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Full Length Research Paper

Screening of teff (*Eragrostis tef*) varieties for genotypic and phenotypic traits in Dejen Woreda, East Gojjam Zone

Asaye Demelash

Agriculture and Natural Resource College, Debre Markos University, Debre Markos, Ethiopia.

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Twenty-four teff varieties obtained from DebreZiet Agricultural Research Center were evaluated for agronomic traits such as days to emergence, days to heading, days to maturity, grain filling period, plant height, panicle length, shoot biomass, straw yield and grain yield in a randomized complete block design, at Dejen Woredain 2015/16 cropping season. The analysis of variance showed that the varieties had significant variation (p<0.01) for days to heading, days to maturity, grain filling period, plant height, shoot biomass, straw yield and grain yield. However, the varieties did not show significant variation for days to emergence and panicle length. It was observed that varieties were significantly different from each other in plant height. Dz-01-3186 (Etsub, 103.06cm) and DZ-01-1681(kayt-ena) (99.73 cm) showed greatest height as compared to other varieties whereas SR-RIL-273(Laketch) (80.46 cm) was the shortest in plant height. Similarly for grain yield per plot, Dz-01-3186 (Etsub) (28.1 qt/ha), Dz-01-2053 (Holeta Key) (24.48 qt/ha) and DZ-01-99 (Asgori) (22.6 qt/ha) were showed significant superiority of yield per plot over the other varieties. Significant variation was observed for straw yield among varieties. Superior performance was observed by varieties Dz-01-3186 (Etsub) (112.8 qt/ha), Dz-01-2053 (holeta key) (105.1 qt/ha) and DZ-01-99 (Asgori) (103.2 qt/ha). Dz-Cr-385 RIL295 (Simada) had the longest grain filling period which was 66.33 days. DZ-Cr-44 (Menagasha) took 114 days to mature. The highest heritability value was observed for days to heading (69.77%) and plant height (49.43%). Days to heading, days to maturity, shoot biomass, plant height, panicle length and lodging index showed positive correlation with grain yield. Shoot biomass (0.81) and plant height (0.66) showed strong significant positive correlation (P < 0.001) with grain yield. It can be summarized that farmers of Dejen district get an access for high yielding varieties Dz-01-3186 (Etsub), Dz-01-2053 (Holeta Key) and DZ-01-99 (Asgori) which would be recommended for better productivity and production of teff.

Key words: Teff, genotypic, phenotypic, heritability, genetic advance, correlation.

INTRODUCTION

Teff [*Eragrostis tef* (Zucc) Trotter, 2n=4x=40] is the majority food crop in Ethiopia. Nowadays, it is annually cultivated on top of more than three million hectares of land, used for over six million of farmers and more than 50 millions of people, used as staple food (CSA, 2015). Compared to other cereals, teff has broad adaptation to the heavy, water-logging, clay soil areas of the Ethiopian highlands and teff in general is resilience to marginal

areas. Grain of teff in our country is mainly adopted for food after baking the ground flour into pancake-like soft and sour bread, '*injera*', which forms the major component of the most favorite national dish. It is also consumed in the form of porridge, and somewhat fermented or un-fermented non-raised breads ('*kita*' and '*anebabero*'), native beer, '*talla*', and more alcoholic cottage liquor, '*katikalla*' or '*arakie*' (Assefa *et al,* 2015).

For human health, benefit of teff is the high fiber content of the grain. This is predominantly important in dealing with diabetes (low glycemic index) and gluten free, preventing anemia (high iron content). Unlike other cereals, the seeds of teff can be easily stored under local storage conditions without losing viability since the grains are resistant to attack by storage pests (Ketema, 1997). In the past to show sustainability of teff in Ethiopia, the late prime minster MeleseZenawi said "Unless a miracle happens, teff will ceased to be staple food for many Ethiopians". But currently, teff is expensive in Ethiopia. Many countries other than Ethiopia are using teff products. Teff has remarkable genetic traits useful for most Ethiopian farmers to utilize for coping with erratic climatic conditions, generation of household income, and fulfilling concerns of nutritional needs. Moreover, the conservation and utilization of teff genetic resources, offer a reliable basis for enhancing food security and developing crop diversification in the moisture stress and challenging agro-ecological areas of the country (Assefa et al., 2015).

In Ethiopia, climate is highly variable, and is projected to become more variable due to climate change, with the potential for increased frequency of extreme weather events. For sustainable and stable food production of teff, maintaining adaptation within and between different agro-climatic conditions is increasingly being realized as the most suitable and crucial action. So the major problems for adaptation for teff are limited availability of varieties, wide scale use of traditional and unimproved cultural practices, susceptible to lodging, inadequate seed and extreme system, changing rain fall patterns. So, due to the above reasons Landraces and current cultivars, teff give low yield in the study area. As far as teff production and area coverage is concerned, Amhara region is ranked 2nd next to Oromia.

Productivity of teff in East Gojjam zone (17.39 qt/ha) is greater than that at national average (15.75 qt/ha) (CSA, 2015). Dejen is one of the district of East Gojjam, which has immense potential for teff production. However, adaptability trial of nationally released teff varieties was not done in the district so far. Improved varieties of teff were not accessed for farmers of Dejene district as well. So, the objective of this study was to evaluate genotypic and phenotypic variability and agronomic performance of recombinant inbred lines (RILs) and varieties of teff, in rain fed condition at DejenWoreda.

MATERIALS AND METHODS

Description of study area

This experiment was conducted in Sebshengo Kebele, DejenWoreda, East Gojjam of Amhara Region in 2015/16 cropping season. DejenWoreda is 230 and 335 km distant from Addis Ababa and Bahir Dar, respectively.

The altitude of Sebshengo kebele varies from 2360 to 2492 masl. Sebshengo kebele has 2278.73 ha (77.2%) of vertisols and 675.5 ha (22.8%) of nitosols. Mean average, average maximum and minimum temperature is 16, 21.3 and 10.21°C, respectively. The annual rainfall is 756.8 mm.

Experimental materials, designs and layout

Twenty-three nationally released and one local check teff varieties were evaluated under the experiment. Varieties were obtained from Deziet Agricultural Research Center (Table 1).

The experiment was laid out with randomized complete block design with three replications. The land was ploughed with oxen four times until it becomes fine, ready for sowing. The plot size was 2 m^2 (2 × 1 m) and the spacing between blocks and plots were 1.5 and 1 m, respectively. The applied seed rate was 15 kg/ha (3 g/plot). Soil fertilizer was applied with the recommended rate to the area that is DAP (100 kg/ha) and urea (160 kg/ha).

Sowing was done on August 04, 2015. And optimum moisture was available for germination. All other management practices were undertaken as per the recommendations. Data for traits such as days to emergence, days to heading, days to maturity, grain filling period, shoot biomass (g), grain yield (g), stand (%) and straw yield (gm) were taken on plot basis. Plant height (cm), panicle length (cm) and lodging index (0 to 5) in% were recorded from 5 randomly sampled plants per plot (15 plants per variety).

Statistical analysis

Mean values of these samples were used to estimate the performance of each variety for the characters/traits under thought. The analysis of variance was subjected to analyze the collected data using R package 'stat' (version 2.12.2) (R Core Team, 2012). The following model was utilized in the analysis of variance;

$$Y_{ij} = \mu + \beta_i + \tau_j + \varepsilon_{ij}$$

Where;

Yij = observed variation
μ = mean effect
$\beta i = i^{th}$ block effect
$\tau_j = j^{th}$ treatment effect
ε_{ij}= treatment x block interaction, treated as error

Phenotypic and genotypic variance components were estimated based on the following formula (Sharma, 1998).

*Corresponding author. E-mail: asayedemelash@gmail.com. Tel: +251911533004.

Table 1. List of tef varieties and recombinant lines (RILs) in the study.

S/N	Name of Variety/ RILs	Type(Variety /RIL)	Remark(released by)
1	DZ-01-354(Enatit)	Variety	DZ ARC
2	DZ-01-99 (Asgori)	Variety	DZ ARC
3	DZ-01-196(magna)	Variety	DZ ARC
4	DZ-Cr-44 (menagasha)	Variety	DZ ARC
5	DZ-Cr-255(gibe)	Variety	DZ ARC
6	DZ-01-974(Dukem)	Variety	DZ ARC
7	DZ-Cr-358 (ziqala)	Variety	DZ ARC
8	DZ-01-1285(koye),	Variety	DZ ARC
9	DZ-Cr-387/RIL-355(quncho)	RIL	DZ ARC
10	DZ-Cr-37(Tseday)	Variety	DZ ARC
11	DZ-01-1281(gerado)	Variety	DZ ARC
12	DZ-01-1681(kayt-ena)	Variety	DZ ARC
13	DZ-Cr-438(Kora)	Variety	DZ ARC
14	Dz-Cr-385 RIL295(simada)	RIL	Adet ARC
16	DZ-Cr-409/RIL50d(Boset)	RIL	DZ ARC
17	DZ-01-899(gimbichu)	Variety	DZ ARC
18	Dz-01-2053(holeta key)	Variety	DZ ARC
19	Dz-01-1278(ambo toke)	Variety	DZ ARC
20	SR-RIL-273(Laketch)	RIL	DZ ARC
21	Dz-01-3186(Etsub)	Variety	DZ ARC
22	Dz-01-2423(Dima)	Variety	DZ ARC
23	23-tafi-adi-72(Kena)	Variety	DZ ARC
24	PGRC/E205396(Ajora)	Variety	Biodiversity institute
25	Local check	Variety	-

Environmental variance ($\sigma^2 e$) = MS_e (mean square of error)

Genotypic variance ($\sigma^2 g$) = $\left[\frac{MS_g - MS_e}{r}\right]$

Phenotypic variance ($\sigma^2 p$) = $\sigma^2 g + \sigma^2 e$

Phenotypic coefficient of variation (PCV) = $\frac{\hat{\sigma}_p}{\bar{x}} \times 100$

Genotypic coefficient of variation (GCV) = $\frac{\sigma_g}{\bar{x}}$ x 100

Where, $\bar{x}$ = grand mean of a character.

Broad sense heritability (H) was computed as, the ratio of genotypic variance to phenotypic variance multiplied by 100.

Genetic advance was calculated according to Allard (1960), using the formula;

$$GA = H \times Vp \times K$$

Where, H= Broad sense heritability, Vp = phenotypic variance, K= is selection deferential 2.06 at 5%.

Lodging index

The degree of lodging was assessed just before the time of harvest by visual observation, based on the scales of 1 to 5 where 1 (0 to 15°) indicates no lodging, 2 (15 to 30°) indicate 25% lodging, 3 (30 to 45°) indicate 50% lodging, 4 (45 to 60°) indicate 75% lodging and 5 (60 to 90°) indicate 100% lodging (Donald, 2004).

The scales were determined by the angle of inclination of the main stem from the vertical line to the base of the stem by visual observation. Each plot was divided based on the displacement of the aerial stem in to all scales by visual observation. Each scale was multiplied by the corresponding percent, given for each scale and the average of the scales represents the lodging percent of that plot. Data recorded on lodging percent were subjected to Arcsine transformation described for percent data by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The analysis of variance showed that varieties had significant variation($p<0.01$) for days to heading, days to maturity, grain filling period, plant height, shoot biomass, straw yield and grain yield (Table 1). Similar result was reported by Adnew et al. (2005) for days to maturity, grain filling period and shoot biomass also cited by Assefa et al. (2015).

