makes it difficult for any predators to approach without being seen by alert guard. They also prefer

night bedding grounds near villages (settlement) close to livestock homesteads during the night. This may also be protection strategy against predators. Most of their predators are nocturnal carnivores.

There is a tendency for communication to be most complex on Burchell's zebra, which live in large group with complex intraspecific interactions (Delany and Happold, 1979). The intensity and frequency of communication between individuals vary according to the moment situations. Some degree of communication occurs all the time but it increases and becomes more obvious during sexual display, in the presence of danger and in disputes conspicifics as described by Estes (1997). Agonistic behaviour occurs when individuals compete for food, water and mates or defense of territory and young as stated by Estes (1997). Some of the agonistic behaviour displayed during the study period on Burchell's zebra was attack, pursuit, fighting in contact, threat, escape and submission. Submissive traits are a defense display, common for all Burchell's zebra during sexual attempts and presence of danger as anti-predator behaviour. It was most frequently observed on the subordinate adult stallions, lower ranked mares and subadults. Fighting happens when bachelor stallion abduct an oestrous filly. Fighting between stallions over oestrous fillies was relatively unritualized and causes the risk of serious injuries as described by Klingel (1969b) and Estes (1997).

The present study showed that Burchell's zebra associate with a few plain ungulates and domestic livestock. These are Grant's gazelle, Swayne's hartebeest, Greater kudu, cattle and Goat. Burchell's zebra associate with Grant's gazelle more than any other wild herbivores as described by Kirubel Tesfaye (1985). This interaction probably explains that the two species are not ecologically competitors and show different feeding strategies. Zebras feed on taller

grasses but Grant's gazelle feed on shorter grasses (5 - 10 cm) and dicotyledonous herbs, which are not consumed by Burchell's zebra as explained by Delany and Happold (1979). The other plain ungulate that aggregates with Burchell's zebra is Swayne's hartebeest. Both are grassland grazers in wet and dry seasons. An indication of differences in feeding habits of these two species has been observed during the study. The Swayne's hartebeest feed on short grasses of 10-15 cm high with a large proportion of leaf and small proportion of stem seen in the Nechisar plains. But, the Burchell's zebra feed upon tall grasses, mainly stem and leaf, all over the Nechisar plains (Vesey-Fitzgerold, 1965). Also few Swayne's hartebeests gain dilution effect of predation when associated with large herds of Burchell's zebra. The domination of ecological competitor (cattle) in the Burchell's zebra range was disastrous to the plain area. Bolton (1970) and Kirubel Tesfaye (1985) have pointed out that overgrazing severely deteriorated the Nechisar open grassy plain area and enhanced outburst of tick invasion during the dry season.

6.2 Human impact

In the Nechisar plains, Kirubel Tesfaye (1985) counted 1,689 heads of cattle and 188 herdsmen. Solomon Eshete (1996) observed 190 households comprising 1330 people and projected the number of cattle as 3,534. The number of cattle doubled within ten years (1985 – 1995). The present study shows that the number of cattle in the Nechisar plains has about tripled within 5 years (1996 - 2001). The Guji Oromo people are traditionally nomadic pastoral-tribes. This is reflected by the distribution of their villages in eight different areas of Nechisar grassland to exploit the plains for grazing. The present study indicates that there is a great increase in human and livestock population. The overgrazing and settlement encroachment are considered primary factors that affect directly and indirectly the population

status of Burchell's zebra, by deteriorating the grass quality of Nechisar plains. Moreover, this enhances trampling and bush encroachment in the Nechisar open grassy plain (Bolton, 1970; Duckworth *et al.,* 1992).

Bolton (1969) reported that wild ungulates in the plains suffer more from disturbance by human and domestic animals. Duckworth *et al.*(1992) and Schloeder (1996) noted that expansion of settlement and human activities in the Nechisar plains cause great disturbance to wild animals. The Guji Oromo people harvest various types of natural resources from the Nechisar plains. The present study shows that grass is the most important resource used for grazing and thatching for hut cover. Wood is collected for fuel and construction. This resource consumption directly influences the population status of Burchell's zebra by reducing the grazing land and destructing vegetation cover. The main road from Arbaminch to Amaro special district, Derbamenana passes through Nechisar central plain. Several foot passers and vehicles on daily basis use this. This interrupts the movement of Burchell's zebra from Nechisar plains to River Sermale during the dry season. In addition illegal fishermen, wild honey collectors and herdsmen take their livestock to the salt lick sites every day. These human activities indirectly influence the Burchell's zebra population as explained by Bolton (1969).

