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Growth performance and carcass characteristics of central highland goats in Sekota District, Ethiopia

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ABSTRACT

On farm monitoring of central highland goats were conducted in Sekota district of the Amhara regional state, Ethiopia to evaluate the growth performances under the traditional management practices. On farm feeding trial was also conducted to see the feeding performances and carcass characteristics of Central Highland goat types. Data used for the study was collected from randomly selected on-farm flocks for two years. Yearling bucks were assigned randomly in to two feed types: grazing only and grazing plus concentrate. The overall mean birth weight, weaning weight and yearling weight obtained were 2.01 ± 0.03 , 9.02 ± 0.18 and 20.61 ± 0.74 kg, respectively. All the fixed effects considered were significantly affected birth weight and weaning weight. However, at yearling age, parity and type of birth were not significant. Kids from larger parity does, single born kids, male kids and kids born in the wet and cool season had higher ($p < 0.001$) birth and weaning weights from their group. Male kids and kids born in the dry season had heavier weight than female and wet season born kids. The overall mean pre- and post- weaning growth rate obtained were 76.6 ± 2.3 and 42.8 ± 2.9 g/day, respectively. Kids born from later parity does, single and kids born at wet season had higher ($P < 0.001$) pre-weaning growth rates than kids born from first parity, as twins and kids born during hot dry season, respectively. The overall mean final body weights of goats from the feeding trial were 28.7 and 30.8 kg for the control and

supplemented groups, respectively. Even though, there were numerical differences on final body weight and carcass parameters, there was no significant difference between supplemented and non supplemented groups of yearling bucks. Central Highland goat in this study showed better growth performances than most of the goat breeds in Ethiopia. The significant effect of fixed effects needs to be considered in developing breeding strategy for the breed. Moreover, integrated efforts combining the feed, breeding and health aspects of production are very important to make use of the breed.

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1. Introduction

The goat population of Ethiopia is estimated to be 21.7 million (CSA, 2011). Goats in Ethiopia make an important contribution to the poor household in particular and national economy in general. They provide 30% of all domestic meat consumption and generate cash income from exports of meat, mainly as live animals and skins (Zelalem & Fletcher, 1991).

Goats in Ethiopia are found distributed in different agro-ecological zones. A large proportion (58%) is found in the lowlands of the country raised in large flocks by pastoralists while the rest, 42% of the total are found in the highlands (ESGPIP, 2008). Goats in the traditional production system are maintained with a very little resource input and therefore are low productive. According to breed characterization reports (FARM Africa, 1996), central highland goats are among the goat breeds found distributed Central highlands, west of the Rift Valley, Wollo, Gondar and Shoa (ESGPIP, 2008; FARM Africa, 1996). These goats are grouped in the small east African family goats. These goats are characterised as Medium-sized, broad-faced, thick horns, reddish-brown colour. Mature males weigh about 43.0 ± 7.7 kg and females weigh 30.1 ± 5.4 kg (ESGPIP, 2008; FARM Africa, 1996). Growth is an important trait affecting the productivity of animals. It is through growth that animals produce meat and cash income as sale of live animals (Belay and Mengistie, 2013). Therefore, understanding and documenting the growth performances of indigenous breeds of goats is very important to design improvement strategies for a particular breed. The objective of this research was to evaluate the growth performances under traditional management systems and see the effect of feeding on feeding performances and carcass traits of Central Highland goats.

2. Materials and methods

2.1. Description of the study area

The study was conducted in Sekota District, which is located in the Amhara Region, Waghimra Administrative Zone. It is located about 720 km North from Addis Ababa. The altitude of the area ranges from 1340-2200 m a.s.l (ZAD, unpublished). Annual rainfall ranges between 350 - 700 mm, falling mainly from July to September. The pattern and distribution of the rainfall is erratic and uneven. Average temperature ranges from 16-27°C (ZAD, unpublished). The vegetation can be characterized as being semi-arid shrubs dominated by various Acacia species with a sparse ground cover of annual grasses. The district is characterized by long dry season lasting from October to June.