The contrasting result was reported by Habitamu et al. (2011). In the ANOVA, days to emergency, panicle length and lodging were not significantly different within varieties (Table 2). Dissimilar argument was reported to panicle length by Dejene et al. (2010). These varieties showed

Table 2. Mean, mean square and CV of tef varieties in DejenWoreda.

Traits	DTE	DTH	GFP	DTM	PLH	PL	SBGP	YD	STRYD
Mean	6.11	53.73	56.98	110.75	88.85	31.81	1905.89	381.14	1524.75
MSt	0.45^{ns}	56.58**	41.23*	14.25*	90.09*	26.73^{ns}	443661**	12249**	329114**
CV (%)	9.09	4.97	6.18	2.29	5.38	17.30	19.16	17.08	21.46

DTE = days to emergency, DTH = days to heading, GFP = grain filling period, DTM = days to maturity, PLH = plant height, PL = panicle length, SBGP = shoot biomass (gm/plot), YD = grain yield per plot, STRYD = straw yield, MSt= mean square due to treatments, CV (%) = coefficient of variation, indicates significance at ** *p< 0.001, * p < 0.05* probability level, ns indicates non significance. ** = highly significant, * = significant, ns = non-
significant.

Table 3. Mean separation for 8 traits of tef varieties.

Treatments	DTH	DTM	GFP	PLH	SBGP	YD	STRYD
DZ-01-354(Enatit)	54.66^{bcdefg}	111.66^{abcd}	57.00^{bcd}	87.00^{defgh}	1953.5^{cdef}	359.8^{cdefg}	1593.7^{bcdef}
DZ-01-99 (Asgori)	55.33^{abcdefg}	111.00^{abcde}	55.66^{bcde}	92.00^{bcde}	2554.5^{ab}	452.1^{bc}	2102.3^{ab}
DZ-01-196(magna)	55.00^{abcdefg}	112.33^{abc}	57.33^{bcd}	83.53^{fgh}	1903.2^{cdef}	351.8^{cdefg}	1551.3^{cdefg}
DZ-Cr-44 (menagasha)	57.33^{abcd}	114.33^{a}	57.00^{bcd}	89.53^{defg}	1906.2^{cdef}	382.1^{cdefg}	1524.0^{defg}
DZ-Cr-255(gibe)	53.00^{defgh}	113.33^{ab}	60.33^{b}	86.66^{efgh}	1557.5^{defg}	360.8^{cdefg}	1196.7^{efgh}
DZ-01-974(Dukem)	59.00^{ab}	113.00^{ab}	54.00^{cde}	82.26^{gh}	1666.7^{cdefg}	301.6^{fg}	1365.0^{defgh}
DZ-Cr-358 (ziqala)	51.66^{gh}	112.33^{abc}	60.66^{ab}	86.46^{efgh}	2024.8^{bcde}	413.5^{bcde}	1611.3^{bcdef}
DZ-01-1285(koye)	51.66^{gh}	111.00^{abcde}	59.33^{bc}	88.93^{defg}	1790.7^{cdefg}	418.3^{bcde}	1372.3^{defgh}
DZ-Cr-387/RIL-355(quncho)	58.33^{abc}	111.00^{abcde}	52.66^{de}	87.06^{efgh}	2091.0^{bcd}	355.6^{cdefg}	1735.3^{abcd}
DZ-Cr-37(Tseday)	44.00i	110.33^{abcde}	66.33^{a}	86.26^{efgh}	1884.2^{cdef}	359.1^{cdefg}	1525.0^{defg}
DZ-01-1281(gerado)	54.33^{cdefg}	113.33^{a}	59.00^{bc}	84.06^{fgh}	1374.0^{fg}	289.3^{g}	1084.7^{fgh}
DZ-01-1681(kayt-ena)	52.33^{fgh}	111.00^{abcde}	58.33^{bcd}	99.73^{ab}	1991.3^{bcde}	402.3^{bcdef}	1589.0^{bcdef}
Dz-Cr-438(Kora)	59.33^{a}	111.00^{abcde}	51.00^{e}	91.00^{cdef}	2248.5^{abc}	423.1^{bcd}	1825.3^{abcd}
Dz-Cr-385 RIL295(simada)	41.00i	107.33^{ef}	66.33^{a}	95.00^{bcd}	1762.5^{cdefg}	344.5^{defg}	1418.0^{defgh}
DZ-Cr-409/RIL50d(Boset)	52.66^{efgh}	108.33^{cdef}	55.66^{bcde}	87.53^{defgh}	1360.3^{fg}	315.3^{efg}	1045.0^{gh}
DZ-01-899(gimbichu)	54.33^{cdefg}	111.00^{abcde}	56.66^{bcde}	89.26^{defg}	2097.8^{bcd}	423.8^{bcd}	1674.0^{bcde}
Dz-01-2053(holeta key)	52.33^{fgh}	109.33^{bcde}	57.00^{bcd}	97.73^{abc}	2553.7^{ab}	489.6^{ab}	2064.0^{abc}
Dz-01-1278(ambo toke)	57.33^{abcd}	111.00^{abcde}	53.66^{cde}	89.13^{defg}	2084.8^{bcd}	431.8^{bcd}	1653.0^{bcde}
SR-RIL-273(Laketch)	57.00^{abcde}	111.33^{abcde}	54.33^{cde}	80.46^{h}	1265.5^{g}	356.1^{cdefg}	909.3^{h}
Dz-01-3186(Etsub)	55.66^{abcdefg}	109.66^{bcde}	54.00^{cde}	103.06^{a}	2819.7^{a}	562.0^{a}	2257.7^{a}
Dz-01-2423(Dima)	53.00^{defgh}	108.00^{def}	55.00^{bcde}	89.93^{cdefg}	1908.8^{cdef}	369.5^{cdefg}	1539.3^{cdefg}
23-tafi-adi-72(Kena)	55.00^{abcdefg}	111.00^{abcde}	55.33^{bcde}	85.53^{efgh}	1840.3^{cdefg}	359.6^{cdefg}	1480.7^{defg}
PGRC/E205396(Ajora)	56.66^{abcdef}	112.00^{abcd}	55.33^{bcde}	87.13^{efgh}	1445.8^{efg}	339.1^{defg}	1106.7^{fgh}
Local check	48.66^{h}	104.33^{f}	55.66^{bcde}	83.06^{gh}	1656.2^{cdefg}	285.8^{g}	1370.3^{defgh}
LSD	4.39	4.17	5.79	7.86	598.7	107.0	537.9
CV (%)	4.97	2.29	6.18	5.38	19.16	17.08	21.46

promising performance in grain and straw yield with less lodging percentage.

High productivity of grain yield from this area is most likely attributed to continuous supply of nutrients through the developmental stages. There was no incidence of disease during the experiment. The ANOVA which depicted acceptable level of coefficient of variation (CV) is for most of the traits/characters. However, higher CV was observed for PL, SBGP, YD and STRYD.

Mean separation of yield and yield related traits

Based on the significance of the ANOVA, test of significance difference of mean values for 7 traits of varieties was employed (Table 3). It was observed that varieties were significantly different from each other in grain and straw yield. Based on this, Dz-01-3186 (Etsub) (28.1qt/ha, 112.8 qt/ha), Dz-01-2053 (holeta key) (24.48 qt/ha, 105.1 qt/ha) and DZ-01-99 (Asgori) (22.6 qt/ha,

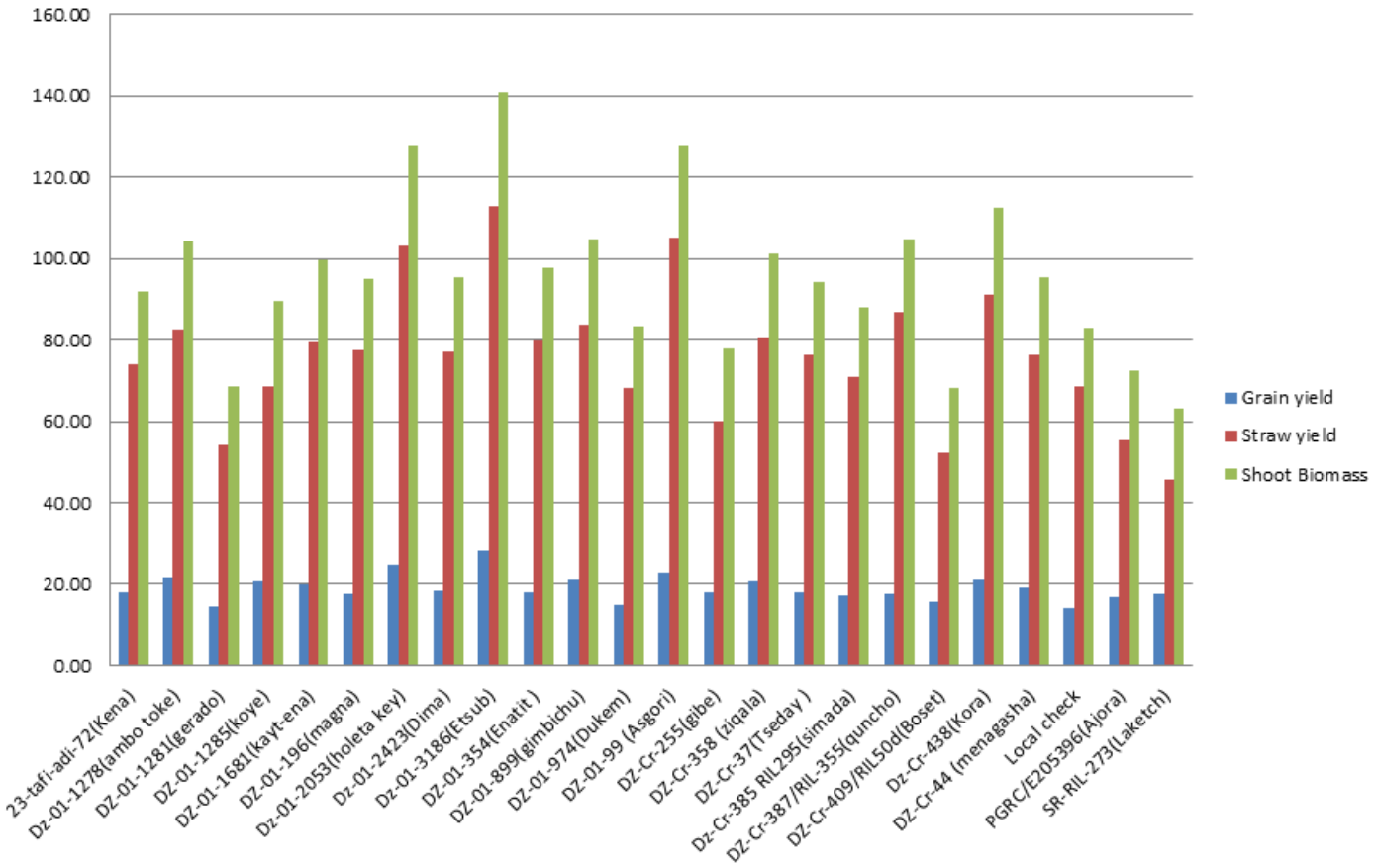

Figure 1. Teff mean shoot biomass, grain yield and straw yield of adaptation in DejenWoreda, Sushengo Kebele.