Discussion with local people and physical vegetation damage assessment has revealed that five main factors degrade the Nechisar plain grass quality. These are recent bush encroachment, forest fire, trampling, livestock fence, and flood catchments construction. One of the causes of recent bush encroachment and habitat destruction is the rapidly increasing livestock herds belonging to Guji Oromo pastoral tribes. Present study showed

the extent of grasslands that support grazing of wild and domestic herbivores was reduced to 33.6% since the last thirty year. Recent bush encroachment has expanded by deliberately planting trees by the local people around their settlement for shade, flood catchments and livestock fence. The cause of habitat destruction is due to the expansion of settlements and the overgrazing of livestock in most parts of Nechisar plain. Bolton (1970) has reported farming activity. This activity is being continued on a large scale. Shifting cultivation is also leading to removal of vegetation cover along the Sermale River. Cultivation of crops takes up the dry season grazing area of livestock and wetlands reducing areas available for grazing activities. This causes grazing pressure, resulting in frequent burning by pastoralists partly to secure new forage for livestock and removal of tall dry grasses.

The negative attitude of the Guji Oromo people towards wildlife conservation may have emanated from fear of displacement from their indigenous habitat for the interest of wildlife conservation. The communities that live in Nechisar plains already use all products of natural resources, except killing wildlife. The local people claim that they have the right to utilize natural resources in their localities as long as they are nomadic pastoralists. The previous military government used force to evictee local people from the Nechisar plains. Hence, the local people have developed the fear and mistrust of conservation practices in the locality. Most of the local people agree to leave the Nechisar plains if government improves their socio-economic standards. But they strongly oppose further displacement and exclusion from the resources. During the study period, some respondents mentioned that algal bloom in Lake Chamo and possession of automatic firearms might account for some poisoning and direct killing of the species. Further, the highest number of skulls was collected around Lack Chamo. However, Tamirat Haleness (1989) in his short review of the death of Burchell's

zebra at Nechisar National Park stated that there was no sign of diseases and algal bloom poisoning in Lake Chamo.

Guji Oromo pastoralists know the Burchell's zebra by its local name "Hare-Dida" (= Wild donkey). The Burchell's zebra play an important role in the culture of Guji Oromo nomadic pastoralists. If the Burchell's zebra aggregate in the central plain, bark at night it is considered as a sign of rain. Then they begin to move their livestock to Nechisar open grassy plain. If the Burchell's zebra move to the surrounding bushlands and remain silent, it is considered as a sign of drought. Then they begin to move to Sermale River Valley. Larger predators around Nechisar plains hunt the Burchell's zebra rather than their livestock. This is also an additional advantage to the community.

They culturally consider them as pack animals. Because of this belief, most local people show benign neglect to the population conservation. The other two ethnic groups that live around the park Gantha (Gammo) and Kore (Koyra) never touch their droppings. In contrast, Klingel (1969b) and Kingdon (1979) have reported that the Karamoja, Uganda women paint themselves with black and white stripes in their dances and the Wanyatura regarded them as the supreme symbol of beauty and fruitfulness. Duncan (1992) noted that in Kenya effort was made to domesticate and harness to use as a transport animals before the arrival of motorcars. In the present study period, most respondents confirmed that Konso people, south of the Nechisar plains, poach them for meat during the dry season when they disperse. The Gumayde Menz people use their skin to decorate and make house furniture. Petersen and Casebeer (1972), Duncan (1992) and IUCN (2000) reported that Burchell's zebras are poached in some African countries such as Kenya, Uganda, Rwanda, Sudan and Zambia.