2.2. Data collection and management

The study had two phases: on-farm monitoring that randomly selected flocks were monitored for two years. The second part was the feeding part that yearling bucks were randomly allocated to two feeding treatments and evaluated.

2.2.1. On-farm flock monitoring

For this study, two rural administrations were purposively chosen for monitoring purpose in sub humid part of the district based on goat population. A total of 22 households rearing central highland goats were randomly

selected. Animals were ear tagged using permanent plastic ear tags applied at the start, when born and purchase. The age and parity of does in the flock were determined by dentition and information from the owners at the beginning of the monitoring activity. Data on growth and other parameters were collected by trained enumerators recruited from the locality and supervised by researchers on monthly basis.

Animals were maintained under traditional management system. They were grazing in a communal grazing land during the whole day and housed in the night times. Breeding was year round and uncontrolled. During the course of data collection, animals were de-wormed and sprayed for internal and external parasite control three times a year. Vaccinations for prevalent diseases of the area were given once in a year.

2.2.2. Data management

Data on growth collected at birth include doe id, kidding date, kid id, kid sex, parity, kid birth weight, birth type (litter size) were recorded with in 24 hrs of kidding by trained enumerator recruited on site. Kids were weighted fortnightly after birth until yearling age using Salter balance. All data were recorded and managed in MS-excel computer program.

2.2.3. On farm feeding trial

On-farm feeding trial was conducted to see the effect of supplementation on growth and carcass characteristics of yearling goats. Since the objective of the trial was to see the effect of feeding, it had only two treatments; control group (animals on grazing only) and those on grazing plus 300 g DM concentrates mix (T2).

2.2.3.1. Experimental animals and treatment

A total of 12 intact male yearling central highland goats with similar body condition and weight were purchased and used in the trial. The mean initial body weight of goats was 23.0. Experimental animals were vaccinated against common diseases as well as drenched and sprayed against common internal and external parasites in the area during the two weeks adaptation period. A complete randomized design was used that animals were randomly assigned to the two feeding regimes (control and supplemented group).

2.2.3.2. Feeding management

All the experimental goats were grazed on the communal grazing area on hill side for 8.00 hours in the day time. The supplemented goats were supplemented with 300 g DM/head/day of concentrate mix consisting of wheat bran and noug seed cake at the ratio of 1:2 at night in their barns. The supplemented feed was offered in individual feeding pens. The trial was conducted for 90 days with 15 days adaptation period. The goats had access to water once a day in a nearby river (1 km distance) and free access to salt blocks. The quantity of supplement offered and refused was measured for each animal per day. Body weight of animals was recorded every 10 days before going out for grazing. The daily body weight gain was analysed by regressing body weight measurements on days of feeding.

2.2.3.3. Carcass evaluation

At the end of the feeding period, all goats were slaughtered for assessing carcass characteristics. Prior to slaughter, body weight was measured to determine the slaughter weight. Following slaughter hot carcass were recorded. Empty body weight was calculated as the difference between slaughter weight and gut content. Dressing percent was calculated as the proportion of hot carcass weight to slaughter weight and empty body weight. Total edible offal percent calculated as the proportion of total edible offal to slaughter weight and total edible percent calculated as the proportion of edible offal plus hot carcass to the slaughter weight. Each carcass was cut between the 12th and 13th ribs perpendicular to the back bone to measure the cross sectional area of the rib-eye muscle area. The cross section of the rib-eye muscle was traced on a transparent folic and measured by use of a square paper superimposed on the transparent folic. The area of the square that fell within the traced area was then counted. The average was taken as the rib-eye area.