103.2 qt/ha) had the highest grain yield and straw yield, respectively. Whereas DZ-01-1281(gerado) (14.46 qt/ha) and local (14.29qt/ha) were inferior in grain yield.

Similarly, SR-RIL-273(Laketch) (45.46 qt/ha) had the lowest straw yield. In this trial, Dz-01-3186(Etsub) (103.06 cm) and DZ-01-1681(kayt-ena) (99.73 cm) showed greater plant height among teff varieties whereas SR-RIL-273(Laketch) (80.46 cm) was the shortest variety. Plant height is an important trait that positively contributes to yield directly and negatively to lodging on the other hand. Even if lodging is a major problem of grain yield production of teff, this finding is not significant. Dissimilar result was also reported by Delden et al. (2010).

Among 24 varieties, Dz-Cr-385 RIL295 (Simada) had 66.33 days for grain filling but 17.2 qt/ha for grain yield. Prolonged grain filling period might leads to drought stress condition and grain yield decreased. DZ-Cr-44 (Menagasha) matured in 114 days was late maturing variety as compared to other varieties tested in this experiment whereas, local check was early maturing compared to the improved varieties (104 days). The depicted, DZ-Cr-44 (Menagasha) cannot acclimatize moisture deficit environment, since it needs enough moisture for prolonged period to be more productive for grain yield whereas, the local check can escape dry condition because of its earliness.

With their mean values, among 24 teff varieties, Dz-01-3186(Etsub), Dz-01-2053(holeta key), and DZ-01-99 (Asgori) showed the highest yield with shoot biomass, grain yield and straw yield. Shoot biomass, grain yield and straw yield showed direct correlation for all varieties (Figure 1).This result was consistent with previous studies on teff which showed that, shoot biomass is the contributor for yield (Chanyalew, 2010) as cited by Assefa et al. (2015). Because of efficient utilization of applied urea fertilizer increased vegetative growth, this resulted for higher biomass production. In this finding, shoot biomass and straw yields contributed significantly for grain yield production and productivity. In teff growing areas, farmer's desire is too high to get more straw yield for their animals feed.

Heritability in broad sense has been found effective in the selection of superior genotypes on the basis of phenotypic performance. The highest heritability value was days to heading (69.77%) followed by plant height (49.43%).This showed that characters are least influenced by environmental factors. In general, most traits explained moderate to high heritability values except for lodging index (Table 4). Habtamu et al. (2011)

Table 4. Treatment mean squares, environmental, genotypic and phenotypic variance, phenotypic, genotypic and environmental coefficients of variation, heritability in broad sense and expected genetic advance.

VAR	MSt	EV	GV	PV	ECV	GCV	PCV	H	GA
DTE	0.45	0.31	0.05	0.36	9.11	3.65	9.81	13.51	2.81
DTH	56.58	7.14	16.48	23.62	4.96	7.55	9.04	69.77	12.99
DTM	14.25	6.46	2.6	9.06	2.29	1.45	2.71	28.67	1.60
GFP	41.23	12.42	9.6	22.02	6.18	5.43	8.23	43.61	7.39
SBGP	443661	132740	103640.33	236380.33	19.11	16.89	25.5	43.84	23.03
PLH	90.09	22.91	22.39	45.3	5.38	5.32	7.57	49.43	7.71
LDI	1254	1002	84	1086	139.56	40.41	145.3	7.73	23.15
YD	12249	4240	2669.67	6909.67	17.08	13.56	21.8	38.64	17.35
STRYD	329114	107125	73996.33	181121.33	21.46	17.84	27.91	40.85	23.49

DTE = days to emergency, DTH = days to heading, GFP = grain filling period, DTM = days to maturity, PLH = plant height, PL = panicle length, LDI = lodging index, SBGP = shoot biomass (gm/plot), YD = grain yield per plot, STRYD = straw yield, MSt= mean square due to treatments.

Table 5. Correlation Coefficient of traits.

TREATMENT	DTE	DTH	DTM	GFP	SBGP	PLH	PL	LDI	YD	STRYD
DTE	1.00	0.33	0.54**	0.01	-0.33	-0.10	-0.12	-0.25	-0.18	-0.34
DTH		1.00	0.35	-0.81**	0.00	-0.10	-0.10	-0.35	0.06	-0.02
DTM			1.00	0.28	-0.04	0.01	-0.18	-0.16	0.04	-0.05
GFP				1.00	-0.02	0.11	0.00	0.26	-0.04	-0.02
SBGP					1.00	0.67**	0.29	0.32	0.81**	0.99**
PLH						1.00	0.33	0.28	0.66**	0.64
PLH							1.00	0.04	0.25	0.29
LDI								1.00	0.25	0.33
YD									1.00	0.73**
STRYD										1.00

DTE = days to emergency, DTH = days to heading, GFP = grain filling period, DTM = days to maturity, PLH = plant height, PL = panicle length, LDI = lodging index, SBGP = shoot biomass (gm/plot), YD = grain yield per plot, STRYD = straw yield.

reported similar result of high heritability values for days to heading, plant height, grain filling period, grain yield and straw yield. Though this does not mean that, these values assurance achievement in selection resemblance between relatives is controlled by the proportion of the additive genes, not by all of the genetic variation (Falconer and Mackay, 1996). High value of genetic gain was observed for yield (17.35), shoot biomass (23.03) and straw yield (23.49). Similar result was also reported by Asefa et al. (1999). Genetic gain showed significance level, indicating to the possibility of selection for a trait. High genetic advance values showed traits, which are governed by additive genes, useful for selection. Genetic variation affects how fast progress will be, during selection on a phenotype.

Association of grain yield with yield and yield related traits

Days to heading, days to maturity, shoot biomass, plant height, panicle length and lodging were positively correlated with grain yield. Shoot biomass (0.81) and plant height (0.66) showed positive and highly significant ($P < 0.001$) associated with grain yield (Table 5).

Grain yield was positively and significant with plant height and panicle length as reported by Bekalu and Tenaw (2015). Shoot biomass was positively correlated with grain yield (Fissehaye et al. 2009). Panicle length showed positively correlated with grain yield (Tefera et al. 1990) and similar correlations were reported in barley by Mekonnen (2005).

Strong correlation coefficient between grain yield with shoot biomass and plant height was used to improve grain yield productivity. But days to heading and grain filling period were negatively correlated with grain yield (Table 5). According to Wondewosen et al. (2012), it was reported that grain filling period was negatively correlated with grain yield. In this area, teff production was a promising because plant height and shoot biomass had direct contribution for grain yield.

CONCLUSION AND RECOMMENDATION

This study has shown the genotypic and phenotypic variability among varieties with many traits. Variability is important in selection of better variety with grain yield and other economic advantages would be easier.

Days to heading, grain filling period, plant height, lodging index, shoot biomass, grain yield and straw yield showed significance differences ($p<0.01$) among the treatments. Amongst the experimental materials, outstanding varieties like Dz-01-3186 (Etsub) (28.1qt/ha, 112.8 qt/ha), Dz-01-2053 (holeta key) (24.48 qt/ha, 105.1qt/ha) and DZ-01-99 (Asgori) (22.6 qt/ha, 103.2 qt/ha) showed the highest grain yield and straw yield, respectively. Heritability values of days to heading (69.77%) and genetic advance for yield (17.35), shoot biomass (23.03), lodging (23.15) and straw yield (23.49) also showed promising result for teff variety selection for improvement.

In both heritability and genetic advance, there was less environmental influence in DejenWoreda. As recommendation based on this finding, promising varieties in grain yield namely Dz-01-3186 (Etsub), Dz-01-2053 (holeta key) and DZ-01-99 (Asgori) would be adapted and used by farmers of DejenWoreda, to enhance tef productivity and production. In general, it can be concluded that adaptation of teff varieties in DejenWoreda possibly will be used to improve the existing potential of teff production. Farmers shall access high yielding varieties which will be more productive and yield increment. This research would be useful as bench mark/good start for teff breeding programmes and policy interventions as far as Dejen is concerned.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Threats and conservation challenges of wildlife in Harenna Forest, Harenna Buluk District, South East Ethiopia

Sefi Mekonen[1]*, Alefu Chinasho[2], Kassegn Berhanu[3] and Sewnet Tesfaye[4]

[1]Department of Ecotourism and Biodiversity Conservation, Madda Walabu University, P. O. Box 247, Ethiopia.
[2]Department of Environmental Science, Wolaita Sodo University, Ethiopia.
[3]Department of Tourism Management, Debre Berehan University, Ethiopia.
[4]Department of Tourism Management, Madda Walabu University, P. O. Box 247, Ethiopia.

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This study was conducted in Harenna Forest, Harenna Buluk District, South East Ethiopia to assess threats and conservation challenges of wildlife in Harenna Forests. Data collection was carried out from March to June, 2016 using questionnaire surveys, interviews and focus group discussion. The wildlife threats and conservation challenges of Harenna Forests were varied among different village's forests. The data revealed that deforestation; habitat loss, degradation and fragmentation; agriculture expansion; settlement; overutilization of forest resources; human-wildlife conflict; fire; district's administration problems and wildlife hunting were the major wildlife threats in the area. Conservation of wildlife resources in Harenna Forest are challenged mainly due to urbanization, agricultural expansion, habitat fragmentation, and resource extraction. Most of respondents (86.5%) acknowledged that the status of wildlife in the Harenna Forest is decreasing particularly due to the above mentioned anthropogenic causes. Therefore, awareness creation programmes should be organized in the community and it will help to reduce wildlife threats and to develop wildlife management.

Key words: Conservation challenge, Harenna Forest, threat, wildlife.

INTRODUCTION

Forests are one of the major biome types on Earth, and of fundamental importance to wildlife. However, the extent of natural forest cover in Ethiopia in the early 1990s was estimated to range from 2.5 to 3.0 million hectares. As a major effort to curb the prevailing destruction of Ethiopia's forests and associated ecosystems and reverse the consequent social and economic disruptions, countrywide tree planting activities and demarcation of forest reserve areas have been undertaken. With respect to the latest, the demarcation

*Corresponding author. E-mail: mekonen.sefi@gmail.com.

and inventorying of 58 natural forest priority areas totaling 4.78 million hectares can be mentioned (Environmental Protection Authority, 2003).

Despite the presence of diversified wildlife and their invaluable benefits, wildlife resources of Ethiopia are under ongoing pressure due to: direct causes including habitat conversion, unsustainable utilization, and invasive species, replacement of local varieties and breeds, climate change, and pollution. Added to these direct causes, demographic changes, poverty, and lack of awareness and coordination, can become indirect causes (Daszak et al., 2000; Ho et al., 2007; IBC, 2014). Wildlife conservation in Ethiopia embodies both utilization of wildlife resources and conservation to make allowance for its continuity in as near natural a state as possible. The need for wildlife conservation evidently became apparent between 1900 and 1945. But the modern system of wildlife conservation in Ethiopia began after 1960s, when international conservation interest was initiated (IBC, 2014).

Wildlife conservation poses a particular challenge to the global community because wildlife has an impact not only on people living in areas where wildlife is found, but also on people located considerable distances away (Bulte et al., 2003). Emerging challenges of wildlife conservation require a multipronged approach in order to have a lasting impact. Conservation of wildlife species, their habitats, and other natural ecosystems such as water catchment areas and wetlands are increasingly coming under intense pressure and threat of extirpation. The pressure is a result of an increase in human population, changing land uses, and the ever-increasing need for goods and services from the ecosystems. These ecosystems therefore need proactive management. One challenge facing conservation is changing the way people perceive wildlife. For as long as they can remember, communities living with wildlife have known a great deal about the animals nearby (Mbugua, 2012).