7. CONSERVATION IMPLICATIONS

The classical approach to wildlife conservation is characterized by a top-down approach that includes the establishment and expansion of protected areas, enforcement of wildlife legislation and the assumption of ownership of wildlife resources by the state. These approaches have ensured the survival of population of certain species and ecosystems, and contributed to the generation of foreign exchange earnings. But, they have slowed down the integration of local people into resource management and decision making activities. The management of protected areas in developing countries often entails huge social and ecological costs. Thus, the general social consensus leading to the designation of certain areas as national parks, reserves and sanctuaries was not and is not, universally shared by the communities. Local communities due to overpopulation are faced with diminishing natural resource base. Conflicts between local communities and conservation authorities have escalated, and law enforcement has become less practical and more costly. As human population escalates, demands on remaining resources also increased leading to environmental degradation and further conflict.

In the Nechisar plains, before it is declared as a national park, there existed scattered temporary dwellings of a few nomadic Guji Oromo pastoral tribes with several herds of cattle. However, the population was very low. The wild ungulates probably suffered more from disturbances by man and domestic animals rather than by direct competition for grazing (Blower, 1967, Bolton, 1970). The Nechisar National Park was established in 1974. Since 1975 human impacts such as overgrazing by the Guji, settled cultivation by the Kore and Gantha ethnic groups together with rampant poaching have been severe. On several

occasions, local communities have been expelled from their settlement without adequate provision for alternative means of survival. In some cases, local people have faced restrictions in their use of natural resources. National parks established on indigenous lands have denied local rights to the resources. To some extent this was responsible for this change in the attitudes of local people from hunters and cultivators to poachers and squatters (Anderson and Grove, 1987; Colchester, 1997; Ghimire and Pimberty, 1997).

In 1980, attempt was made to forcefully remove the settlers from the Nechisar plains and left them idle. Just after the overthrow of the military government in 1991, a power vacuum was created in the country for a short period of time. During this time, the local people who lived adjacent to the park returned to the Nechisar plains, killed large number of wildlife especially the Burchell's zebra, and demolished the infrastructure of the NNP. Then the national park area was totally occupied by Guji Oromo nomadic pastoralists and the Kore begun cultivation around the Sermale Valley flood plains. As a result of these activities, the habitat was affected and the wildlife diminished. It was increasingly realized that without the cooperation of rural communities, wildlife conservation effort is doomed to failure. This was certainly true in some African countries where rural inhabitants often viewed wildlife conservation as a misguided venture that put wildlife protection before human needs (Anderson and Grove, 1987; Pimberty and pretty, 1997). The past few decades have witnessed the importance of traditional wildlife conservation and management practices. Until very recently, conservationists and policy makers paid little attention to the indigenous biodiversity management systems and did not accord them any credibility. Recent interest in indigenous resource management systems arose from the failure of many conservation projects and led to research for viable and sustainable alternatives to current models of resource uses.

Renewed interest is partly due to a renaissance in traditional value and institutions, both in developing and developed countries. However, most cultures and practices in the developing countries should emphasize responsibility and a vested interest in the community rather than on individuals (Zelealem Tefera, 2001). This has led to the emergence of other approaches in the management of biodiversity. The approach that has evolved is aimed to involve local communities in the process of resource management and decision-making through what is known as community based conservation (Western and Wright, 1994). The co-existence of people and nature, as a distinct form of protectionism is the central point of community based conservation (Western and Wright, 1994; Ghimire and Pimberty, 1997). Through intimate knowledge of their physical environment and wildlife, communities have devised techniques for sustainable management through harvesting, improving, protecting and regenerating natural resources. Law and regulations of wildlife conservation within the tradition of the society ensure the smooth functioning of the system by integrating the indigenous knowledge with scientific knowledge (Ostram, 1991).

From the socio-economic stand point of view, the government authority should justify nature preservation faced with ever increasing demand for pasture and agricultural land. Decentralization of resource management from the central authority to local communities is considered as the first step forward for a successful community based conservation program. The key element of such program is that local communities participate in natural resource planning and wildlife management and that they gain economically from resource utilization. It also promotes the legal and sustainable use of the wildlife and other natural resources. In Ethiopia, recently the management of most of the country's protected areas was transferred to Regional governments. The wildlife conservation policy of the Region is therefore built

around two basic principles. The first is protected areas must be economically productive and the second is that the surrounding communities must participate in management decisions and the distribution of benefits. The issue of conservation becomes more relevant to the local community around national parks (Graham, 1996).