2.3. Statistical analysis

Data on growth performances and carcass characteristics were analysed using the General Linear Model Procedures of Statistical Analysis System (SAS, 2003). The dependent growth variables analysed were birth weight,

weight at different ages, growth rate, feeding body weight gain and carcass characteristics. Weight at three months, six months and at yearling was adjusted as follows:

$$\text{Adjusted weaning weight (kg)} = \frac{90(w_2 - w_1)}{D} + w_1$$

$$\text{Adjusted six months weight (kg)} = \frac{180(w_3 - w_1)}{D} + w_1$$

$$\text{Adjusted yearling body weight (kg)} = \frac{365(w_4 - w_1)}{D} + w_1$$

Where: W2, W3 and W4 = weight at a given age

W1 = birth weight

D= number of days between weighing date and date of birth

Pre- and post- weaning growth rates were calculated as:

$$\text{Pre-weaning growth rate (g)} = \frac{(AWWT - BWT)}{90}$$

$$\text{Post-weaning growth rate (g)} = \frac{(AYWT - AWWT)}{275}$$

Where: BWT= birth weight

AWWT= adjusted weaning weight at 90 days

AYWT= adjusted yearling weight at 365 days

The fixed effects considered for the analysis were parity of doe, type of birth and season of birth. Season was categorized as 1) Wet season: spans from July to September and green natural pasture is available; 2) Cool season: from October to January which is characterised as relatively cool temperature with aftermath grazing. The quantity and quality of natural pasture is depleted at this time; 3) Hot season: from February to June and have a very hot temperature and both the natural pasture and aftermath grazing is scanty. Type of birth was classified as single when single and multiple when it is two and above.

The models used were:

$$Y_{ijkln} = \mu + S_i + B_j + P_k + T_l + \epsilon_{ijkln}$$

Where:

Y_{ijkln} = observation on birth weight, weight at different ages and growth rate

μ = overall mean

S_i = fixed effects of the sex (i = male, female)

B_j = fixed effects of the birth type (j= single, multiple)

P_k = fixed effects of the parity (k= 1, 2, 3 4, 5, >6)

T_l = fixed effects of the season of birth (l= Wet season, Cool season, Hot season)

ε_{ijkln} = is the random error

For the analysis of the feeding experiment (final body weight, weight gain) and carcass parameters the following model was used.

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Where:

Y_{ij} = observation on final body weight, weight gain, carcass characteristics

μ = overall mean

Ti= the effect of treatment (i= control, supplemented)

εij= random error

3. Results and discussion

3.1. Birth weight

The overall least-squares mean birth weight of Central Highland kids were 2.01 ± 0.03 kg (Table 1). This result is lower than the value reported for the same breed by Tesfaye et al. (2006). However, it is in agreement with the value of 1.9 ± 0.14 kg, reported for Abergelle goats of raised under traditional management system (Belay and Mengistie, 2013).

The fixed effects considered had exerted a significant effect on birth weight of central highland goats. Does beyond third parity tend to produce heavier ($P < 0.001$) kids than their first and second parity does. This might be related to the doe weight at kidding. This type of effect is similar with literature (Ahuya et al., 2009; Belay and Mengistie, 2013). The heavier birth weight at late parities can be explained by the heavier dam weight and larger size at later parities (Awgichew, 2000), and the physiological imprint in the uterus during the first pregnancy will facilitate relatively greater foetal growth in subsequent pregnancies (Gardner et al., 2007). Contrary to this, Zeleke (2007) stated that kids born from dams of fifth parity had lighter weights at birth compared to kids born from dams of first to fourth parities in Somali goats at Haramaya University.

Birth type showed significant effect on birth weight of kids that single born kids were heavier ($P < 0.001$) at birth than those born as twins (Table 1). This difference may be due to the effect of maternal influence. The reduction in birth weight of lambs for large litter size is related to the fact that as the number of fetuses increases in utero, the number of caruncles attached to each fetus decreases, as a result the feed supply to the fetuses thus reduces (Robinson et al., 1977). Gardner et al. (2007) stated that because of the finite capacity of the maternal uterine space to gestate offspring, as litter size increases individual birth weights decline.