According to Ministry of Environment and Forest, the forest coverage of Ethiopia has reached 15% (ENA, 2015). However, as in other parts of the developing world, these areas face many challenges of conservation practices of wildlife and forest resources (Hulme and Murphree, 2001; Tessema et al., 2010). An effective management practice of protected areas is one of the best methods to harmonize nature conservation in a given ecosystem. However, the implementation of conservation management plans on protected areas also have many conservation challenges in Ethiopia including Harenna Forest (Amare, 2015a).

However, Harenna Forest ecosystem is vulnerable to many factors such as deforestation of bamboo trees and illegal settlement in and around the forest which affect wildlife resources and their habitats. On the other hand, the irreplaceable wildlife resources in Harenna Forest and BMNP are facing stiff conservation challenges to alleviate these threats both from human and natural induced factors. These points have led to the formulation of the objective of this study. In order to mitigate such threats, the present investigation has contributed ample data on wildlife in regards to major threats, and conservation challenges required to minimize threats to wildlife.

Despite its ecological values and endemic wildlife resources which have captured the attentions of domestic and international researchers to Harenna Forest, wildlife threats and conservation challenges in the Harenna Forest has not been well studied or monitored. The challenges of wildlife conservation have not been studied and there is no individual or investor who provides a sound plan for identifying wildlife conservation obstacles and forwarding solutions in this area, but wildlife are still struggling to survive in Harenna Forest. Therefore, research on wildlife threats and conservation challenges is crucial in its contribution to address some of the gap areas on wildlife conservation research in Ethiopia in general or in Harenna Forest in particular.

The findings of this study will provide details and comprehensive information about the prevailing challenges of wildlife conservation in Harenna Forest ecosystems so that various stakeholders such as the government bodies at all levels, and other local and international NGOs who are interested to work on wildlife conservation, local communities, national and international research institutions, Higher Education Institutions, International Conservancy Organizations and any other concerned bodies play their role to mitigate the problems. In addition, the findings and recommendations part of the study have significances for policy and decision makers so that they can take measures which will in turn help to ensure sustainable utilization of wildlife resources in the forest. Last but not least, this study will help researchers who are interested in undertaking related or further research in the study area.

RESEARCH METHODOLOGY

Description of the study area

Harenna Forest is a moist Afromontane Forest, located in South Eastern part of Oromia regional state. It is a state forest found in Bale Mountain National Park and it situated on the southern slopes of the Bale Mountain, and is about 480 km from Addis Ababa, Ethiopia (Figure 1). Harenna Forest is located between latitude 60^0 20' and 60^0 50' N and longitudes 390 and 400 E. Along with the adjacent state- and community-managed forest outside the park, it constitutes an area of over 4,000 km^2. It is also the largest cloud forest in the country. It lies between altitudes of 3300 m to 1150 m asl. (Zerihun et al., 1988 cited in Tesfa, 2006).

Vegetation and animals

Mountain bamboo grows within the forest, particularly on steep

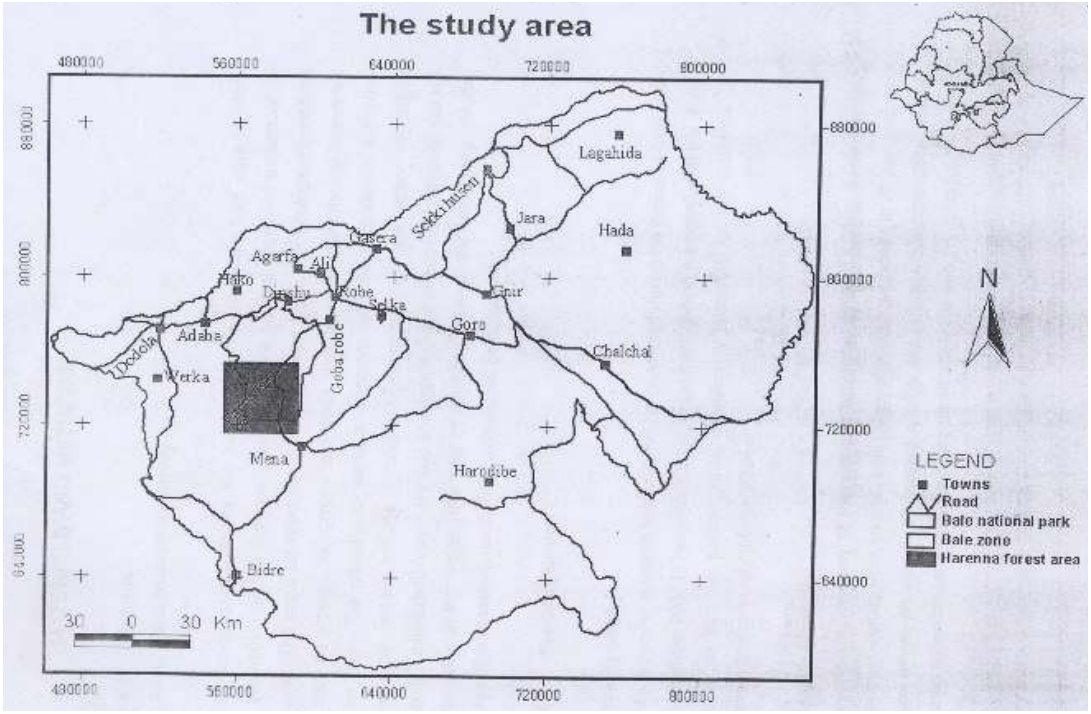

Figure 1. Map of Harenna Forest (Source: Tesfa, 2006).

slopes. The upper area of the Harenna Forest is wet cloud forest with an extensive bamboo belt, while the lower parts are drier mountain forest. At about 2,200 m as the slopes become gentler, larger trees of up to 30m tall appear, and the canopy closes (GMP, 2007). In the lower areas of the forest, wild forest coffee (*Arabica* sp.) grows. Because the forest is so dense and clearings are few and far between, the elusive animals of the forest have little trouble staying hidden. Black-and-white colobus monkey, olive baboon, warthog and Menelik's bushbuck are common. With a little luck and perseverance, you might see a giant forest hog, a bush pig or an endemic Bale monkey (Williams, 2002). Clearings are the best places to look for lion, leopard and African wild dog. Genet, civet, porcupine, and hyena are all active at night. Birds of the Harenna Forest are equally elusive. Look for the *Abyssinian hill babbler*, *Abyssinian crimson-wing*, Ayre's *hawk eagle*, *silvery-cheeked hornbill*, black-winged lovebird, *Abyssinian oriole*, *yellow-fronted parrot*, *white-cheeked turaco* and *Narina trogon*. A wide range of migrant birds can also be spotted, including *Palearctic warblers* (EWCA, 2013).

Methods of data collection

Both primary and secondary sources of data were used. Primary sources of data were gathered via household survey, focus group discussion (FGD), in depth interview and observation to find out information related to factors that influence wildlife resources and conservation practices within the forest. Secondary sources of data includes, journal articles, websites, action plans, minutes, folders, brochures/leaflets and GMP of the parks, reports, bulletin and proceedings, Oromiya Forest Enterprises, Farm Africa, Agriculture and Rural Development Offices, Land and Natural Resource Conservation Offices, Culture and Tourism Offices, Frankfurt Zoological Society, Ethiopian Wolf Conservation Program and Ethiopian Wildlife Conservation Authority were reviewed to get ideas about the practice and challenges of wildlife conservation.

A household questionnaire survey was conducted. The questionnaire was first prepared in English and translated into Afaan Oromo language. The questionnaire containing both closed and open ended items, while close ended items were used to help a researcher examine respondents' response about the conservation and challenges opportunities for wildlife conservation, open ended questions were particularly essential for identifying the reasons why respondents hold some kind of view on related issues. The survey questions include a category with closed style items requiring the respondents to rank their rate of agreement with a particular item such as 'yes' or 'no'; 'increasing', 'decreasing' and unchanged; and a 3-point Likert scale (where 1=disagree; 2= neutral; and 3=agree) depending on a particular question.

For household surveys, a total of 10 villages were selected purposively, because the forest resources are highly available and adjacent at these villages. According to Harenna Buluk district Agriculture and Rural Development Office (2015), there are 8883 households in the 10 villages. The sample size was determined using the Israel (1992) sample size determination formula:

$nT = \frac{N}{1+N(e^2)}$, where n is number of sampled households, 'N' is total target population, n_T is total number of household, and e is level of precision. Hence, according to the formula, sample size determined at 5% precision and 95% of confidence level will be 382 households. That is

$n_T = 8883/1+8883(0.05)^2 = 382$

In order to determine the sample size of each Village, stratified sampling techniques were employed. According to Kothari (2004),

Table 1. Background of the respondents who were involved in questionnaire survey.

Background of the respondents		No. of respondents	%
Sex	Male	216	63.5
	Female	124	36.5
Age	Adult (18-35)	138	40.6
	Middle (36-45)	158	46.5
	Elder (>46)	44	12.9
Educational Status	Uneducated	178	52.4
	Elementary	95	27.9
	Secondary school	22	6.5
	College	23	6.8
	University	22	6.5
Household economy	Agriculture	20	5.88
	Trade	17	5.00
	Governmental work	38	11.18
	Mixed	265	77.94

in stratified sampling technique, the sample size of different stratum is determined proportional to the size of population. Hence, the researchers calculated the sample size for each village (nk) as:

$$\mathrm{nv} = \frac{\textbf{Number of households}}{8883} * 382$$

In-depth interviews were carried out using structured and semi-structured questions. In doing so the participants for the in-depth interview were selected purposively based on the responsibilities they have, experience, and relevance to issues understudy. Accordingly, From Harenna Bulluk District Agriculture and Rural Development Office (1 animal science expert, 1 plant science expert), from Harenna Bulluk District Land and Natural Resource Conservation Office (2 NaRM experts), from Farm Africa (1 Manager, 1 Wildlife and Community Expert), from Oromiya forest enterprise (1 Conservation Expert), from Harenna Bulluk and Angetu District Court (2 judges), from Harenna Bulluk District Police Office (2) were interviewed in detail about wildlife resources of Harenna Forest.

Two focus group discussions were conducted. The participants were selected purposively based on the responsibilities they had experienced, and the relevance to the issues under study. The first FGD was held *with experts* (2 agriculturalists, 1 tourism expert, 1 natural resources expert, 2 plant scientists, 2 animal scientists, 2 wildlife experts, and 2 Experts from Oromiya Forest Enterprise). The second FGD was held with local communities, (2 from religious leaders, 5 members from forest dwellers association, and 4 village administrators). The issues to be discussed include the current challenges for wildlife conservation, the opportunities for conservation and possible solutions for challenges of conservation.

Purposeful, systematic and selective observation and recording of information regarding the challenges and opportunities for wildlife conservation were undertaken by using observation checklists. Digital camera was used to take the pictures of wildlife and habitat degradation as well as conservation practices in and around the forest.

Data analysis

Statistical package software SPSS version 16.0 was used to analyze the data. Quantitative data which were obtained by using questionnaires was presented using descriptive statistics such as percentages, frequencies and means. The finding from quantitative data was presented or reported through tables, bars, and pie charts. In addition, the findings of questionnaires were integrated and compared with that of in-depth interviews, field observation, focus group discussion and document analysis.

