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Full Length Research Paper

Distribution, abundance and population status of Burchell's zebra (*Equus quagga*) in Yabello Wildlife Sanctuary, Southern Ethiopia

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A study on the distribution, abundance and population status of Burchell's zebra (*Equus quagga,* Gray 1824) was carried out in the Yabello Wildlife Sanctuary, Southern Ethiopia from October, 2009 to March, 2010 including wet and dry seasons. Distance sampling line-transect counting method was used to estimate the population status. A total of 5151 individuals were estimated with a population density of 6.5 km^2. The population was female biased. The sex ratio of adult male to adult female was 1.0:1.27 and adult to young ratio was 2.9:0.6. Age composition of Burchell's zebra comprised 78.2% adult, 13.0% sub-adult, 5.3% juvenile and 3.5% foal. Group size changed seasonally and the mean group size was 12.5. The average herd sizes of one male harem and bachelor stallion herds were 7.8 and 5.3, respectively. Distribution and vegetation utilization of the animal showed a marked preference for open grassland habitat. However, there was a seasonal change in the preference of habitat. Increase in human and livestock population was observed in the study area. Overgrazing by cattle and encroachment are the primary factors that affect the population status of Burchell's zebra by reducing the grass quality in the Sanctuary. The study recommends an effective and realistic management policy to control illegal human settlement and encroachment in the sanctuary.

Key words: Abundance, distribution, *Equus quagga,* Oromia, population size, Yabello sanctuary.

INTRODUCTION

Burchell's zebra (*Equus quagga*) is the only equid that is still wide spread, and it is one of the most abundant ungulates in Africa (Cumming, 1982). The species is a useful model for the conservation and management of other equids, some of which were similarly abundant and widespread in historical times (e.g. Mountain zebra (*Equus zebra*), Grevy's zebra (*Equus grevyi*) and African wildass (*Equus africanus*).

An understanding of the economic and ecological factors that contribute to maintaining the abundance and genetic diversity of this species will help to improve the status of the other equids. Three of the four indigenous African equids are rare or restricted in distribution, while Burchell's zebra rivals the horse as the most successful member of the family (Estes, 1997). At present, their distribution spans is across the Somali-Masai arid zone through the southern savannah and marginally in the southwest arid zone, from south eastern Sudan to South Africa and Angola (Duncan, 1992b; Estes, 1997). In Ethiopia, major populations of Burchell's zebra occur in Omo, Mago and Nechisar National Parks, as well as in Yabello Wildlife Sanctuary (Bolton, 1973; EWCO, 1995; Kirubel, 1985).

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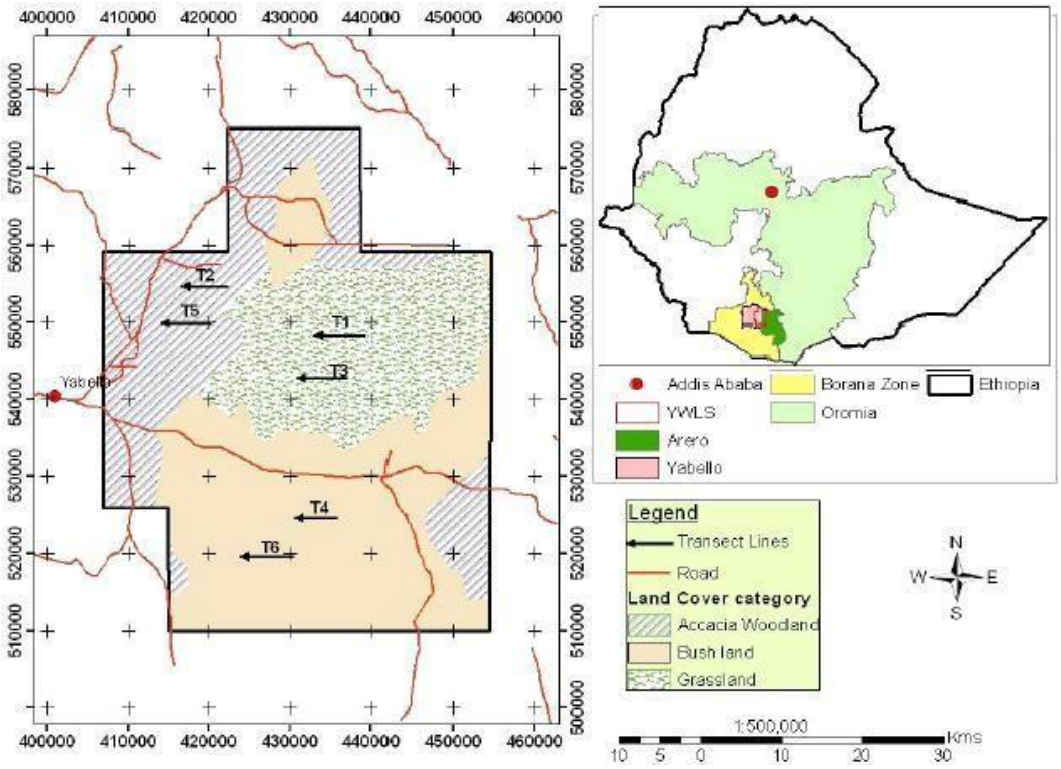

Figure 1. Map of Yabello Wildlife Sanctuary showing the transects (1-6). Inset: the map of Ethiopia showing the location of YWLS. YWLS = Yabello Wildlife Sanctuary.

