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REGULAR ARTICLES

Growth, reproductive, and productive performance of Begait cattle under different herd management systems in northern Ethiopia

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Abstract

The performance of indigenous Begait cattle (498 cows, 284 calves, and 48 heifers) in northern Ethiopia was studied. System of herd management significantly ($P < 0.01$) influenced all production traits. Calves in medium-input herds (MIHM) grew faster than those in low-input herds (LIHM), by 232 g/d from birth to 9 months ($Gain_1$) and by 385 g/d from 9 to 12 months ($Gain_2$). Cow's dry period, calving interval (CI), and age at first calving (AFC) were 234, 222, and 343 days shorter for MIHM than for LIHM. Compared with LIHM, cows from MIHM had 74% higher daily milk yield (DMY) and 91% higher lactation milk yield (LMY). Calves born at wet season grew faster by 14 and 10% than those calves born in the dry season at $Gain_1$ and $Gain_2$. The subsequent CI of cows calved in the wet season had 77 days shorter, 0.45 kg DMY, and 93 kg LMY increment. The differences between production systems can be attributed to differences in management skills and access to better quality feeds. Technical intervention is needed to ensure provision of balanced rations to exploit the potential productivity of Begait cattle.

Keywords Fertility trait · Milk yield · Production system

Introduction

Demand for animal products continues to grow, driven by growth in the human population and dietary changes associated with urbanization (FAO 2015). By 2050, the global demand for dairy and meat is projected to increase by 74 and 58%, respectively, and a large part of this demand will originate from developing countries (FAO 2012). Similarly, Ethiopia's increasing human population, urbanization trends, and rising household incomes are leading to a substantial increase in the demand for livestock products, particularly milk and meat. However, the productivity of our livestock at large and cattle in particular is not developed across the demand. According to Ethiopian Livestock Master Plan projection, the current production of cow milk and total meat should be increased by 93 and 59%, respectively, to meet the demand (LMP 2015).

In Ethiopia, the distribution of Begait cattle is solely known in two adjacent zones of western Tigray national regional sate (IBC 2009). However, the dominance of these cattle is found in the hot-warm lowlands of Kafta-Humera district. Begait cattle have relatively higher productivity potential and larger body size with well-developed udder and long teats compared to other Ethiopian indigenous cattle (Zerabruk et al. 2007; Gebretnsae et al. 2017). They are widely produced in extensive farming system and in some extent in confined production systems mainly as income generation.

Improving productivity of cattle is one of the major options to satisfy the ever increasing demands. Van Arendonk (2011) suggested that increasing cattle production can be achieved through improving lifetime productivity. However, the efficiency of cattle production and productivity is affected by different factors like nutrition, cattle genetic composition, access to infrastructures, climate, and health (Thatcher et al. 2010; Lamy et al. 2012).

To minimize the effect of these limiting factors, it is essential to design mitigation strategies by using local genetic resources, which are known by their ability to decrease production costs like disease or environmental control and feed supplementation. For implementing this kind of strategy, it is

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essential to obtain detailed and up-to-date information on the existing productivity performance and their limiting factors. Thus, the objective of the current study was to estimate growth, reproductive, and productive performance and their limiting factors of Begait cattle under two management systems, namely on-station and extensive production systems in northern Ethiopia.

Material and methods

Study area

The study was conducted in Kafta-Humera district, Tigray, Ethiopia (13°42′ to 14°28′ N; 36°20′ to 37°31′ E) with an elevation of 530 to 1831 m (Lemlem 2017). It has unimodal rainfall pattern with 400–650 mm average rainfall and classified as hot-warm semi-arid lowlands with the hottest (42 °C) months between April and June and 25 to 35 °C between July and February (Girma 2011).

Herd management

In the extensive rearing system or low-input herd management (LIHM), Begait cattle mainly feed on natural pasture and crop aftermath grazing. Sorghum straw, natural grass hay, forage sorghum hay, and sorghum chaff are used as additional feeds in the dry season, especially for calves, emaciated animals, cows giving birth in the dry season, lactating cows, and old cows (Gebretnsae et al. 2017). Veterinary services are available only twice a month through mobile animal health technicians.

In the confined management or medium-input herd management system (MIHM), cattle are feed sorghum straw and natural grass hay supplemented with forage sorghum hay, sorghum chaff, and/or 1–3 kg/d of concentrate (67% wheat bran, 17% Noug seedcake, and 17% cotton seed) depending on age and availability of concentrate. Cattle are vaccinated for major diseases (black leg, anthrax, contagious bovine pleuropneumonia, pasteurellosis, lumpy skin disease), dewormed twice a year, and given other veterinary treatments when necessary.