Table 1

Least-squares means (\pm SE) of kid birth weight (kg), three months weight (kg), six months weight (kg) and yearling weight (kg) of Central Highland goats in Sekota district

Variables	Birth weight		Three months weight		Six months weight		Yearling weight	
	N	LSM \pm SE	N	LSM \pm SE	N	LSM \pm SE	N	LSM \pm SE
Overall	608	2.01 ± 0.03	476	9.02 ± 0.18	318	13.82 ± 0.39	89	20.61 ± 0.74
Parity of dam		***		***		***		NS
1	107	1.74 ± 0.05^c	77	7.74 ± 0.24^c	39	12.40 ± 0.55^c	11	19.81 ± 1.09
2	96	1.90 ± 0.05^b	84	8.39 ± 0.23^{bc}	60	12.81 ± 0.47^{bc}	17	19.86 ± 0.84
3	99	1.88 ± 0.05^{ab}	82	9.10 ± 0.22^{abc}	56	14.11 ± 0.47^{abc}	13	21.51 ± 0.98
4	116	1.99 ± 0.04^{ab}	90	9.33 ± 0.20^{ab}	63	14.09 ± 0.41^{abc}	20	20.08 ± 0.76
5	104	2.11 ± 0.05^a	81	9.87 ± 0.21^a	61	14.92 ± 0.40^a	17	20.91 ± 0.73
6	86	2.09 ± 0.05^a	62	9.69 ± 0.24^a	39	14.59 ± 0.51^a	11	21.50 ± 0.99
Type of birth		***		***		***		***
Single	432	2.08 ± 0.03^a	353	10.06 ± 0.12^a	238	15.32 ± 0.26^a	59	21.92 ± 0.50^a
Twin	176	1.83 ± 0.04^b	123	7.98 ± 0.18^b	80	12.32 ± 0.40^b	30	19.30 ± 0.67^b
Sex		NS		***		NS		*
Female	276	1.92 ± 0.03^a	224	8.72 ± 0.14^b	152	13.52 ± 0.31	43	19.73 ± 0.56^b
Male	332	1.99 ± 0.03^a	252	9.32 ± 0.14^a	166	14.12 ± 0.32	46	21.49 ± 0.58^a
Season of birth		***		***		***		NS
Cool season	331	2.03 ± 0.03^a	285	8.81 ± 0.12^b	206	12.08 ± 0.23^c	50	20.44 ± 0.47
Hot season	160	1.72 ± 0.04^b	80	7.74 ± 0.21^c	30	14.14 ± 0.59^b	9	21.04 ± 1.13
Wet season	117	2.11 ± 0.05^a	111	10.51 ± 0.19^a	82	15.24 ± 0.37^a	30	20.35 ± 0.61

a,b,c means with different letter with in the same column of the same variable are significantly different at the indicated p-value; *** $P < 0.001$; NS: Not significant; N= number of observation

Kids born in the wet and cool dry season were heavier ($P < 0.001$) than those born in the hot dry season. This is probably due to doe's nutritional status during the late stage of pregnancy. Doe's kidding during the wet and cool dry season have got better browses and green pasture at late stage of pregnancy than doe's kidding during the dry season. Dunn and Moss, (1992) explained that rapid rate of fetal growth occurs at late stage of pregnancy, nutritional stress during this time resulted to body weight losses and increased the risk of reproductive wastage due to abortion, retardation of fetal growth and reduced birth weight.

3.2. Weaning and yearling weight

The least squares overall mean adjusted weaning weight of Central Highland kids obtained in the current study (9.02 ± 0.18 kg; Table 1), was comparable with Arsi Bale goats (Tatek et al., 2005), Boran Somali kids (7.2 kg) and Highland kids (9.02 ± 0.18 kg) (Tucho et al., 2000). However, this value was higher than the value reported for Abergele weaner kids (Belay and Mengistie, 2013), Mid Rift Valley kids and Highland goats (Tucho et al., 2000).

Analysis of variance of weaning weight showed significant difference on parity. There was an increasing trend from first parity does to the later parity does. It is clear that, as age increases from first parity onwards, the mothering ability of dams i.e., nursing ability; milk production gets improved thereby increasing the growing performances of their kids. The better birth weight from larger parity dams can be reflected here too. Similar type of effect is reported in different literatures (Belay and Mengistie, 2013; Jiménez-Badillo et al., 2009; Dadi et al., 2008; Zeleke, 2007; Liu et al., 2005).