The Nechisar National Park wildlife conservation management responsibility was given to the Southern Nations Nationalities and Peoples Regional Government. The Guji Oromo people inhabiting Nechisar plains are traditionally nomadic pastoralists. But adjacent Kore and Gantha people are two different communities with various cultures administrated by Gamo-Gofa zone under Southern Nations Nationalities and Peoples Regional Government. These different communities with internal conflict and divergent interests have often split along economic and ethnic lines. These local communities should get proper education in wildlife conservation methods in order to develop public interest and sympathy for Burchell's zebra population management in the Nechisar plains.

8. CONCLUSION

The current population density of Burchell's zebra was estimated to be $16\pm1.5/km^2$. The trends of Burchell's zebra population in the Nechisar plains have been so irregular that specific conclusion might not be possible. However, the underlying trend is that the Burchell's zebra population has declined rapidly in much of its former range since 1992 as indicated earlier (Brown, 1967; Bolton, 1970; Kirubel Tesfaye, 1985; EWCO, 1995). The current population size of Burchell's zebra is estimated to be 4482 individuals. Comparing with the previous population estimates, this number is not very high. The local people suggested that Burchell's zebra populations have been increasing. The relatively high

percentage of breeding females and high proportion of young showed that current Burchell's zebra population might be recovering. This might be as a result of less poaching by the local people since scouts patrol in the Nechisar National Park.

This study showed that seasonal variation in the quality and abundance of forage affects the habitat preference of Burchell's zebra. There was a marked preference for Nechisar open grassy plain during the wet season and Hare hill plateau bushland during the dry season. It was observed that grasses comprised the main diet during both wet and dry seasons. As a result of rainfall, seasonality in the Nechisar plains green flushes and surface water supplies vary considerably both in distribution and abundance of the population of Burchell's zebra.

In this study, it was observed that during the wet seasons the resources are abundant throughout the range, thus the Burchell's zebra population disperse to central Nechisar open grassy plains. Kirubel Tesfaye (1985) has reported the same trend. However, during the dry season, the required resources are isolated and restricted largely to ephemeral wet grazing areas along watercourses and surrounding bushlands. The Burchell's zebra populations build up on such areas as Hare hill plateau bushland, Kilisa plain and Gatira plain during the dry season. Their local distribution ranges was limited inside the NNP during the wet and expand outside the park during the dry seasons. The expanding human settlements and the seasonal grazing pattern of livestock probably displaced the Burchell's zebra population from these dry season refuge habitats. These two populations showed a degree of overlapping distributions during the wet season.

The population structure and group composition of the Burchell's zebra population were adult female biased. The high proportion of immature individuals and an increased

percentage of potential breeding females are determinants of population growth. Seasonal changes in the group size are also found in other species, usually during migration or seasonal concentrations on localized food resources. The Burchell's zebra herd sizes and compositions seem to be consistent with both food dispersal (Jarman, 1974) and anti-predator (Harvey and Greenwood, 1978; Delany and Happold, 1979) hypotheses. Conversely, during the dry season, the Burchell's zebra herd sizes had fewer individuals in each social group. The one male harem with more members seemed to have high bondage and stable family group. But bachelor stallion herds with fewer members seemed to have less bondage and less stable social group.

The Burchell's zebra give single birth per year in wet season but a peak birth rate recorded in April, which coincides with the highest rainfall. Low reproductive rate due to delayed age at first breeding (5 - 6 years in males), small litter size and long gestation period were compensated by polygamous reproductive behaviour, polyestrous within monthly intervals and a weekly post-partrum estrous were factors for increase in population. The main factor that causes death to Burchell's zebra in the Nechisar plains was predation and old age. The two main predators of Burchell's zebra are lion and spotted hyena. Burchell's zebra are diurnal herbivores with active periods ranging from 0600 to 2000 hr. Occasionally, few individuals were observed while feeding before midnight during the dry season. In the Nechisar plain, Burchell's zebra showed a tendency of association with a few diurnal plain ungulates. The domination of ecologically competitor cattle in the Burchell's zebra range was disastrous to the plain area and the livestock number should be reduced to overcome this problem.