The knowledge of distribution of animals in relation to their environment is essential for effective game management and range utilization control. Because habitat destruction due to overgrazing could reduce the fertility and growth rate of animals (Laws and Parker, 1968), the knowledge of distribution of animals in the habitat is of crucial importance in population control and habitat management. The major physical factors affecting the distribution of animals in any habitat are the availability of water, effect of fire, topography, temperature variability and relative humidity (Odum, 1971). In areas where artificial permanent waters such as dams and bore holes have been established, the distribution of ungulates that require water for drinking and wallowing is directly influenced by their presence (Field, 1970). Thus, water becomes an important ecological factor affecting the distribution of animals in such areas. The objective of the present study is to provide information on distribution, abundance and population status of Burchell's zebra in Yabello Wildlife Sanctuary.

MATERIALS AND METHODS

The study area

The present study was carried out in Yabello Wildlife Sanctuary which is located in the Borena Zone of the established in 1979 E.C. with an area of 2496 km^2 for conservation of endemic and other birds as well as mammals, which are found in the sanctuary. The sanctuary lies between the meridian 4°37'-5°12'N and 38° 09'-38°37'E (Figure 1). It has an approximate north-south dis-tance of 65 km and 48 km East-West with an average altitude between 1800 and 2000 m above sea level. The sanctuary is 17 km away from the nearby town Yabello and 565 km from Addis Ababa.

The physical features of the sanctuary are dominated by bush and range land. The climate of Borana rangeland is typical of the equatorial regions of East Africa, but is locally modified by altitude. The seasonal distribution of rainfall is almost entirely controlled by the annual north and south shifting of the Intertropical Convergence Zone that forms the northern boundary of the area of equatorial low pressure (Agroteck, 1974). The rain-fall regime in Borana dry lands is bimodal with two rainy seasons. The main rainy season, known as the long rainy season, is between March and May with the peak in April, and the short rainy season is between September and November, with peak in October. The mean annual rain fall for the period 2000-2009 was 612.36 mm. The peak mean monthly rainfall is in April (152.9 mm) and October (127.6 mm). The least mean monthly rainfall is in January (17.6 mm). The hottest months are from January to February and temperature fluctuates between 27.9 and 28.9°C. The weather remains pleasant between June and August. The mean annual maximum temperature is 28.9°C. The mean annual minimum temperature is 12.2°C.

The commonest habitat inside the Yabello Sanctuary is savanna woodland dominated by various species of thorny acacia (*Acacia tortilis, Acacia brevispica*, *Acacia horrida* and *Acacia drepanolobium*) and *Commiphora*, and broad leaved *Terminalia* and *Combretum* (Borghesio and Giannetti, 2005). In addition, small patches of*Juniperus procera* forest can also be found in high altitude just outside the boundaries of the sanctuary, although grazing and logging threaten its persistence (Borghesio et al., 2004).

Geologically, the area is dominated by quaternary deposits (40%), basement complex formation at bottomlands (38%), volcanic

(20%) and sedimentary deposits of 2% (Coppock, 1994). The soil is mainly red, ferruginous character in sloping areas with dark vertisols in the bottomland, while the upland soils occurring elsewhere are well drained and usually have equitable proportion of sand (53%), clay (30%) and silts (17%) (Haugen, 1992).

Burchell's zebra is found in the sanctuary with Grant's gazelle (*Nager granti*) and Gerenuk (*Litocranius walleri*). Yabello Wildlife Sanctuary is one of the best places in Ethiopia to see Besia oryx (*Oryx beisa*), Bohor reed-buck (*Redunca redunca*), bushpig (*Potamochoerus larvatus*), hare (Lepus fagani), Guenther's dik-dik (*Madoqua guenther*), Greater kudu (*Trageraphus strepsiceros*), Lesserkudu (*Tragelaphusimberbis*) and warthog (*Phacochoerus africanus*). Carnivores including lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), African wild dog (*Lycaon pictus*), golden jackal (*Canis aureus*), serval cat (*Leptailurus serval*), side striped jackal (*Canis adustus*), spotted hyena (*Crocuta crocuta*) and Anubis baboons (*Papio anubis*).

There are 280 species of birds recorded in the Sanctuary. The Ethiopian Bush-crow (*Zavattarions stresemanni*) and White-tailed swallow (*Hirundo megaensis*) are endemic. The other endemic bird is the Prince Ruspoli's Tauraco (*Tauraco ruspolii*), which is found in Borena zone around Arero Juniper forest (Bobela forest) to Dawa river. Ostrich (*Struthio camelus)* is also found in and out of the sanctuary.