Type of birth and had significant influence on three months weight of Central Highland goats that single birth and male kids were heavier ($P < 0.001$) than their multiple born and female contemporaries. Effect of birth type can be explained by the carry-over effect of the heavier weight of single-born kids at birth (Duguma et al., 2002) and the fact that single-born kids are the sole users of milk from their dam (Tibbo, 2006). The superiority of males over females could be due to hormonal differences in their endocrinological and physiological functions (Ebangi et al., 1996).

Season of birth showed significant ($p < 0.001$) difference; kids born during the wet season had heavier weaning weight followed by cool season born. This effect can be explained by the better nutritional availability of for both the dam and kid during the wet and cool seasons. This effect is reported in the literature (Belay and Mengistie, 2013; Jiménez-Badillo et al., 2009; Dadi et al., 2008).

Six month and yearling weights of Central Highland goats were 13.82 ± 0.39 and 20.69 ± 0.74 kg (Table 1). These were larger than that for Mid Rift Valley (7.87 ± 1.62 and 12.85 ± 2.55 kg) reported by Tucho et al. (2000). These were comparable with 13.61 ± 0.40 and 20.15 ± 0.67 of the same breed at Debre Berhan area (Tesfaye et al., 2006). Fixed effects affected six months weight almost in a similar fashion with birth weight and three months weight. The exception is sex to which it was not significant for this trait. The effect of type of birth was persistent to yearling age.

3.3 Growth rate

The overall mean least squared pre- and post- weaning daily weight gains obtained in this study are presented in Table 2. Pre-weaning weight obtained (76.6 ± 2.27) was lower than pre-weaning growth rate under traditional managements (104 g/day) of Ethiopian goats reported by Mukassa-Mugerwa et al. (1989). However it is higher than extensively managed Somali goats in Eastern Ethiopia (Zeleke, 2007) and Abergelle goats (Belay and Mengistie, 2013). The differences in the pre-weaning weight gains are closely associated with the differences in level of milk intake during milk feeding period and the nutritional status of the doe (Negi et al., 1987; Singh et al., 1987).

Analysis of variance of pre-weaning growth rate showed significant difference ($P < 0.001$) on parity. This trait was lower for first parity than later parity does. This indicates that as the does parity increase, they were able to provide more milk than first parity does. The pre-weaning growth rate of kids depends on the dam's milk yield and nutrition status of the dams (Wilson 1987). Does at first parity may have less mothering ability than those in later parity.

Type of birth exerted significant effect on kid growth rate that single born kids grow faster than their multiple born kids (87.8 ± 1.38 vs. 65.3 ± 2.22 , $p < 0.001$). This effect might be because of nutrition that multiple born kids need to compete for milk consumption from their dam while single born kids are sole users of milk from their dam. This type of effect is reported in the literature (Belay and Mengistie, 2013; Zeleke, 2007).

The pre-weaning growth rate of Central Highland kids was affected by sex of kid; males grow better than their female counterparts (73.7 ± 1.69 vs. 79.4 ± 1.67 , $p < 0.001$). The higher daily weight gains in male kids than in females is in agreement with the reports of other scholars (Zelege, 2007) and (Belay and Mengistie, 2013). This is a natural phenomenon that male kids grow faster than females, as their mature weight is also heavier.

Kids born during the wet season had better ($p < 0.001$) growth rate followed by those born in the cool season. Like that of weaning weight, this might be because of better nutritional availability in the said seasons for both the dams and the kid. The effect of season on growth rate of kids is reported somewhere in the literature (Belay and Mengistie, 2013; Ahuya et al., 2009; Jiménez-Badillo et al., 2009; Zelege, 2007)

Post-weaning growth rate obtained in the current study (43.41 g/day, Table 2) is larger than those reported for Abergelle goats (Belay and Mengistie, 2013). Analysis of effect of fixed factors showed that parity and type of birth did not show significant effect on post weaning growth rate. This might be because the growth of kids after weaning is largely dependent on their genetic make. The dependency of kids on their dams gets diminished as age of kid increases from weaning. Das et al., (1993) explained that the rate of growth of kids after weaning was partly determined by the genetic potential of the kids and the level of environmental influences.