The local people claim that they have the right to utilize the natural resources in their localities as long as they are nomadic pastoralists. The present study showed that there is an increase in human and livestock populations in the area. Overgrazing and trampling enhances habitat destruction and bush encroachment. Human disturbance in the Nechisar plains has also limited the movements of Burchell's zebra. The negative attitude of the local people towards wildlife conservation may have resulted from fear of displacement from their indigenous habitat to the interest of wildlife conservation. However, most of the Guji Oromo people agree to leave the Nechisar plains if the government improves their socio-economic development. But they strongly opposed further displacement from the park area without proper conservation. Older people (> 30 years of age) suggest community based conservation implications while the educated people seek community participatory conservation strategy. The respondents participated in wildlife conservation workshop or seminars at the Kebele or NNP office. Also few elementary level educated persons have got job opportunity in the Nechisar National Park. They support wildlife conservation and they have positive attitude towards wildlife conservation.

All concerned institutions at the local, regional and federal levels should participate in conservation programs. Private investors, NGOs and religious organizations also have important contributions to make in the conservation efforts and in improving the socio-economic status of the local people. Educating the local people to develop community based wildlife conservation by integrating indigenous traditional knowledge with the modern strategy is a must. This may also generate income. The local people who have settled around the park should participate in the management decisions and accrue the benefit.

9. RECOMMENDATIONS

The population of Burchell's zebra in Nechisar plains and its surrounding Gatira plain is the only viable population of this species in Ethiopia. The present population census has shown that there is an increase in the population size of these plain ungulates. At the same time, the present study has also indicated that the Burchell's zebra population is at risk due to settlement encroachments in to their habitat and these human related disturbances. As a result, fragmentation and degradation are the important factors that limit distribution and movement this species. Therefore, effective regular monitoring should be conducted to reduce these adverse effects.

Additional comprehensive study should be carried out to identify the limiting factors and to determine evidences of exogenous processes regulating the Burchell's zebra population. Assessment of niche overlap between the Burchell's zebra and the larger plain herbivores and domestic livestock in the Nechisar plains would help to understand the intensity of competition for resources. The population status and ecology of the two main predators of Burchell's zebra, lion (*Panthera leo*) and spotted hyena (*Crocuta crocuta*) should be carried out in detail. Furthermore, ecto-parasite (tick) and water poison (algal bloom toxin) problems associated with the death of Burchell's zebra should be studied in detail.

The continued existence of Burchell's zebra in its natural range depends upon effective protection and proper management of the Nechisar National Park. Implementation of rural development should be designed to move local people to the buffer zone so as to reduce the human activities in the Nechisar plains. Buffer zones should be established to reduce the movement of Burchell's zebra outside a protected area in the south direction by planting

indigenous trees, which are useful to local community for fuelwood and for construction purposes. The need of the local people for fire wood and construction should best be supplied by growing trees that is integrated into local multiple land use practices such as agroforestry.

Action should be taken to increase the area of land available to Burchell's zebra. The Nechisar National Park boundary should be expanded to the south to include the potential ranges of Burchell's zebra population. The main track built through Nechisar central plain to Derbamenana is totally against the future survival of Burchell's zebra and should be discouraged. The local people should protect the use of automatic firearms to stop opportunistic poaching and direct shooting of wildlife.

The future of the Burchell's zebra and the critically endangered Swayne's hartebeest in the Nechisar plain depends primarily on the reduction of recent bush encroachment. Action to retard wood regeneration using controlled fire management should be implemented in parts of Nechisar plain. A controlled fire management system based on Burchell's zebra range should be imposed in order to control ecto-parasite (tick) population and suppress bush encroachment.

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 Burchell's zebra conservation forms part of a multiple land-use system. The local people should develop their awareness on conservation, so that they appreciate the benefits of nature conservation. It is important to integrate the useful indigenous knowledge and modern conservation systems to develop a deeper understanding of the species and their ecosystems.