RESULTS

Demographic characteristics of respondents

Out of 382 household questionnaires administered, a total of 340 responses were received and suitable for analyses. The results of demographic characteristics showed that 63.5% were males and 36.5% were females (Table 1).

Wildlife conservation challenges

According to community elders, farmers and indigenous peoples who have lived in and around the forest, the major threats and conservation challenges of wildlife are urbanization, agricultural expansion, habitat fragmentation, accessibility and resource extraction (Figure 2). The majority of respondents agreed that overgrazing the forest (95%), human settlement (87.9%), agricultural expansion (91.8%), pastoralist movement

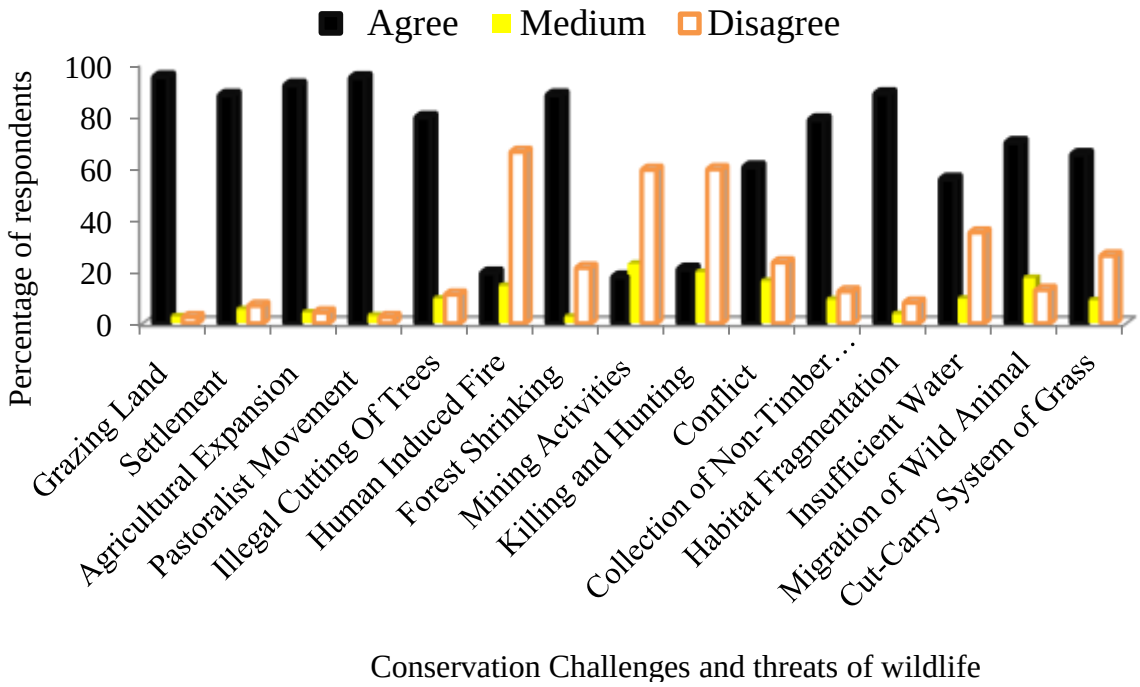

Figure 2. Responses of respondents regarding challenges for wildlife conservation in Harenna Forest.

Table 2. Responses of interview on challenges to conserve wildlife.

S/N	Challenges encountered to wildlife conservation	Scale				
		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	Plant and animal diseases in the forest.	1	3	5	2	
2	Invasive/non-native species	1	2	3	5	
3	Shortage of water	5	2	1	2	
4	Expansion of agricultural practices.			1	4	6
5	Climate change/ global warming			1	5	5
6	High habitat loss, degradation and fragmentation				8	3
7	Unwise utilization and cutting trees	1	1		4	5
8	Gathering of plants or plant products (for non-timber consumption).			1	5	5
9	Human–wildlife conflict		2	2	6	1
10	Hunting of wildlife	2	3	2	3	1
Total frequency		10	13	16	44	26

(94.7%), illegal cutting of trees (79.4%), forest shrinkage (88%), human–wildlife conflict (60.3%), collection of non-timber products (78.5%), habitat fragmentation (88.5%), insufficient water (55.6%), migration of wild animal (69.7%), and cut-carry system of grass (65.1%) were major conservation issues. While, out of the total respondents, 66.1%, 59.2% and 59.4% respondents were stated strongly disagreed to the presence of human induced fire, mining activities and killing and hunting of wildlife, respectively.

According to interview, there were also a total of 10 challenges to wildlife conservation in Harenna Forest (Table 2). On the other hand the main challenges mentioned by the Harena Bulluk district offices were:

i) High turnover of expertise due to lack of incentives in motivating the conservation experts and inadequate salary payment.
ii) Less attention given by NGOs (non-governmental organizations) for wildlife conservation and community

Table 3. Threats of wildlife in Harenna Forest.

Threats	Frequency	%
Habitat loss, degradation and fragmentation	10	14.29
Deforestation	11	15.71
Expansion of Agriculture	10	14.29
Over utilization of forest resources	8	11.43
Settlement	9	12.86
Administration problem	4	5.71
Pollution	2	2.86
Fire	6	8.57
Human-wildlife conflict	8	11.43
Hunting	2	2.86
Total	70	100%

participation to work in collaboration with local community and natural conservation offices in each Kebeke.
iii) Difficulties in creating awareness for the community on the issues of wildlife and forest management.
iv) Illegal practices of cutting of forests and land ownership for renting after getting a license.

According to field observations and respondent information of this study, the major conservation challenges of the wildlife around the study area were habitat disturbances by expansion of agriculture and settlement, competition with livestock and resource and human and wildlife conflict due to its crop raider and livestock attack problems.

The result from the Focus Group Discussion summarized the views and interest of discussants with experts of different sectors and local communities (Figure 4). Most discussants considered the local people affect wildlife in and around the Harenna Forest through overgrazing, firewood collection, settlement, agriculture expansions, fire and giving less attention to conservation of forest and wild animals from the side of local people. Most experts of different sectors and local community discussants described the shortage of private grazing land and decreased farmland holding. This could have increased the pressure on the Harenna Forest resources for livestock grazing and agricultural expansion local communities encroached in to the area for subsistence agricultural land. These events are the main conservation challenges of wildlife in Harenna Forest. Based on this issue, local community discussants said that “if the government and other stakeholders support us we are willing and interested to conserve Harenna Forest resources and wild animals”. Very few local community discussants had negative attitude towards the Harenna Forest conservation system, because these discussants use the resources like firewood and grazing land without any restriction.

Threats to wildlife

The study revealed that all of the selected interviewed Harenna Bulluk District offices respondents have feeling of threat towards wildlife due to the increase in deforestation (15.71%), habitat loss, degradation and fragmentation and expansion of agriculture (14.29% equally each), displacement from the residence owing to housing development program and illegality of their land ownership (settlement) (12.86%), overutilization of forest resources and human-wildlife conflict (each of 11.43%), fire (8.57%), district administration problems and pollution and hunting (each of 2.86%) (Table 3).

According to direct field observations, there were many anthropogenic threats and conservation challenges of wildlife directly or indirectly (Figure 3). Settlement, Logging, agriculture expansion, direct human disturbance through behive setting, fence making and pollution collecting of fuelwood, overgrazing by livestock, and habitat fragmentation were the most crucial challenges directly to the Harenna Forest that in turn will affect on wildlife conservation in the area.

According to field observation various development activities, such as roads and canals passing through forest, agriculture and settlements have also created an edge. Habitat fragmentation has restricted the migration and mobility of many species and has increased the incidence of wildlife damage to human life and property. Such people-wildlife conflicts have frequently given negative impression of wildlife conservation. The damage incidents are reported from the migratory route which has been converted into agricultural fields and new human settlements.

Status of wildlife

Out of the 340 respondents, most respondents [294

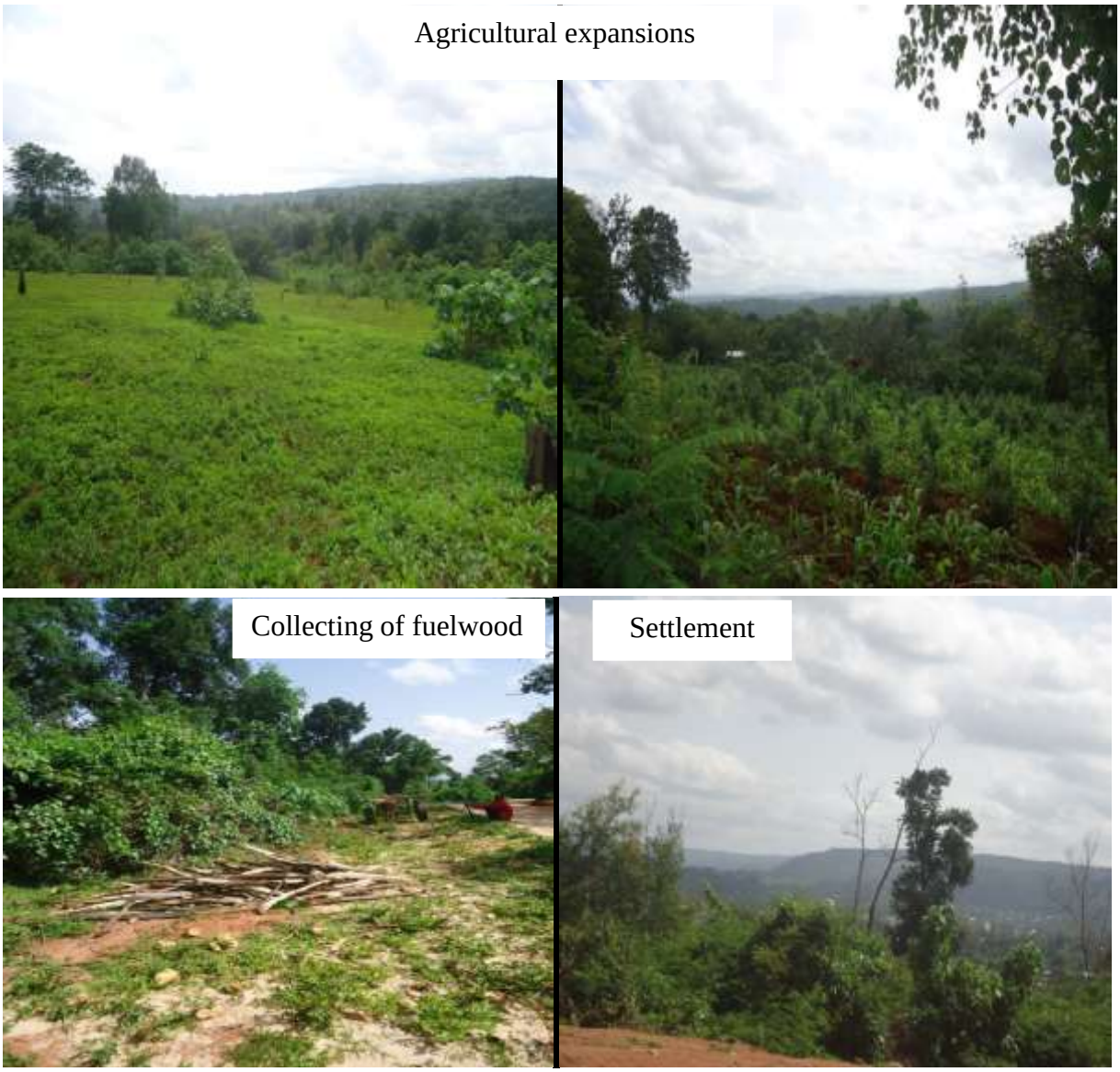

Figure 3. Major threats of Harenna Forest (Photo: Sefi and Alefu, 2016).