However, Season of birth exerted a significant effect ($P < 0.001$) on post weaning growth of kids of Central Highland goats. Kids born during dry season had heavier post weaning growth rate followed by their cool season born kids. This might be because, kids born in the dry season were not able to get enough amount of feed in their pre-weaning age and when they get enough feed in the coming wet season they tend to grow better. This can be explained partly by compensatory growth.

Table 2

Least squares means (\pm SE) of pre- and post- weaning daily body weight gains of Central Highland goats in Sekota district

Variables	Pre-weaning growth rate (gm/day)		Post-weaning growth rate (gm/day)	
	N	LSM \pm SE	N	LSM \pm SE
Overall	476	76.6 \pm 2.27	89	42.8 \pm 2.90
Parity of dam		***		NS
1	77	62.1 \pm 2.91 ^b	11	46.3 \pm 4.16
2	84	68.7 \pm 2.73 ^{ab}	17	43.0 \pm 3.19
3	82	77.2 \pm 2.64 ^a	13	50.5 \pm 3.71
4	90	80.1 \pm 2.38 ^a	20	38.6 \pm 2.89
5	81	85.9 \pm 2.54 ^a	17	39.2 \pm 2.80
>6	62	85.3 \pm 2.89 ^a	11	39.2 \pm 3.68
Type of birth		***		NS
Single	353	87.8 \pm 1.38 ^a	59	42.0 \pm 1.91
Twin	123	65.3 \pm 2.22 ^b	30	43.6 \pm 2.56
Sex of kid		**		NS
Female	224	73.7 \pm 1.69 ^b	43	43.1 \pm 2.14
Male	252	79.4 \pm 1.67 ^a	46	42.5 \pm 2.21
Season of birth		***		***
Cool dry	285	72.2 \pm 1.50 ^b	50	43.0 \pm 1.83 ^b
Hot dry	80	62.2 \pm 2.65 ^c	9	51.3 \pm 4.29 ^a
Wet	111	95.3 \pm 2.33 ^a	30	34.1 \pm 2.29 ^c

a,b,c means with different letter with in the same column of the same variable are significantly different at the indicated p-value; ** $P < 0.01$; *** $P < 0.001$; NS: Not significant; N= number of observation

3.4 Feeding performances and carcass characteristics

Feeding performances and carcass characteristics of Central Highland goats is presented in Table 3. There was no significant difference ($P > 0.05$) in growth performances and carcass characteristics between supplemented and non-supplemented grazing group. This might be due to the time that the trial carried out was when there was

relatively better feed available. However, the supplemented groups performed numerically better than the non-supplemented group.

Table 3

Feeding performances and carcass characteristics of Central Highland goats kept on grazing only and/or supplemented with graded levels of noug seed cake and wheat bran mixtures at a 2:1 ratio.

Variables	T1	T2	SEM	SL
Initial body weight(kg)	23.1	22.8	0.93	NS
Final body weight(kg)	28.7	30.8	0.99	NS
Average daily weight gain (g/day)	37.6	54.0	3.27	NS
Carcass characteristics				
Slaughter weight	28.7	30.8	0.99	NS
Hot carcass weight	11.2	12.5	0.49	NS
Empty body weight	22.6	24.9	0.83	NS
Dressing percent on slaughter weight basis	38.9	40.5	1.01	NS
Dressing percent on empty body weight basis	49.5	50.2	1.30	NS
Fore quarter	3.0	3.5	0.15	NS
Hind quarter	3.0	3.3	0.13	NS
Rib-eye muscle area	11.7	12.3	1.36	NS

SEM=mean of standard error and SL= Significant level; T1= grazing only and T2= grazing + 300g noug seed cake and wheat bran mix at a ratio of 2:1; NS – Not significant

4. Conclusion

From the trial it is possible to conclude that Central Highland goat have better growth performances than most of the goat breeds in Ethiopia like Abergelle. The significant effect of parity, type of birth and season at different ages indicates the potential of the breed for better productivity under improved management system. Therefore, the significant effect of fixed effects needs to be considered in developing breeding strategy for the breed. Moreover, integrated efforts combining the feed, breeding and nutritional aspects of production are very important to make use of the breed.

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