Data collection

Data for production and reproduction traits were collected from two Peasant Associations (PAs), private cattle enterprise farms and Humera Ranch. Each experimental animal was identified to give complete information on calf sex, herd, parity, calving date, calf birth weight, and calf weight at different ages, daily milk yield, date of drying off, the next calving date, and age at first calving.

Calves were weighed at birth using a platform mechanical scale balance, and at 3-month intervals from 3 to 18 months, weight was estimated using a heart girth-weight conversion tape developed by Katongole et al. (2013). Milk yield of cows was measured every morning and evening using a plastic measuring cylinder and recorded. Secondary data were obtained from records of Humera Ranch, Humera Agricultural Research Center, and Hiwet Agricultural Mechanization PLC.

Data analysis

A calf record was included if it included birth weight and 3-month weight. Regarding milk production, a cow was included if it had a milk record for at least 60 days and terminated with a registered voluntary drying-off date. Parity was coded as 1, 2, 3, and ≥ 4; as the number of cows with four or more parities was small, the data were amalgamated. After screening the data, the number of records available for some of the traits was very limited. Thus, the analysis was done using 284 growth, 397 reproductive, 48 AFC, and 498 milk production traits.

Pre-weaning average daily gain ($Gain_1$) and post-weaning average daily gain ($Gain_2$) were computed as $ADGt_2 - t_1 = (Wt_2 - Wt_1)/t_2 - t_1$ where $ADGt_2 - t_1$ is the weight gain between periods t_1 and t_2, Wt_2 the weight at age t_2, Wt_1 the weight at age t_1, and $t_2 - t_1$ is the number of days between ages t_1 and t_2. The available data for fixed effects were analyzed using general linear model procedure of SAS (2008). The presence of any significant differences was checked by using Duncan's multiple range test. Depending on the trait, fixed effects such as birth season, calf sex, dam parity, and herds were included in the following models:

Model 1: Growth performance traits $Y_{ijklm} = \mu + S_i + P_j + H_k + T_l + e_{ijklm}$

Model 2: Reproductive performance $Y_{ijkm} = \mu + S_i + P_j + H_k + e_{ijkm}$

Model 3: Milk production performance $Y_{ijkm} = \mu + S_i + P_j + H_k + e_{ijkm}$

where

Y_{ijklm}	the observation of each traits;
μ	overall mean;
S_i	fixed effect of i^{th} season of birth (i = wet, dry);
P_j	fixed effect of j^{th} parity; (j = 1, 2, 3, 4)
H_k	fixed effect of k^{th} herd (k = MIHM, LIHM)
T_l	fixed effect of l^{th} sex of calf (l = male, female); and
e_{ijklm}	residual random error term

Results

Growth performance

Table 1 presents the effects of herd, season, parity, and sex on growth performance of Begait calves. All considered non-

Table 1 Growth traits showing effects of herd, season, parity, and sex

Effects	BWT (kg)	3MWT (kg)	6MWT (kg)	9MWT (kg)	12MWT (kg)	15MWT (kg)	18MWT (kg)	$Gain_1$ (g)	$Gain_2$ (g)
Overall	21.9	60.6	98.1	133	158	167	176	411	203
CV%	14.7	22.6	20.8	22.4	18.0	15.4	15.5	26.2	73.6
SE	3.22	13.7	20.4	29.8	28.5	25.6	27.2	108	149
Herd	**	Ns	*	***	***			***	***
MIHM	25.6^{a}	64.6	108^{a}	199^{a}	266^{a}	NA	NA	630^{a}	569^{a}
LIHM	21.7^{b}	60.4	97.5^{b}	129^{b}	153^{b}	167	176	398^{b}	184^{b}
Season	Ns	**	**	*	Ns	**	Ns	**	*
Wet	22.1	62.7^{a}	101^{a}	142^{a}	162	171^{a}	177	444^{a}	210^{a}
Dry	21.8	57.7^{b}	94.2^{b}	127^{b}	156	160^{b}	175	388^{b}	192^{b}
Parity	Ns	*	Ns	*	*	**	*	**	Ns
1	22.0	58.8^{b}	95.2	128^{b}	151^{c}	161^{b}	171^{b}	390^{b}	194
2	21.9	62.5^{ab}	101	138^{b}	165^{b}	174^{a}	182^{ab}	429^{b}	202
3	21.5	64.5^{a}	103	150^{a}	178^{a}	176^{a}	187^{a}	476^{a}	205
Sex	**	**	**	**	*	**	*	*	Ns
Male	22.8^{a}	63.2^{a}	101^{a}	139^{a}	164^{a}	171^{a}	182^{a}	429^{a}	204
Female	21.1^{b}	58.3^{b}	95.3^{b}	128^{b}	154^{b}	163^{b}	171^{b}	395^{b}	201