(86.5%)], acknowledged that status of wildlife in the Harenna Forest is decreasing, while 11 (3.2%), 16 (4.7%), and 19 (5.6%) of respondents stated increasing, remaining the same and not known, respectively (Table 4). However, there was a significant difference on status of wildlife in the forest among kebele residents (x2 = 70.955, DF=27, P=0.000). There was no significant difference in the view of status of wildlife between different age classes (x2 = 4.892, DF=6, P=0.558). Sex was not important in determining the view of status of wildlife in the area (x2 = 0.652, DF=3, P=0.885). Relatively better-educated groups (elementary, secondary, college and university) (x2 = 17.213, DF=12, P=0.0014) had more view of the status of wildlife than non-educated groups (illiterate and read and write only group).

DISCUSSION

Human population growth, land use transformation, species habitat loss, degradation and fragmentation, growing interest in ecotourism and increasing access to nature reserves, increasing livestock populations and competitive exclusion of wild herbivores, abundance and distribution of wild prey, increasing wildlife population as

Table 4. Status of wildlife in the Harenna Forest.

Kebele	Status of wildlife in the forest			
	Increasing	Decreasing	Remained the same	Not known
Angettu	13.8	65.5	13.8	6.9
Kumbi	0	100	0	0
Hawwoo	2.4	90.4	2.4	4.8
Bulluk	6.8	75.0	13.6	4.6
Heeroo	0	100	0	0
Soorbiraa	0	85.7	14.3	0
Suduweelmel	3.6	75.0	3.6	17.8
Shawwee	0	78.0	6.0	16.0
Sodu Lalaftoo	0	100	0	0
Garba Gaaloo	6.9	93.1	0	0
Total	11 (3.2%)	294 (86.5%)	16 (4.7%)	19 (5.6%)

a result of conservation program (Hill, 2000). In the same case Harenna Buluk district, demographic and social changes place more people in direct contact with wildlife; as human populations grow, settlements expand into and around protected areas, as well as in urban and sub-urban areas. As the human population keeps expanding, there is an increasing demand for land for agriculture, and natural resources for industry, leading to increased contact opportunities for wildlife and people, resulting in conflict (Naughton-Treves, 1998).

Many wildlife areas in Ethiopia are threatened due to ever increasing population, habitat loss and degradation (Amare, 2015a). Due to increasing human population, encroachment in to the wildlife area increases and more lands adjacent to the wildlife area used for farmland, this creates pressure on wildlife population. Land use changes through agriculture, rural and urban development activities have led to the decline and alteration of wild areas, resulting in the extinction to wildlife species and natural areas which serve as their habitat. The results of this study also were addressing some of the causes of losses of forest resources which directly impose wildlife conservation. The transformation of forests, savannah and other ecosystems into agrarian areas or urban agglomerates is a consequence of the increasing demand for land, food production, energy and raw materials. In Ethiopia including Harenna Forest, as well as many areas with abundant wildlife, conflict is intensified by land use fragmentation and the development of small-scale farming (Hill, 2000).

Conflicts over natural resources between the communities living adjacent to forest have increased because of changes in land use and accompanying new ideas about wildlife resource management and utilization. These events also in line with other studies which have been done on other parts of Ethiopia on challenge of wildlife conservation (Magige, 2012; Amare, 2015b). Increased insatiable/voracious demand for resources results to land use changes hence loss to genetic diversity, species reduction and increased ecosystem changes such as random population changes, disease outcrops, habitat fragmentation among others resulting in biodiversity losses (Thecla, 2009).

Human-wildlife conflict is a major concern of most people living next to protected areas in developing countries due to their subsistent live (Amare, 2015b). It arises when growing human populations needs overlap with wildlife areas and results scrambling for resource. As Ethiopia's population increases, there is an increasing demand for space and resource utilization and effects on wild animal's habitat (Yihune et al., 2008). In the same scenario, the Harenna Forest's wildlife resources were decreased and challenged for conserving. According to interview, there were also a total of 10 challenges to wildlife conservation in Harenna Forest (Table 2).

According to field observations and respondent information of this study, the major conservation challenges of the wildlife around the study area were habitat disturbances by expansion of agriculture and settlement, competition with livestock and resource and human and wildlife conflict due to its crop raider and livestock attack problems. These findings of the present study are also in agreement with Redfern et al. (2003). Human activities influence ecosystem structure and function, in particular the spatial and temporal distribution of wild animals (Ogutu et al., 2010). This is especially true for the Harenna Forest, in which forest resources becomes progressively limited, and become points of contacts, conflicts and competition between wildlife and livestock. These threats of the wildlife arisen from settlement and expansion of agriculture.

Overgrazing and deforestation also happened in the study area. These and other activities resulted in disturbance, decrease in abundance and diversity of

wildlife due to destruction of habitat and competition on foraging in the area. Similarly, as reported by Zelealem (2001), livestock from nearby villages stay for longer time, and local community used firewood more frequently in Harenna Forest. According to Newmark, et al. (1994) the major problem facing wildlife areas today is the increase in human settlement of adjacent lands and the unauthorized harvesting of resources within the areas in Africa. In case of Harenna Forest also there is the development of settlements which might be a threat to forest and wildlife resources.

Deforestation resulting land degradation is the global threats for many wild animals with its natural habitat and affects the wild animal's life style in their preferred habitats. The extensive deforestation has also led to the extinction of various biota as resulting in significant biodiversity loss. Much of Harenna Forest land is now widely used for cultivation, grazing, fuel wood and construction. The human population around most protected areas over the years has been changing in terms of its size, density and livelihood strategies (Masanja, 2014). Uncontrolled logging, illegal charcoal production and fuel wood collection were some of the major causes of deforestation that might be directly influenced wildlife's habitat. Habitat degradation and depletion, overexploitation and wildlife diseases are impact on population viability (Daszak et al., 2000) which agreed with the present study. Moreover, human activities impose to decline the scenic beauty of the wildlife area which also affects wildlife resources.

CONCLUSION AND RECOMMENDATION

Conclusively, the major challenges to the conservation of wildlife resources identified in Harena Forest were overgrazing, human settlement, agricultural expansion, pastoralist movement, illegal cutting of trees, forest shrinkage, human–wildlife conflict, habitat fragmentation, insufficient water, migration of wild animal, and cut-carry system of grass, with little occurrence of human induced fire, mining activities and killing and hunting of wildlife. The following recommendations and suggestions were made based on the findings for the sustainable utilization of wildlife, minimizing threats and the coexistence of wildlife and local people: increasing awareness to different sectors and local communities should continue and be strengthened, community-based conservation approaches must be strengthened, and the implementation of local and national conservation regulations should be maintained. Furthermore, higher institutions with governmental and nongovernmental conservation officials should establish a conservation education center that helps to raise awareness to the community and to reduce wildlife conservation challenges in the Harena Forest.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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The influence of some ecological factors on drill monkeys *Mandrillus leucophaeus* (Cuvier) - in Limbe wildlife center (LWC), Southwest Region, Cameroon

Melle Ekane Maurice*, Nkwatoh Athanasius Fuashi and Tim Killian Lengha

Department of Environmental Science, Faculty of science, University of Buea, Cameroon.

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The influence of ecological factors on the behavioral pattern in animals is attracting research interest, particularly for drill monkeys. The aim of this study was to check if ecological changes influence behavior of captive drill monkeys. The study was carried out in Limbe Wildlife Center (LWC) from May 15th 2016 to August 15th 2016 while scan and focal samples were collected in mixed strategy. Continuous sampling started from 6:00 in the morning and ended at 6:30 in the evening, where the following behavioral categories were recorded: feeding, foraging, movement, resting, socialization, grooming, play, aggression and vocalization. Simultaneously, data were recorded on weather changes. Data analysis in this survey comprised of the descriptive and inferential statistics. The study showed a significant difference for the daily activity at different time ranges (X^2=172.282 df =24 P<0.05). There was no significance between 6:8.59 am to 12:2.59 pm for foraging (X^2=0.103 df =1 P=0.749). In addition, there was significance on foraging from 12 am to 2.59 pm and 3 to 6:30 pm (X^2=9.607 df =1 P<0.002). The drills spent more time resting between 6 to 8.59 am and 12 to 2.59 pm (X^2=6.164 df =1 P<0.013). There is a significance for feeding between 6 to 8.59 am and 3 to 6.30 pm for (X^2=85.63 df =1 P<0.05). The results show that the drills spent more time feeding in the morning period than in the evening period of the day, but correlated with foraging behavior. There is a positive correlation between resting and weather changes (rain and sun) R^2=0.11 P<0.05. All the age sex class categories spent less time foraging. (X^2=12 df =1 P<0.05) is for time resting during the wet and (X^2= 94.6 df=1 P<0.05) for sunny weather. This study revealed that ecological factors like weather and photo-period influence the behavior of drill monkeys in captivity.

Key words: Weather changes, wildlife, vocalization, habitat, behavior.

INTRODUCTION

The behavioral study in wildlife is a key element for proper management and conservation purposes in captivity. It plays an eminent role in understanding both the causes and solutions to threaten species (Eadie et al., 1998). Understanding the ways in which animals sense and respond to their environment can provide crucial contexts for the preservation of viable populations in captive habitats. Studies of behavioral ecology can

provide significant contributions to conservation through evolutionary and ecological perspectives of how animals adapt to their environment (Krebs and Davies, 1993). Captive studies can also aid in understanding aspects of species-specific behavior, especially when behaviors are difficult to observe in the wild.

Zoos provide advantages to researchers by allowing longitudinal studies of behavior and reproduction, as well as opportunities for gathering data on all aspects of life history (Hardy, 1996). More so, preserving the behavioral and developmental diversity of animals maintained in captivity allows zoos to achieve their full potential in conservation. Captive propagation efforts and reintroduction programs in particular are dependent on captive animals, exhibiting normal reproductive and behavioral repertoires.

Primates attract attention of many researchers because they are closely related to human in terms of human social behavior. According to Chalmers (1979), primates are social animals and most of them interact with each other in their species. Social behavior refers to any behavior that involves another person (Else, 1991). Studies have shown that primate social behavior is more or less similar to human behavior such as eating, playing, fighting, keeping the baby and others (Rod, 1992).

Activity budgets for primates in disturbed areas such as human settlements are different from those in their natural habitat (Krebs and Davies, 1993). Many serious ecological changes had occurred due to the increasing human population and development of agricultural areas (Krebs and Davies, 1993). Primates have to change their daily behavior according to the environment to ensure their survival. Many studies have shown that the activity budgets vary by several environmental factors include diet, distribution and food sources (Passamani, 1998). It has been shown that the activity budgets of the species are influenced by several environmental factors, such as weather season as well as distribution and food sources (Passamani, 1998; Sato, 2012; Oates and Butynski, 2008). Studies of activity budgets in drill monkeys have shown that, the time spent in different activities vary diurnally and seasonally within age sex class groups in the rainforest and shrub land habitats.