Methods

Reconnaissance observations were made before data collection to provide information on accessibility, climate, vegetation cover, topography, infrastructure, fauna, distribution of Burchell's zebra and launching sampling plans. A research design was established based on these initial observations. The data were collected by dividing the study period into dry and wet seasons. Data collection was carried out from October to November 2009 and March 2010 to accommodate the wet season and from December 2009 to February 2010, to accommodate the dry seasons with fragmented short term stay in the study area. Seasonal differences in the population size, age categories of Burchell's zebra were compared. Separation of dry and wet seasons was based on the change of rainfall pattern and vegetation cover. Quantitative data were collected on the population size, age and sex categories, habitat preference and vegetation utilization, and distribution on the dry and wet seasons. A Line-transect census method was employed to assess the current population status of Burchell's zebra as adopted by Ratti et al. (1983), Brennan and Block (1996) for different mammals and Yisehak et al. (2007) for zebra. Line-transect sampling was designed based on six straight transect lines or a series of straight line segments (Anderson et al., 1979). Each of these transect-lines was 8 km long and located randomly in the study area using Global positioning system (GPS). Among these, two were in the open grassland habitat, two were in the bush land and two were in the *Acacia* woodland. Transects were placed according to stratified random sampling, in which transect placement was proportional to the area of this habitat type. Adjacent transects were at least 1500 m apart. All transects were roughly parallel to each other and their ends were not less than 1000 m far from the habitat edge.

Silent detection method was practiced to minimize disturbances (Wilson et al., 1996). During transect walking, the observers recorded the start and end time, start and end GPS location, and GPS ID. Whenever Burchell's zebras were encountered, the observer recorded the time, GPS location, group size, group spread, presence of other large mammal species in the vicinity, animal-observer distance, transect-animal distance or perpendicular distance (PD), and habitat type where the group was feeding. Censuses were conducted once per month on foot by the researcher and a well trained field assistant together with villagers who are familiar with the area (approximately 9 persons) were assigned to each of the transects for counting.

In the beginning of the study, the field assistant was trained to estimate animal -observer distance, and perpendicular distances. Surveys were conducted on transects starting from 06:00 to 12:00 h in the morning and from 14:00 to 18:00 h in the afternoon at an average speed of 1 km/h in the *Acacia* woodland and bush-land or 2 km/h in the grassland habitats. The starting and ending GPS co-ordinates of the transects were predetermined prior to starting of the census. On census days, transects were walked from east to west and walked so as to prevent the suns glare from distorting visibility. A GPS was used to walk along transects and the starting and ending coordinates were recorded in the GPS. The censuses were conducted for both seasons (wet and dry) in order to achieve representative estimate. Any change in the population size between the dry and wet seasons was noted. When an animal or a group was spotted the following estimation was made: D = ns/2LW, where D = estimated density of animals (or animal groups), n = number of animals (or animal groups) seen, s = mean group size, L = length of transect line(s) and W = mean perpendicular distance of animals (or groups) seen. The population size of Burchell's zebra was estimated by multiplying the population density (D) with total extent of habitat by the present study (A = 72 km^2), following the method of Buckland et al. (1993), Sutherland (1996) and Yisehak Doku et al. (2007).

N = D x A, where, N = total population size D = Population density (individual per km^2)
A = Total extent of habitat by the present study (in km^2).

Each of this individual in a group were identified and categorized into its respective age and sex categories during counting. The categories used were adult male, adult female, sub-adult, juvenile and foal. To categorize the animals into such groups, the works of Yisehak (2003), Lewis and Wilson (1979), Bowyer (1984), Ndhlovu and Balakrishnan (1991) Bergerud (1971) and Kingdon (1997) were followed. Identification of sex and age category were carried out in the field by using body size such as the relative size, external genitalia and furry-hair as adopted by Klingel and Klingel (1966). Sex ratios for the herds were obtained from direct count of the animals using the methods of Woolf and Harder (1979), Melton (1983) and Mumin (1999). Population trend of Burchell's zebra was also analyzed by comparing the present findings with the previous findings of different researchers in Yabello Wildlife Sanctuary.

Group composition and herd size were shown by using direct count and focal observation methods as used by Sutherland (2000) and Befekadu and Afework (2004) in the study of other animals. Repeated counting of the same herd or cluster was avoided using recognizable features such as cluster size, harem composition and distinct individuals with body deformities such as cut tail and ear (Wilson et al., 1996).

Following Lewis and Wilson (1979) and Borkowski and Furubayshi (1998) for the study of different animals, individuals were considered as members of the same group if the distance between them was less than 50 m. Single animals were included within the term 'group' for the purposes of analysis (Arcese et al., 1995). The method of Larson et al. (1978) and Norton-Griffiths (1978) was used to describe the dry and wet season distribution and the vegetation type utilization of the animal. By taking each group or individual sighting as scores with respect to habitat types and comparing their frequencies to the relative availability of vegetation type, it was possible to detect the utilization of vegetation type and the distribution of the zebra. Data were analyzed using SPSS soft ware version 17.0. Population estimate of Burchell's zebra during the wet and dry seasons was compared using t-test for independent sample (P = 0.05). Mann-Whitney U test was used to analyze age structure, sex ratio and group composition.

Table 1. Number of herds (ni), mean heard size (si) and individual Burchell's zebra counted (xi) in each sampled transects during the wet and dry seasons.

Transect	Number of Burchell's zebra observed								
	Wet season			Dry season			Mean		
	ni	si	xi	ni	si	xi	ni	si	xi
T1	14	8.0	112	14	9.1	127	14.0	8.6	120
T2	7	6.5	46	13	9.3	121	10.0	7.9	83
T3	12	7.1	85	9	8.5	77	10.5	7.8	81
T4	13	7.2	94	3	8.1	24	8.0	7.7	59
T5	2	5.5	11	12	9.1	109	7.0	7.3	60
T6	8	6.0	48	8	8.2	66	8.0	7.1	57
Total	**56**	**40.3**	**396**	**59**	**52.3**	**524**	**58**	**46.4**	**460**

ni = mean number of herds (zebra clusters observed) per transect, si = heard size(mean number of individuals per cluster)per transect , xi = sum of individuals counted per transect. T1 = transect one, T2 = transect two, T3 = transect three, T4 =transect four, T5 = transect five and T6 = transect six.