Means within a column group with the same letter are not significantly different ($P > 0.05$)

Ns non-significant, *CV* coefficients of variation, *SE* mean standard error, *BWT* birth weight, *3MWT* 3-month weight, *6MWT* 6-month weight, *9MWT* 9-month weight, *12MWT* 12-month weight, *15MWT* 15-month weight, *18MWT* 18-month weight, $Gain_1$ average daily gain from birth to 9 months, $Gain_2$ average daily gain from 9 to 18 months, *MIHM* medium-input herds, *LIHM* low-input herds, *NA* records were not available

*$P < 0.05$

**$P < 0.01$

***$P < 0.001$

genetic factors had significant ($P < 0.05$) influence on cattle growth stage (Table 1). Weights of calves were superior for MIHM over LIHM by 4, 4, 11, 70, and 110 kg at birth, 3, 6, 9, and 12 months, and growth was faster by 230 and 390 g/d in $Gain_1$ and $Gain_2$, respectively.

Calves born in the wet season had 9, 7, 12, 3, and 7% heavier than those calves born in the dry season at 3-, 6-, 9-, and 15-month weights, respectively. Calves that were born from third parity of dams were achieved 10, 8, 18, 17, 9, and 10% heavier weight over calves those born from first parity cows at 3-, 6-, 9-, 12-, 15-, and 18-month ages, respectively.

Reproductive performance

Table 2 summarizes reproductive performance of Begait cattle. MIHM recorded significantly shorter dry period, CI, and AFC compared with LIHM. No MIHM cows had a dry period longer than the overall mean (316 days) while 57% of LIHM cows had a dry period greater than 316 days. Regarding CI, only 6% of MIHM cows had longer CI than the overall mean (600 days) in comparison with 46% of LIHM cows. A similar pattern was observed for AFC. The majority of LIHM cows calved every 2 years, whereas a substantial proportion of MIHM cows calved every year.

Table 2 Reproductive performance showing effects of herd, season, and parity

Effect and level	Dry period (days)	CI (days)	AFC (days)
Overall mean	316	600	1040
CV%	48.7	35.4	15.4
MSE	154	212	160
Herd	***	***	***
Medium-input herds	124^{b}	419^{b}	863^{b}
Low-input herds	358^{a}	641^{a}	1210^{a}
Season	Ns	*	*
Wet	308	569^{b}	959^{b}
Dry	327	646^{a}	1160^{a}
Parity	***	***	
1	383^{a}	716^{a}	
2	275^{b}	509^{b}	
3	263	442^{c}	
4	226^{b}	415^{c}	

Means within a column group with the same letter are not significantly different ($P > 0.05$)

Ns non-significant, *CV* coefficients of variation, *SE* mean standard error, *CI* calving interval, *AFC* age at first calving, *NA* records were not available

*$P < 0.05$

**$P < 0.01$

***$P < 0.001$

For first parity cows, subsequent dry period and CI were 383 and 716 days, considerably longer (by 157 and 301 days) than for the higher parity cows.

Milk production performance

Table 3 presents the effects of non-genetic factors on production traits. Herd management, season of birth, and cow parity had significant ($P < 0.05$) influence on DMY and 305-day milk yield. However, LMY and lactation length (LL) were influenced only by herd and season and herd and parity, respectively. Compared with LIHM, the MIHM achieved 2.8, 830, and 780 kg greater values of DMY, 305-day milk yield, and LMY, respectively (Table 3).