The knowledge of the proportion of time that individuals spend on different activities during a day is important for understanding ecology and life-cycle of the studied species. The activity budget of the drill monkeys indicates how the species group interacts with environment and shows the investment of time, necessary for the understanding of its survival strategy (Defler, 1995). The variation in time budgets between primate species has been shown to fit certain physical traits and environmental conditions; for example the proportion of the time spent foraging is positively correlated to body weight and negatively correlated to the proportion of foliage in the diet (Clutton-Brock and Harvey, 1985). Time budgets are influenced by group size, habitat quality and proximity to human settlements (Singh and Vinathe, 1990). Very little research has been done on the activity budget of drill monkeys and mandrills in the wild and captivity. Social behavior in mammals is governed by bonding relationship, which consist mostly of affiliative interactions and dominant relationship that are established and maintained with agonistic interactions used in determining social status (Sachser et al., 1998).

The behavioral ecology of the drill monkeys may be quite different in their captive environment as compared to the wild. This is important for zoo biologists and conservationists to understand if the preservation of a species in a wild state is the main purpose that is for reintroductions. To preserve behavioral diversity among animals maintained in zoos, it is important for captive animals to develop normal behavioral repertoires (Carlstead, 1996). Environmental factors including weather changes and photoperiod have been suggested as proximate factors influencing primate behavior. The role played by these environmental factors on the group behavior of social drill monkeys in captivity is not fully understood (Harrison and Dukelow, 1973).

The main aim of this study is to find evidence on, the roles that these two environmental variables may play on the activity budget of the drill monkeys in Limbe Wildlife Center, Moreso. This study is important in developing our knowledge on the behavioral ecology of the drill monkeys that live in captivity, to clearly understand the daily activity budgets of this primate species which leads to its effective management.

MATERIAL AND METHODS

Description of the study area

The Limbe Wildlife Center (LWC) is located in the center of the city Limbe (SW Cameroon, 4.1°27.12°N, 9.12°53.64°E), which was established in 1993 by the Cameroon's Government and the Pandrilus Foundation. The location is crossed by roads, and situated near Limbe City Council. All species harbored in this place had been donated by the local hunters or confiscated by the Government of Cameroon. The LWC primarily helps to rescue these species and reintroduce them to natural environment in mount Cameroon national park. The climate of Limbe area including the reintroduction site, Mount Cameroon National Park is characterized by a period of heavy rains occurring from the

*Corresponding author. E-mail: melleekane@gmail.com.

Figure 1. Map of Limbe city showing the location LWC (Source, field study 2016).

months of June to October, and a dry period extending from November to May. At lower altitude, the annual rainfall ranges from 1,000 mm^3 at Cape Debundscha to less than 2,000 mm^3 in the north-east around Munyenge area (Figure 1).

The mean annual rainfall decreases with altitude to approximately 4,000 mm^3 at 1000 m and less than 3,000 mm^3 above 2,000 m (Payton, 1993).The temperature falls with increasing elevation where mean air temperature is 26.78°C, with monthly values ranging from 24.98°C in August, the rainiest month. Payton (1993) points out that, the humidity remains at 75 to 85% due to the influence of the marine ecosystem.

Zoo is enclosed with a strong wire-net fence with an estimated height of 10 m and a circumference of 400 m. In the heart of this enclosure is the drill monkey cage occupying an estimated area of 900 m^2.The wire-net cage with 100 has a few trees and a constructed woody stand device serving the 100 drill monkeys in the cage for climbing.

Data collection

The research data on the drill monkeys was collected during four months (from 15th May to 15th August, 2016), six days each month. Preliminary non formal observation was carried out to determine the behavior categories of the subjects (Md-Zain et al., 2008b).

Preliminary, observation is critical for the observer to be familiar with the subjects and their behaviors, thus enabling them to choose the right measures and recording methods (Martin and Bateson, 1993). The enclosure was divided into seven observational areas called zones; each zone had its distinctive point for clear identification. Behavioral observations began in the morning between 6:00 and 6:30 am and ended at 6:30 pm each day of the study. Data were collected using instantaneous scan sampling at predetermined intervals. Martin and Bateson (2007) define "instantaneous scan sampling" as when "a whole group of subjects is rapidly scanned, or "censured," at regular intervals and the behavior of each individual at that instant is recorded."

Behavioral data can be collected in several ways (Altmann, 1974). In categorizing these methods, Martin and Bateson (2007) distinguish between sampling rule (whose behavior is watched and when) and recording rules (how the behavior is recorded). Hence, the scan sample data for this survey was collected after every 10 min (Altmann et al., 1993). Between the 10 min of scan, sampling a focal sample was conducted for 5 min. All the scan observations were done from right to left throughout the study. The focal animal was randomly selected for the day, based on the age sex classes. The drill behaviors were recorded during scan and focal. The following behaviors were recorded; feeding, foraging, locomotion, social behaviors and resting.

The frequency data generated were analyzed by the use of exploratory statistical distribution tool for each observed behavior in the study. Perason chi-square was also used to compare the different activity budget for the behavior of each sex age class in the drill group.

RESULTS

From Figure 2, feeding behavior has the highest

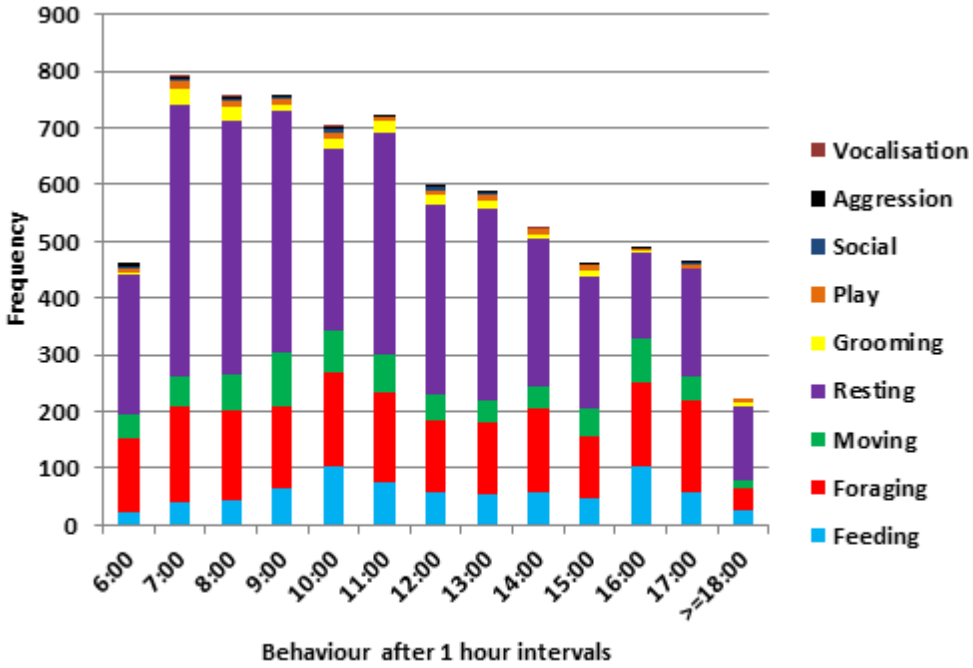

Figure 2. The frequency of behavioral activities within a one- hour-interval period.

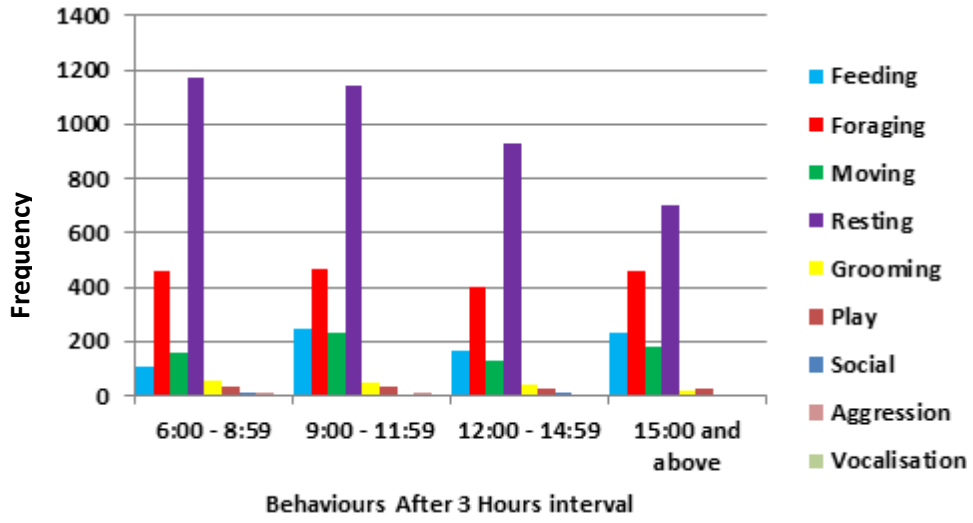

Figure 3. The frequency of behavioral activity within a three-hour-interval period.

frequency at 10 am and 4 pm while foraging has its peak at the hours of 7 am and 5 pm. Resting behavior was observed with a significant drop at 4 pm and observations were done each day between 6 am and 6:30 pm as shown in Figure 3.There is a significance for the daily activity at different time ranges (X^2=172.282 df =24 P<0.05). There was no significance between 6:8.59 am to 12:2.59 pm for foraging (X^2=0.103 df =1 P=0.749) however, there was a significant difference on foraging from 12 am to 2.59pm and 3 to 6:30 pm (X^2=9.607 df=1 P<0.002) where the drills spent more time resting from 6 to 8.59 am and 12 to 2.59 pm (X^2=6.164 df=1 P<0.013). Also, there was a significance for feeding between 6 to 8.59 am and 3 to 6.30 pm (X^2=85.63 df =1 P<0.05). The drill group spent more time feeding in the morning than in the evening period of the day (Table 1).

Table 1. The definition of behavioral categories.

Activity type	Description
Feeding	Process of drinking water or eat food
Foraging	Process of looking for food and insects
Locomotion	Any locomotory process
Resting	The state of being inactive
Social (grooming, play, aggression)	Any interaction within individuals in the group
Vocalization	The act of producing sound for predators or against predators

Table 2. Monthly activity budget.