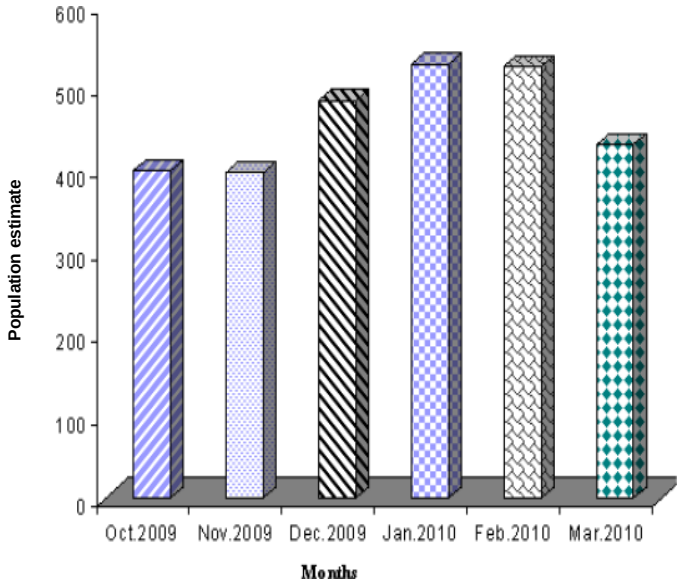

Figure 2. Monthly comparison of Burchell's zebra population estimate in Yabello Wildlife Sanctuary.

Table 2. Comparison of number of zebras transects counts between dry and wet seasons using t-test.

Transect	t-value	p-value
T1	15.93	0.03
T2	2.23	0.269
T3	20.24	0.031
T4	1.68	0.341
T5	1.22	0.436
T6	6.33	0.1

T1 = transect one, T2 = transect two, T3 = transect three, T4 = transect four, T5 = transect five, T6 = transect six.

RESULTS

The results of transect counts for each month for both wet and dry seasons are given in Table 1 and Figure 2. Among 115 total herds of Burchell's zebra observed in Yabello Wildlife Sanctuary, 56 herds were counted during the wet season and 59 herds were observed during the dry season. A total of 396 individual zebras were counted during the wet season and 524 individuals during the dry season. Counts during the dry season were significantly higher than counts during the wet season ($t = 15.212$, $P = 0.021$). The highest and the lowest count were in January and November, respectively. There was no significant variation ($t = 2.873$, $P = 0.287$) in the counts of some transects between the two seasons, but there was significant difference ($t = 18.085$, $P = 0.0031$) between transects number one and three (Table 2).

Although, the methods used by the previous workers was different from the present study, the past and present trend of population of Burchell's zebra shows irregularity based on conservation effort made during the phase (Table 3). In the present study, the average of dry and wet seasons transect count at the study area was 1536 and 1224, respectively. The population density of Burchell's zebra in Yabello Wildlife Sanctuary was 5.0 ± 2.4/km^2 during the dry season and 8 ± 2.1/km ^{2} during the wet season. The average mean population density of Burchell's zebras in Yabello Wildlife Sanctuary was estimated to be 6.5 ± 2.3 individuals/km^2 during the study period. The population size of Burchell's zebras were estimated to be 4570 and 5732 individuals during dry and wet seasons, respectively, with 95% confidence interval of 4048 - 5067 and 5030 - 5978 at 5 degree of freedom. The total population size estimate calculated from the mean population density estimate (D = 6.5 ± 2.2) was 5151 individuals with 95% confidence interval of 4539 - 5523 at 1 degree of freedom. The population structure

Table 3. Past and Present Population status of Burchell's zebra in Yabello Wildlife Sanctuary.

Year	Population size	Trend	Method	Source
1990	1290+/-180	Stable/increasing	Aerial samples	Thouless,1995
1995	2840	Stable	Aerial sample	Syvertsen,1992
2009- 2010	2760	Decreasing	Distance sampling	Present study

Table 4. Population structure of Burchell's zebra in Yabello Wildlife Sanctuary.

Month and year	Number of zebras		Sex and age categories					Ratio	
								Sex	Age
	ni	xi	AM	AF	SA	Juv	Fo	AM: AF	Ad:Yg
Oct.2009	55	398	132	164	58	28	16	1:1.24	1:0.34
Nov.2009	58	396	128	160	61	29	18	1:1.25	1:0.38
Dec. 2009	59	483	174	230	49	20	10	1:1.32	1:0.19
Jan. 2010	62	528	189	241	58	25	15	1:1.28	1:0.37
Feb.2010	60	525	178	220	70	31	26	1:1.24	1:0.32
Mar.2010	59	430	150	190	64	14	12	1:1.27	1:0.26
Average	**58**	**460**	**159**	**201**	**60**	**25**	**16**	**1:1.27**	**1:0.28**

ni = herds observed, xi = number of individuals , AM = adult male , AF = adult female ,SA = sub adult ,Juv = Juvenile , Fo = foal , Ad = adult (AM+ AF), Yg = young (SA + Juv+ Fo).