Discussion

Growth performance

Calves with favorably high average daily gain have higher slaughter weight, shorter AFC, and increased lifetime productivity (Cooke et al. 2013). Froidmont et al. (2013) observed more lactations and productive days during their life with higher milk productions from early calved cows. Beavers and Van Doormaal (2015) calculated an increment of $1400 per animal resulting from a 15% reduction of AFC. Conversely, increasing AFC by 16% increased replacement costs by 14% (Tozer and Heinrichs 2001). Cooke et al. (2013) observed 6-month reduction of AFC through improvement of body weight gain by 12.6% and achieved higher days (over 5 years) in milk production. Bhatti et al. (2007) obtained 1.5-year reduction age of puberty for Sahiwal cattle through better feeding management. Yohannes et al. (2011) also achieved 22.6% average daily gain increment and 3-month reduced AFC from 2 kg hay and 1 kg concentrate supplemented for pasture grazing heifers than 2 kg hay-supplemented heifers.

In our study, the 58 and 210% increments in $Gain_1$ and $Gain_2$ were accompanied by a 1-year reduction in AFC from MIHM (roughage supplemented with improved forage or 1–3 kg concentrate) over the LIHM (pasture and crop after-mash grazing with roughage support feeding system). This implies that the efficiency of cattle productivity especially in the extensive farming system can be increased even by small improvements in the nutritional values of roughage feeds.

Cattle productivity

Reducing the CI to an optimal 12 months had been maximized returns on production by increasing the number of peak lactations for a cow in its lifetime while extended CI resulted in higher production cost and reduction in annual milk production (Hare et al. 2006; Ali 2011). Do et al. (2013) estimated as number of lactation increases from 1 to 10, lifetime profit increased for 83.0–182%, while for one lactation, the production cost exceeded by $528. Moreover, reduced calving interval can give birth early in the calving season that will tend to

Table 3 Milk yield traits showing effects of herd, season, and parity

Effects and level	DMY (kg)	305DMY (kg)	LMY (kg)	LL (days)
Overall	4.04	1360	936	222
CV%	30.4	20.7	47.6	30.9
MSE	1.21	281	446	68.7
Herd	***	***	***	*
Medium-input herds	6.50[a]	2090[a]	1630[a]	246[a]
Low-input herds	3.74[b]	1260[b]	852[b]	220[b]
Season	**	*	*	Ns
Wet	4.28[a]	1440[a]	983[a]	224
Dry	3.83[b]	1280[b]	890[b]	221
Parity	***	***	Ns	***
1	3.57[c]	122[c]	861	230[a]
2	4.01[b]	1360[c]	961	233[a]
3	4.59[a]	1680[b]	1030	216[a]
4	4.94[a]	2220[a]	961	183[b]

Means within a column group with the same letter are not significantly different ($P > 0.05$)

Ns non-significant, *CV* coefficients of variation, *SE* mean standard error, *DMY* daily milk yield, *305DMY* 305-day milk yield, *LMY* lactation milk yield, *LL* lactation length

*$P < 0.05$

**$P < 0.01$

***$P < 0.001$

conceive cows more easily and increase growth performance of calves. As noted by Vickers (2014), increasing the number of calves reared per 100 cows by 2%, calf sales increased by $1100 to $1400 yearly. This may be more promised in tropical cattle, which are characterized by early ceases of milk production before the depressing effect of gestation on milk production is noticeable (Syrstad and Ruane 1998).

However, achieving optimum calving interval with the required milk production poses many challenges. Inadequate and highly variable quality and quantity of feeds are the major factor affecting both CI and milk production (Rege et al. 2011; Kiplagat et al. 2012; Bujko et al. 2013). As noted by FAO (2012), the Indian National Dairy Development Board has achieved a 10–15% net daily income increment of smallholder farmers through provision of technical cow ration formulation. Similarly, Mulugata (2015) observed 67% DMY improvements through 43% increment in crud protein contents of his experimental feeds for Begait cattle. Our findings comparing the MIHM and LIHM systems are in agreement with this, showing 35% reduction in CI, 74% increase in DMY, and 91% increase in LMY. Technical intervention is needed in quantity and quality of feed preservation, improving nutritional values of roughages, expansion of improved forages, and improving the way of accessing agro-industrial by-product to smallholder farmers.

Conclusion

Our results indicate that herd management is a critical factor affecting the productivity of indigenous cattle. Compared with traditional low input management, the relatively better herd management system achieved 4 and 110 kg superiority in birth and yearling weights, 234, 223, and 343 days shorter dry period, CI, and AFC, respectively, and 74% higher DMY and 91% higher LMY. The differences between production systems can be attributed principally to differences in management skills and access to better quality feeds. Technical intervention is needed to ensure provision of balanced rations to exploit the potential productivity of Begait cattle.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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