Such participatory activities on the population management of Burchell's zebra should be integrated with minimal provision of the socio-economic incentives, where development and poverty alleviation activities could be related to wildlife conservation. Local communities should be encouraged to focus on conservation issues through the support of community-initiated projects. Finally, community based conservation should be encouraged in order to maintain the Burchell's zebra population in the Nechisar plains.

10. APPLICATION OF THE OUTPUT

The present study has result of the current population status and human impacts on the Burchell's zebra population in Nechisar plains. Effective conservation of local biological resources that occurs in human dominated landscapes could only be achieved through the implementation of such field based data. The result would help the local community and wildlife authority to plan a meaningful conservation management and protective measures for Burchell's zebra population and its ecosystem.

The relations between the Burchell's zebra population and the pastoralists have been stressed and the need to involve the community on the issues of conservation has been focused. If the local people are better informed about the aesthetic, educational and economic values of Burchell's zebra, conservation measures would easily form part of the multiple land-use system in the area.

The present study provides recent relevant information of the current population status and human pressure threatening the survival of the species to EWCO and its counterpart NNP. It will enable to put foreword community based conservation that integrates local needs and

resolve conflicts by developing local people participation. Such participatory activities on the population management of Burchell's zebra should be integrated with minimal provision of the socio-economic incentives, where development and poverty alleviation activities could be related to wildlife conservation.

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APPENDICES

Appendix I. The estimated national population size and trend of Burchell's zebra in Africa.

No.	Country	Grant's zebra (*E.b.boehmi*)		Upper Zambezi zebra (*E.b.Zambeziensis*)		Crawshay's zebra (*E.b. Crawshayi*)		Chapman's zebra (*E.b. Chapmani*)		Damara zebra (*E.b.antiquorum*)		sum	
		Popn.	T	Popn.	T	Popn.	T	Popn.	T	Popn.	T	Popn.	T
1	Sudan	?	?	-	-	-	-	-	-	-	-	?	?
	Ethiopia	6000	I	-	-	-	-	-	-	-		6000	I
3	Somalia	?	?	-	-	-	-	-	-	-	-	?	?
4	Uganda	3,280	D	-	-	-	-	-	-	-	-	3,280	D
5	Kenya	146,030	S	-	-	-	-	-	-	-	-	146,030	S
6	Rwanda	< 1,000	D	-	-	-	-	-	-	-	-	<1,000	D
7	Tanzania	335,780	D	-	-	-	-	-	-	-	-	335,470	D
8	Angola	-	-	?	?	-	-	-	-	-	-	?	?
9	Zambia	-	-	18,220	D	20,900	D	-	-	-	-	39,470	D
10	Congo-Zaire	-	-	< 1,000	D	-	-	-	-		-	<1,000	D
11	Malawi	-	-	-	-	670	S	-	-	-	-	670	S
12	Mozambique	-	-	-	-	?	?	65	D	-	-	65	D
13	Namibia	-	-	-	-	-	-	-	-	9,300	D	9,300	D
14	Botswana	-	-	-	-	-	-	-	-	34,300	D	34,300	D
15	Zimbabwe	-	-	-	-	-	-	20,135	S	-	-	20,135	S
16	South Africa	-	-	-	-	-	-	-	-	>48,500	I	>48,500	I
17	Swaziland	-	-	-	-	-	-	-	-	1,000	S	1000	S
Total		>492,000	S	>19,000	D	>21,500	D	20,200	S	>93,100	?	>643,000	S

I: increasing, D: decreasing, Popun. : population, S: stable, T: trend, and ? : unknown

(**Source**: IUCN, 2000)

Appendix II. Vegetation types found in the Nechisar plains

Tree species

Acacia brevispica
Acacia mellifera
Acacia nilotica
Acacia senegal
Acacia seyal
Acacia tortilis
Balanites aegyptica
Balanites rotundifolia
Combretum spp
Cadaba farinose
Dracaena sp
Dichrostachys cinea
Grewia spp.
Maytenus senegalensis
Rhus natalensis

Woody shrubs

Saccharum spontaneum
Commiphora sp.
Dodonoea angustifolia
Euphorbia sp.
Euphorbia tirucalli
Juncus sp.
Kalanchoe sp.