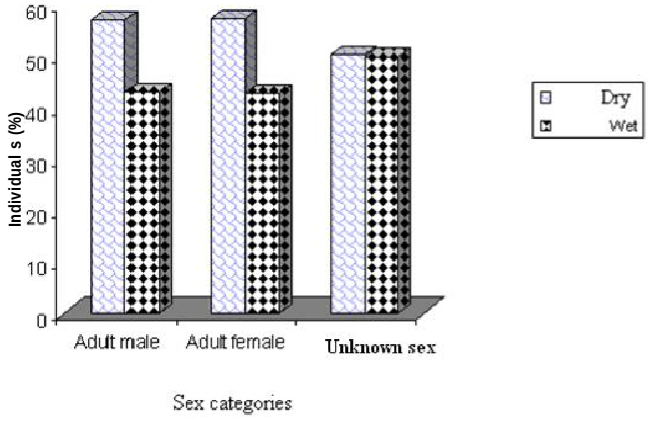

Figure 3. Percentages of sex categories of Burchell's zebras during the wet and dry seasons.

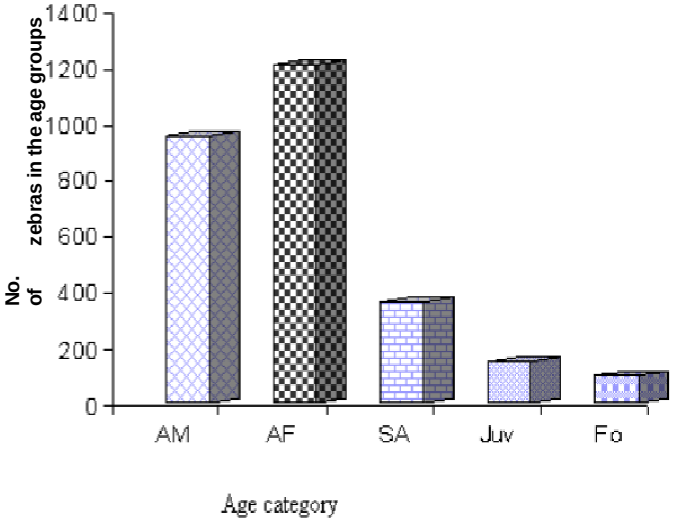

Figure 4. Number of Burchell's zebra in each age category.

and the proportion of various age-sex categories in the Yabello Wildlife Sanctuary are provided in Figures 3 and 4, respectively. Out of a total number of 2760 individuals observed during the present study period, 951 (34.5%) were adult male, 1205 (43.7%) were adult females, 360 (13.04%) were sub adult, 147 (5.3%) were juvenile and 97 (3.5%) were foals. The age ratio of adult to young was 1:0.25 and 1:0.32 during dry and wet seasons, respectively (Table 4). There was no significant difference in the age ratio observed during both seasons (Mann Whitney test, U' = 1236, P = 0.286). Averagely, 78.2% of the total population was adults and only 21.8% was young. Individual zebras encountered during the study period were grouped as adult male: 541 (56.9%) and 410 (43.1%), adult females: 691 (57.3%) and 514 (42.7%) and unknown sex: 304 (50.3%) and 300 (49.7%) during dry and wet seasons, respectively (Table 5 and Figure 3). The adult male to adult female sex ratio was 1:1.27 and 1:1.25, adult to unknown sex ratio was 1:0.25 and 1: 0.32 during dry and wet seasons, respectively. The age structure was also stable across periods with no significant variation in the proportions of adult and sub-adult, yearlings and foals (Mann Whitney test, U' = 1014, P = 0.758).

Table 5. Proportions of different age-sex categories of Burchell's zebra counted in dry and wet seasons.

Season	Sex and age structure ratio						
	Sex		Age			Sex Age	
	AM	AF	SA	Juv	Fo	AM:AF	Ad:Yg
Dry	541	691	77	76	51	1:1.27	1:0.25
Wet	410	514	83	71	46	1:1.25	1:0.32
Average	476	603	180	74	49	1.27	1:0.31

AM = Adult male, AF = adult female, SA = sub adult , Juv = juvenile, Fo = foal.

Table 6. Group composition of Burchell's zebra in Yabello Wildlife Sanctuary**.**

Month and year	Number of herds		Herd size, mean		Sex and age category of family				
	Stallion	Family	Stallion	Family	AM	AF	SA	Juv	Fo
Oct.2009	15	42	5.8	8.5	1.6	4.8	1.4	0.3	0.4
Nov.2009	17	33	5.5	8.2	1	5.1	1.5	0.4	0.2
Dec.2009	13	24	4	6.7	1.2	4	1.0	0.3	0.2
Jan.2010	18	27	4.5	8.6	1.5	5.2	1.3	0.4	0.2
Feb.2010	16	32	5.3	7.9	1.1	4.7	1.0	0.7	0.4
Mar. 2010	19	41	6.8	8	1.1	4.8	1.2	0.5	0.4
Average	16.3	33.5	5.3	7.8	1.2	4.7	1.2	0.4	0.3

AM = adult male, AF = adult female, SA = sub-adult, Juv =juvenile, Fo = foal.