Months	Feeding %	Foraging %	Resting %	Moving	Play %	Social	Grooming %	Aggression %	Volcalisation
May	14.7	17.9	51.7	10.7%	2.7	-	2	0.1	0.1%
June	15	17.1	50.5	12.5%	2.1	0.6%	2	0.1	-
July	6.3	29.1	51.4	9.%	0.9	0.3%	2.3	0.6	0.1%
August	5.9	28.1	55.5	5.9	0.8	0.8%	2.3	0.7	0.1%

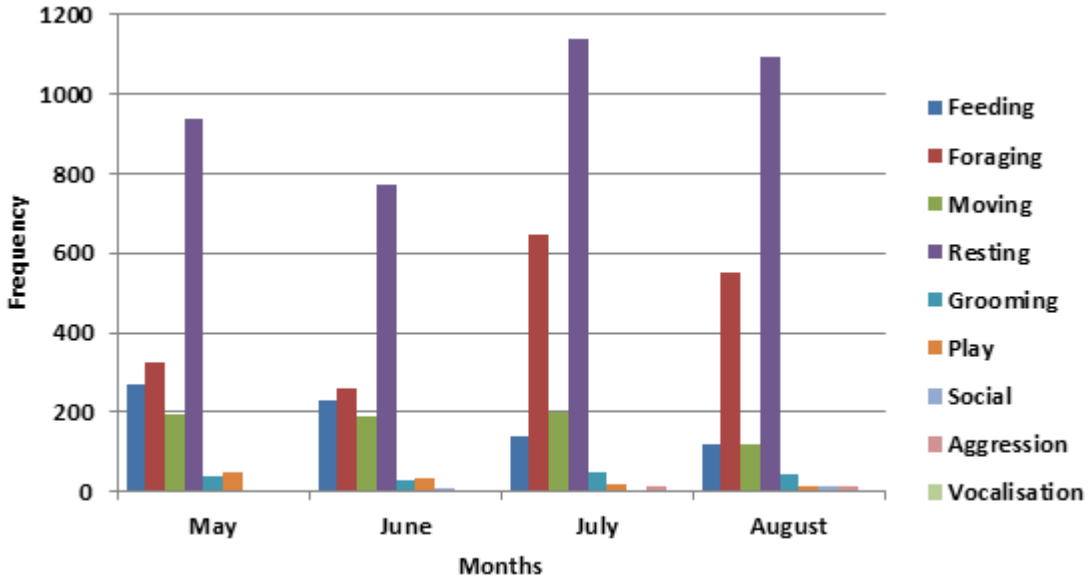

Figure 4. The monthly drill behavior of all age-sex classes.

Table 2 shows the monthly time budget for the behaviors in which resting was the highest throughout the months with a mean value of (51.7%) followed by foraging with a mean value of (22.2%), feeding with a mean value of (10.25%) and movement with (9.5%). Furthermore, there is a significance between movement in the month of May and August (X^2=27.52, df = 1, P< 0.05). There also exist no significance between resting in the month of May and August (X^2=6.82, df = 1, P = 0.009) and no significance in the Months of May and June (X^2= 0.464, df = 1, P > 0.05).

Resting behavior of the drill group was dominant and peaked in the month of July and August as shown in Figure 4. Foraging also was recorded high in July and August as compared to the other months. Movement behavior was reduced in August as compare to other months due to heavy rains that would always cause the drill group to rest. Other social behaviors like aggression, play, grooming and vocalization were also varied during this period of time.

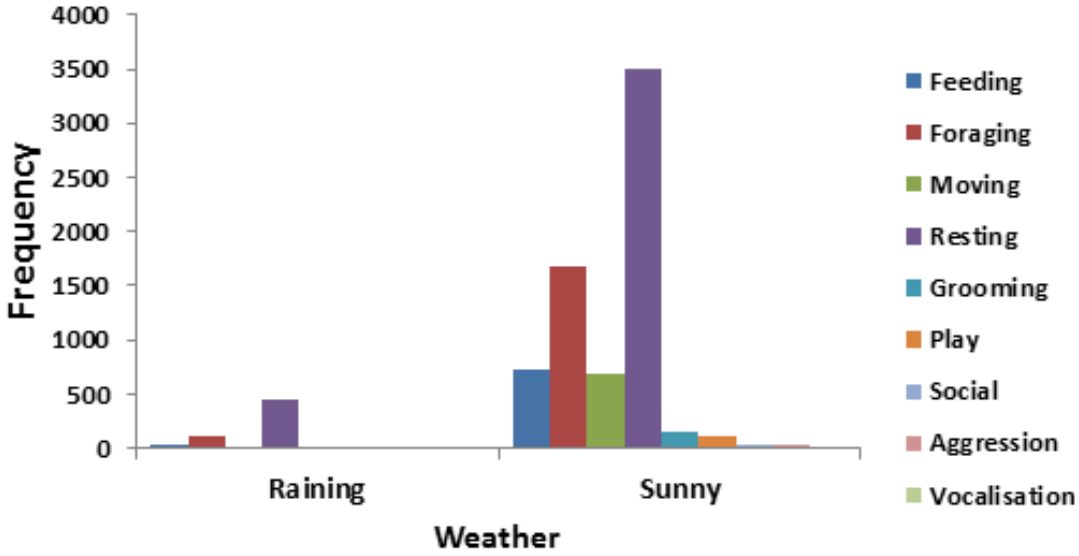

Figure 5. Time budget with respect to sunny and raining weather.

Table 3. The correlation between behaviors and weather changes.

BEHAVIOUR	R^2	X^2	P<
Resting	0.11	94.6	0.000
Feeding	-0.06	30.7	0.000
Moving	-0.06	29	0.000
Foraging	-0.04	12	0.000
Grooming	0.001	0.004	0.94
Play	-0.001	0.8	0.36

R^2=Pearson correlation value, X^2=Pearson chi square value, P = confident interval.

Rain fall actually brought a change in the time budget, much time was spent resting the reason for which it recorded the highest activity budget (Figure 5). Table 3 has shown a positive correlation between resting for raining and sunny weather (R^2=0.11 P<0.05). All categories of age-sex class spent less time foraging (X^2=12 df =1 P<0.05) and more time resting during raining than sunny weather (X^2= 94.6 df=1 P<0.05). There was no significance for grooming and playing on weather changes (P>0.05).

DISCUSSION

Activity budget in the drill monkeys

Primates can flexibly adjust their activity budgets to deal with environmental changes. The amount of time that primate individuals allocated to each activity is affected by ecological and social factors (Gursky, 2000; Di and Fiore Rodman, 2001). This survey reveals that, the time budget for different behaviors differed significantly in daily observations. This agrees with study of Umapathy and Kumar (2000) on *Macca silenus* that showed fluctuation in daily activity budget.

Resting

Resting was the dominant behavior in this study. The group was observed spending resting time in sitting postures, quadrupedal standing and lying postures. During this period, the hind limbs were placed in a variety of position while the fore limbs often rest on the knees or between the hind limbs. Resting time however, is an unlimited source of additional time not only an absolute limit which is imposed by the fact that, there are only 12 h of the day light in the tropical day but some resting time may be for some other purposes like vigilance, allowing tired muscles recover, digestion, or simply as time gaps between successive bouts of activity.

The use of resting time for digestion may be important in drill monkeys, especially after feeding on food rich in fibers or leaves in order to extract nutrients from plants structural elements (Gursky, 2000). In addition to time required for digestion, environmental conditions may improve limitation on the amount of time that the animal can be active. This is particularly relevant in habitats characterized by high temperature where animals may be obliged to rest in the shade during the hottest part of the day. Furthermore, the animal groups' feeding was

programmed two times a day only causing the group to rest for longer periods.

Monthly time budget for the drill monkeys

This study shows the month of May with the highest activity while the August has the least. This supports the study of Di Fiore and Rodman (2001) who found that primate activity, feeding, foraging, resting, grooming, movement, vocal, social, aggression, and play are affected by rainfall intensity in the tropics. Following strategy two above, their results suggest that rather than increasing time dedicated to foraging or feeding, the monkeys rested more when fruit availability was lower.

In contrast to Isbell and Young (1993), study of Cercopithecus feeding and foraging time increased significantly in the season, in which the animals' diets were limited almost entirely to the seeds of single plant species with presumed high handling time. Numerous studies have demonstrated that primate activity patterns change over time in response to seasonality Oates (1987) and Di Fiore and Rodman (2001). In consequence, there are seasonal peaks and troughs in the abundance of particular primate foods Oates (1987). When resource availability goes down, animals are expected to either increase time dedicated to feeding and foraging, thus an increase in energetic costs of finding food and reduced feeding is selective at the expense of resource quality which also generally minimize energy expenditure. The diets of drills in captivity do not depend on the seasons or monthly periods, where food is provided every day. This means that their time budget cannot be influenced by fruits scarcity or abundance.

Weather influence on the social behavior of drill monkeys

The maintenance of homeothermy in primates involves a combination of both autonomic and behavioral processes, where behavioral changes should be used first as a means to conserve the water and energy, required for autonomic processes (Dunbar, 1992). Direct weather constraints on activity budgets have received little attention. It is known that at high temperatures, some the animals tend to spend more time resting (Hill, 2006; Campos and Fedigan, 2009; Korstjens et al., 2010; Sato, 2012; Majolo et al., 2013), and that resting and shade-seeking which are critical for thermoregulation (Campos and Fedigan, 2009): high heat load can cause severe dehydration and potentially fatal hyperthermia. In contrast to the reduced demand for shade-seeking and resting in colder temperatures, the energetic demands of thermoregulation and digestion are higher in cold conditions, which mean that more time are needed to be spent on feeding (Satinoff, 2011; Majolo et al., 2013).

Grooming in drill monkeys is a very prominent form of social activity that was observed in this group early in the day, during the mid-day quiet period, and when the animals approach the sleeping site in the evening period of the day. The adult females with juveniles were observed groomed more by the adult males. This agrees with the findings of Silk et al. (2009) which states that grooming in primates is more frequent with lactating adult females. Majority of social primates spend time in maintaining their grooming relationships with conspecifics, which may detract them from their available feeding and resting time.

Conclusion

Captivity remains a key place to restore the decrease population of the endangered species in the wild. Drill scheduled their daily time into particular activities while foraging is the most intensified at the morning and evening resting at 12 to 14h.

The associations of these groups resemble that of any primate, where affiliative and agonistic interactions always keep individuals apart and some closer. The present decline of drill in the wild, paints a picture of the world in which the most second sexually dimorphic species to mandrills shall be found extinct. Wild drills habituate thick forest, usually foraging on the forest floor which possessed litter leaves, rotten logs of wood; where termites, insects are founds with other arthropods. Resting was the dominant activity recorded in the study, due to their relatively small enclosure with a two times feeding daily programme. Little had been seen on this species climbing the platform which may be considered as trees, male adult are regular individuals on the floor resting. Even though drill monkeys show high sexual dimorphism, male drills jump across trees with little stress looking for stable branches (Astaras, 2009).

The survey revealed a deviation in the activity budget for this group of captive drills, while their natural behaviors are being affected in captivity. Foraging, feeding and vocalization are key activities for their survival in a natural habitat, but when these behaviors are altered the changes of surviving in the wild might be limited. In case of any reintroduction or release programme, I strongly recommend a soft, semi-provisioned food release before a hard release. Drill will exhibit all their social behavioral repertoires which constitute agonistic and affiliative interactions. Certain behaviors like movement/resting should frequently be checked on age/sex classes because so much resting may be due too much food intake by male adults, which can result to diseases.

According to the results obtained from the study; resting, foraging, feeding and moving were the most

dominant behaviors while grooming, playing, social, aggression, and vocalization were the least dominant behavior. This study is important in order to understand clearly the daily activity budgets of drill monkeys on ecological changes in captivity, leading to the effective management and conservation of this species in the future.

RECOMMENDATION

The authorities should budget and provide enough food and medical care for the drill monkeys in the zoo to normalize some of the social behaviors like resting believed, which will be high unprecedentedly. The zoo enclosure and cages should be equipped climbing, playing, feeding and resting facilities to simulate the wild environment where these animals are being prepared for reintroduction.

Animals should be kept whenever possible, in social groups that are most reflective of natural social systems. Keepers and collection managers will have to closely monitor newly placed males and remove them, where the males experience higher than normal levels of aggression. To ensure that captive animals are experiencing an environment that best represents the wild condition, animals should not be housed together with other species unless there is natural overlap in their ranges. Species with overlapping range are less likely to promote stress responses (assuming we are not housing prey with predators).

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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