Herbs

Ageratum conyzoides
Cynodon plectostachyus
Dobera glabra
Justica flava

Grass species

Bothryochloa radicans
Cenchrus ciliaris
Chloris roxburghiana
Chrysopogon aucheri
Chrysopogon sp.
Heteropogon controtus
Ischaemum afrum
Lintonia nutans
Loudentia phragmitoides
Setaria sphacelata
Themeda traindra

Appendix III. A checklist of some identified wild mammalian species of Nechisar NP.

Order	Family	Scientific name	Common name
1. Perissodactyla	Equidae	*Equus burchelli*	Burchell's zebra*
2. Artiodactyla	Bovidae	*Tragelaphus strepsiceros*	Greater kudu*
		Kabuselli psiphymnus defessa	Waterbuck
		Rudunca rudunca	Bohor Reed buck
		Rudunca fuvorufla	Mountain Reed buck
		Alecelaphus buselaphus swaynei	Swayne's hartebeest*
		Gazella granti	Grant's gazelle*
		Ourebia ourebi	Oribi
		Oreotragus oreotragus	Klipspringer*
		Madaqua guentheri	Guenther's Dikdik*
		Sylvicapra grimmia	Duiker*
	Hippopotamidae	*Hippopotamus amphibious*	Hippopotamus*
	Suidae	*Phacochoerus africanus*	Warthog*
		Potamochoerus larvatus	Bush pig*
3. Carnivora	Canidae	*Octocyon megalotis*	Bat eared fox*
		Canis mesomelas	Black backed jackal*
		Canis aureus	Golden jackal
		Canis adustus	Side striped jackal
		Lycaon pictus	Hunting dog
		Canis domesticus	Feral dog
	Mustelidae	*Cotoryx striatus*	Zorila
		Mellivora capensis	*Ratel*
	Vivredae	*Viverra cilletta*	Africa civet
		Genetta genetta	Common genet*
		Genetta rubiginusa	Large spotted genet
		Genetta maculata	Rusty spotted genet
		Helogale parula	Dwarf mongoose*
		Herpestes ichneumon	Egyptian mongoose

		Herpestes sanfuineus	Long tailed mongoose
		Ichneumia albicauda	White tailed mongoose*
		Mungus mungo	Banded mongoose
	Felidae	*Acinonyx jubatus*	Cheetah
		Panthera pardus	Leopard*
		Panthera leo	Lion*
		Felis silvestris	Wild cat*
		Felis serval	Serval cat
		Felis caracal	Caracal
	Hyaenidae	*Gocuta crocuta*	Spotted hyaena*
4. Hyracoidea	Procavidae	*Procavia capensis*	Rock hyrax*
		Heterohyrax brucei	Yellow-spotted hyrax
5. Tubulidentata	Orycteropodidae	*Orycteropus afer*	Aardvark*
6. Lagomorpha	Leporidae	*Lepus habessinicus*	Abyssinian hare*
7. Rodentia	Hystricidae	*Hystrix cristata*	Crested procupine*
	Sciuridae	*Xerus erythrophus*	Striped ground squirrel*
		Helio sciurus	Gambian sun squirrel
		Xerus rufilus	Unstripped ground squirrel*
8. Insectivora	Soricidae	*Crocidura bicolor*	Shrew
	Macroscelidae	*Elephantulus rufescens*	Elephant shrew
9. Primate	Cercopithecus	*Galago senegalensis*	Bush baby
		Cercopithecus aethiops	Grivet monkey*
		Cercopithecus pygerythrus	Vervet monkey*
		Colobus gureza	Colobus monkey*
		Papio anubis	Anubis baboon *

*: Mammal species observed during the study period.