The herds are composed of adult males, adult females, sub adults, juveniles and foals. Group sizes, composition and structure changed with the season. There was difference in grouping characteristics between groups containing juvenile and foals and those containing only stallions. Adults were consistently larger than young. Small groups containing 7 and 25 individuals were most common throughout the study period. The average number of wet season counts (1224) was grouped in 56 herds (groups) and the mean group size was 14.6. During dry season, the total count (1536) was grouped into 59 groups and the mean group size was 10.4. In October, November and March, up to 44 animals congregated in large groups. In December, January and February, they split up into smaller groups. The most frequently observed group size was 14 animals in the wet season and 7 ani-mals in the dry season. A herd of below seven was rare in the study area. The highest range of group size was recorded during the wet season with the mean group size of 14.6. However, the total number of groups observed during the wet season was minimal. While during the dry season, the total number of zebra groups observed was highest, but the range of group size was smallest with mean group size of 10.4. Large group sizes of zebras were aggregated during the wet season, while during the dry season, they split in smaller number of groups and distributed in a wider area during the wet season. Individual groups varied in size across the study area, with a modal group size of seven (Figure 5).

Mann-Whitney U test showed that there were significant differences in the group size across different sites (U' = 326, P = 0.012). The largest groups were observed in grassland and the smallest within woodland and bushland. Group size over the two seasons showed a significant difference (Mann Whitney test, U' = 4890, P = 0.03).

There are two types of social groups in Burchell's zebras including family groups (stallion, mares and their foals) and stallion groups (males only, including solitary males). Out of 299 total observations, 67.2% were family herds and 32.8% were stallion herds. Adult male to adult female ratio of the family herd was 1.2:4.7 and adults to young ratio were 2.9:0.6. Family groups include one to six mares with the stallion and foals making up to 14 members. Mean family size was 7.8. Group composition was dominated by mares 60%, stallion 15%, sub adults 15.7%, juvenile 5.5% and foals 3.8% (Table 6). Mann-Whitney U- test showed that the proportions of stallions, mares, sub adults, juvenile and foals differed significantly (U' = 1125, P = 0.0041).

Distribution

During dry season, 59 groups of Burchell's zebra comprising 1536 (57%) individuals were recorded in Yabello Wildlife Sanctuary. While in wet season, 56 groups comprising 1224 (43.3%) individuals were recorded (Figure 6). This indicates that Burchell's zebra tend to converge in areas with strategic and scarce resources such as water and pasture in the dry seasonwhile in the wet season these resources are well distributed in the range,

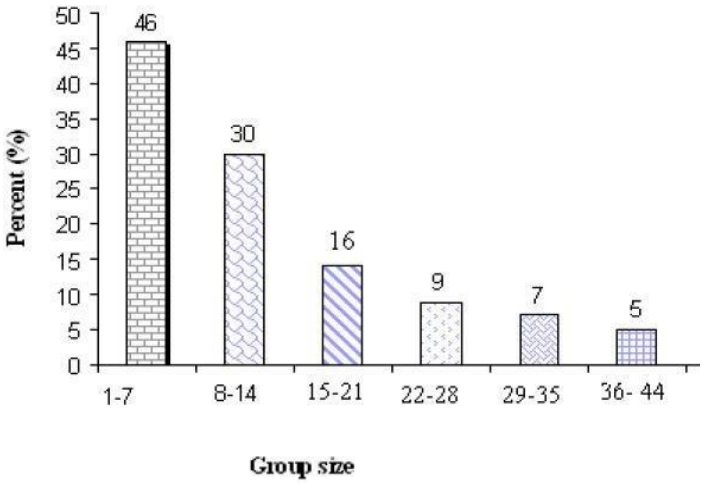

Figure 5. Percentage distribution of size of Burchell's zebra groups.

therefore zebras scatter over a large area, reducing their density.

Habitat preference and abundance

Out of the 56 groups of Burchell's zebra observed in the wet season, 39 groups (69.6 %) were in the grass-land, six groups (10.7%) were in the woodland and 11 groups (19.7%) were in the bush land. In the dry season, 22 groups (37.3%) were in grassland, 30 groups (50.8%) were in woodland and 7 groups (11.9%) were in the bushland habitats. Burchell's zebra preferred open grass-land habitats in wet season and woodland in dry season (Figure 7). Burchell's zebra showed high prefer-ence for open grassland habitats and the distribution of the animal varied according to the season. The highest number of Burchell's zebra were observed in all vegetation types during the dry season than the wet season ($t = 5.614$, $P = 0.023$).

Food preference of Burchell's zebra

Table 7 shows the main grass species that Burchell's zebra consumed during the dry and wet seasons. Burchell's zebra in Yabello Wildlife Sanctuary showed preference to certain grass species over other species ($t = 8.036$, $P = 0.014$). During the study period, Burchell's zebra was never seen feeding on bushes and leaves. The grazing frequency was 27.5% on *Themeda triandra*, 20.4% on *Cynodon dactylon*, 13.5% on Setaria *verticallata*, 11.4% on *Ischaemum afrum*, 9% on *Chryospongon aucheri, 5.3*% on *Elusine intermedia*, 5% on *Lintonia nutans*, 4.1% on *Aristida adoensis* and 3.8% on *Cenchrus ciliaris* as reported in Table 7. *T. triandra* and C*. dactylon* were the most preferred grass species accounting for 47.9% of grass intake*, S. verticillata, I. afrum and C. aucheri* were the medium preferred grass species accounting for 33.9% of the total sighting freq-uency of grass intake and *E. intermedia, L. nutans, A. adoensis* and *C. ciliaris* were the least preferred grass species accounting only for 18.2% of the total grass in take.

DISCUSSION

At present, the conservation effort made in the Yabello Wildlife Sanctuary is not promising and management systems are also poor. In order to manage the population of Burchell's zebra properly and to take conservation measures accordingly, estimating their population status, distribution and abundance in the study area is important. Separation of the study period into dry and wet seasons was important in order to observe the influence of the different seasons on the vegetation cover and hence, the distribution of animals. More zebras were counted during the dry seasons because the dry season coincides with fawning. Even though, breeding in the Burchell's zebra is not seasonal and foals may be born at any time of the year, there is a breeding peak from December to January, and 85% of the foals are usually born from October to March (Skinner and Smithers, 1990; Furstenberg, 2002).

A population build up could be expected in the wet season, but this was not well confirmed by the result of the present study. There was no significant difference on the counts of some transects between the two seasons.

A line-transect count of Burchell's zebra among transects one and three were significantly different. This could be due to a number of ecological factors. The relative abundance of animals is naturally associated with preference towards a given habitat. This depends on what the habitat provides in terms of food, breeding site, protection from predators, overheating and cold and free space.

Counts of Burchell's zebras showed significant differences between open grassland, woodland and bush land habitats. Differences in the counts of zebras in the six transects have most likely resulted from the tendency of Burchell's zebras to seek for habitat with a good supply of nourishment. This showed that in a place where a good supply of food is available more number of zebras was found. This supports the findings of Dankwa-Wiredu and Euler (2002), which confirmed that utilization of habitat, is often determined by the availability of cover, food and the rich plant growth.

This study shows that Burchell's zebras are abundant in open grassland habitat. The highest count recorded in transect 1 and 3 was in accordance with the preference of the open grassland habitat. The vegetation map of the study area (Figure 1) shows that transect 1 and 3 are mostly covered with open grassland and transect 4 and 6 were covered with bush land. Burchell's zebra preferred open grassland mostly and bushland in medium and least in woodland in wet seasons. In contrast, they prefer wood-