Source: Kirubel Tesfaye, 1985; Duckworth *et al.*, 1992

Appendix IV. Line transect data sheet of Burchell's zebra population census

Name of the data Collector_____ Survey site_____ Date_____

Line transect direction__ Line transect no. ___ Line transect length (km)_____
Altitude _____ Temperature_____ Season _____ Weather condition_____
Start time_____ End time _____ Location _____

No. of Observ.	Sight Distance and angle		Sex & Age categories						Total	Animal activities	Habitat type	Other mammal species	Remark
	r_i(m)	θ_i	AM	AF	AU	SA	Juv.	Fo.					
Total													

r_i: sight distance AM: Adult male SA: Subadult Fo: Foal
θ_i: sight angle AF: Adult female Juv: juvenile

Appendix V. Daily activity pattern recording sheet of Burchell's zebra

Name of the data Collector _____ Date _____
Survey site _____ Season _____ Altitude _____Temperature_____
Weather condition _____ Habitat type _____ Vegetation type _____
Group size _____ Social organization _____ Social composition _____
Number of dropping per animal per time _____ start time _____ End time ____

Time (min.)	Feeding habit a) grazing b) browsing c) drinking	Movement a) walking b) running	Resting sleeping	Social behaviour for five minute grooming communication fighting defense	Reproductive behaviour/5 min. rutting sniffing mating pregnancy	Remark

Appendix VI. Post-mortem data sheet for Burchell's zebra

Collector's name _____ Date ___ Survey site_____ Transect No ___

Whether _____ Altitude _____ Temperature_____ Time_____

The dead animal or carcass (skull, bone, teeth, others) observed

Items observed_____

Age categories _____

Sex categories _____

Estimated age since death_____

Reason for death: 1. Parasites_____

2. Poached _____

3. Predator _____

4. Disease _____

5. Starvation _____

6. Old age _____

7. Other reason_____

8. Juvenile or foal lost during the next observation time from social identified herds (one-male harem): _____

Appendix VII. Sex characteristics and age estimate used for field identification

Categories	Sex and age characteristics
Adult males	Full-grown animals. Estimated age was more than 30 months. Inter-femoral's hairless, stripe narrow and black. Testes are often visible. Abdominal curvature is less pronounced than in females. Circumference of nose is greater than in females.
Adult females	Full- grown animals. Their age was estimated more than 30 months. Inter-femoral's hairless, stripe black and broad. Abdominal curvature is more convex than in males'; circumference of nose is smaller than in males.
Subadults	Animals not full have grown, but larger than juveniles. Sexually immature. Fuzzy brown "foal hair" is absent. Their age was estimated from 18-30 months.
Juveniles	A weaned young mammal that still associated with its mother, may nurse infrequently. They are usually smaller than a subadult and larger than foals. Less conspicuous fuzzy brown "foal hair". Their age was estimated from 1-18 months.
Foals	A newborn offspring. Fuzzy "brown hair" more conspicuous. Frequently nursing and associated with its mother. Their age was estimated as less than one month.

Appendix VIII. Individual interviews

1. Introductory questions

1.1 Survey site _____ 1.2 Village _____ 1.3 Sex _____

1.4 Age _____ 1.5 Marital status_____ 1.6 Family size _____

1.7 Education level _____

1.8 Duration of Residence_____

1.9 The effect during and after previous government change over_____

2. Household economy

2.1 Do you have livestock?

2.2 How many heads of cattle?

2.3 How many goats?

2.4 The number of fences of cattle?

2.5 How many flood catchments (dams) do you use?

2.6 How many livestock did you buy or sell during the previous years?

2.7 How is the Burchell's zebra (Hare-Dida) population status and conservation?

2.8 The wildlife species that you know in the Nechisar Plains, could you identify their name?

2.9 Is there an increase, decrease or as is in the population of wildlife in the plains? Give reasons.

2.10 Do you see wildlife problems? If yes, what are the problems?

2.11 Do you support wildlife conservation? If yes/no, why?

2.12 Is the number of Burchell's zebra (Hare-Dida) in the Nechisar plains increasing or decreasing? If decreasing/Increasing, Why?

2.13 Is the Burchell's zebra (Hare-Dida) useful or harmful species? If useful/harmful species, Why?

2.14 Do you know local names of Burchell's zebra (Hare-Dida) used in different ethnic groups? Enumerate?

2.15 What do you think the main cause of death in zebra (Hare-Dida)?

2.16 Do you support the conservation of Burchell's zebra (Hare-Dida)?

Thank you!