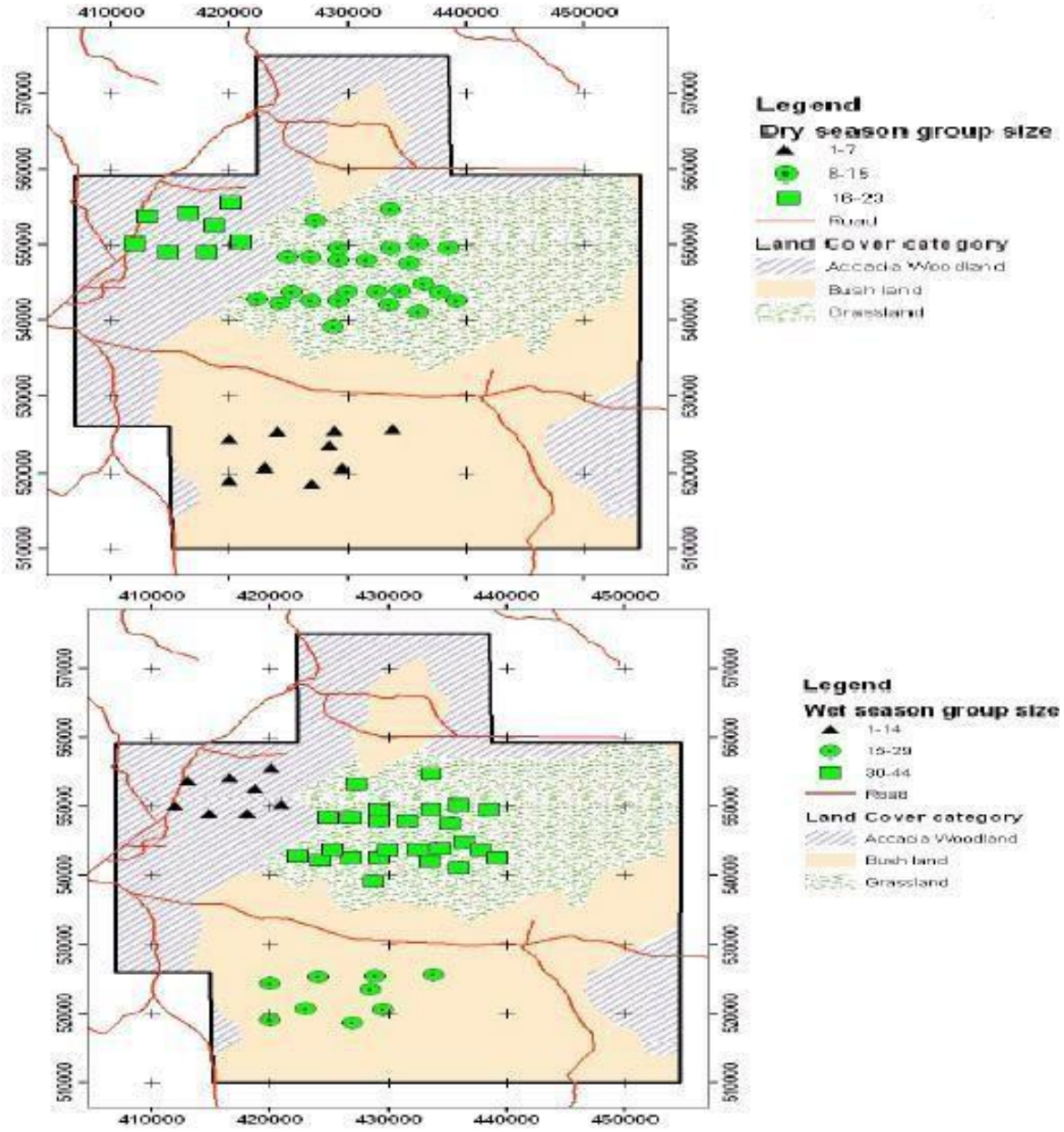

Figure 6. Distribution of Burchell's zebra during the wet and dry seasons in different vegetation types in Yabello Wildlife Sanctuary.

land more in dry season, because of the abundance of resources, availability of water and ambient weather conditions such as hot sun. This is in line with the findings of Mwangi and Western (1988), distribution of wildlife population can be explained mainly in terms of water and food. The knowledge of sex ratio and age distribution of individual mammals is vital for evaluating the viability of a species because these variables reflect the structure and the dynamics of population (Wilson et al., 1996). Sex and age structure of a population at any given point of time is also an indicator of the status of the population (Woolf and Harder, 1979). The high population of females and fairly high proportion of young indicate a healthy, increasing zebra population in the study area, similar to the study carried out by Yisehak et al. (2007) in Nechisar National Park. An increase of the young numbers recorded during the dry season observations suggest that birth is in the beginning of the dry season. The present study is in agreement with the findings of the previous studies on plains zebra showing that family groups (harems) are stable in the adult age class (Skinner and Smithers, 1990).

The pattern of group size in the different habitat types in both seasons was entirely different. Despite the highly significant difference indicated for groups in the open

Table 7. Grass species consumed by Burchell's zebra during the dry and wet seasons in Yabello Wildlife Sanctuary.

Scientific name	Vernacular name	% of frequency	Intake
Aristida adoensis	Saatuu biilaa	4.10%	+
Cenchrus ciliaris	Mat-guddeessa	3.80%	+
Cynodon dactylon	Sardo	20.40%	+++
Chryospogon aucheri	Alaloo	9%	++
Elusine intermedia	Coqorsa	5.30%	+
Ischaemun afrum	Guuree	11.40%	++
Lintonia nutans	Hiddo(luucolee)	5%	+
Setaria verticillata	Raaphuphaa	13.50%	++
Themeda triandra	Gaaguroo	27.50%	+++

High preference =+++, medium preference =++, low preference =+

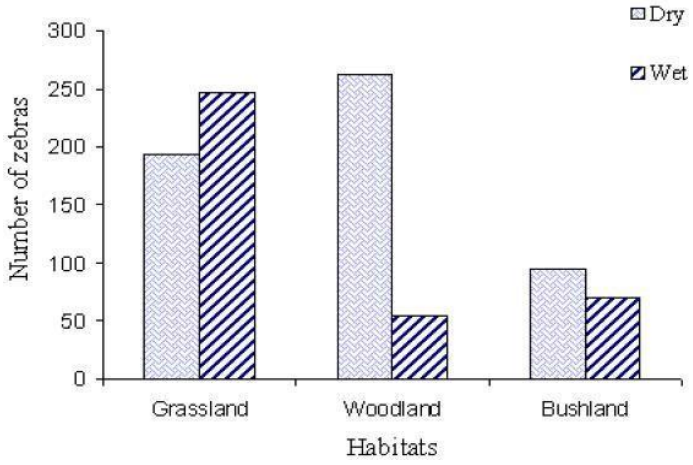

Figure 7. Abundance of Burchell's zebra during the wet and dry seasons in different habitats.

grassland as compared to those dense and intermediate habitats, very little differences could be detected when adults, sub-adults and yearlings were observed. Group size varies in relation to different external conditions. Data on grouping patterns of herbivores may be indicative of the effects of a changing environment (Leuthold and Leuthlod, 1975), reproductive behavior (Jarman and Jarman, 1973) and environmental disturbance resulting from heavy grazing, fire and other factors.

Significant difference in group size was found in all three habitat types and such differences persisted when group sizes were dispersed into the most important categories: mares, stallion and mixed groups. Ungulate species living in open habitats generally form larger groups than those in bush land or forest (Jarman, 1974). The density of food resources alone may explain the occurrence of small groups of ungulates in woodland habitats because of limited vegetation on the forest floor, which is too sparse for a large feeding group (Owen-Smith, 1982).

In open fields or grasslands, food resources are more abundant and sufficient to support large feeding groups of ungulates (Hirth, 1977). In the study area, water is also a limiting factor for the distribution of group sizes of Bur-chell's zebras as they cannot survive the dry season with-out water. Habitat requirements of Burchell's zebras were closely associated with the availability of water and edible grasses. Lamprey (1963) estimated that 92.5% of the food of zebra was grass, 5.4% was herb and 2% was shrub. Vesey-Fitzgerald (1965) noted that Sporobolus and Vossia species are preferred grasses of Burchell's zebra in the Rungwa Valley, Tanzania. In the present study, the diet of Burchell's zebra comprises grass species in both dry and wet seasons in Yabello Wildlife Sanctuary.

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