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ON-FARM GROWTH PERFORMANCE EVALUATIONS OF KIDS BORN FROM ARSI-BALE GOATS IN THREE AGRO-ECOLOGIES OF BALE ZONE, ETHIOPIA

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ABSTRACT

Goat rearing is a key livelihood sector in Ethiopian agriculture, upheld in diversified agroecology and inputs, which calls for the study of innate performances description. Moreover, performance determination at age intervals has an immense role in management and genetic interference in the near future for selection and upgrading. As a result, the study aimed to evaluate the effects of agroecology, birth type and sex on the growth performance of Arsi-Bale goat-born kids under old-style supervision practices in three agro-ecologies. Live body weight data were recorded on 71 kids from the birth period until yearling age for a total of 25 days in a year. Statistical Analysis Systems version 9.4 was used to analyse the data. The average live weight at birth, three months, six months and yearling ages were 2.0, 7.6, 13.0, and 19.3 kg, respectively. As well, the average weight gain immediately after birth, three months, six months and yearling ages were 125.3, 60.4, 70.1 and 40.2 g/day, respectively. The effect of agroecology was highly significant ($p \leq 0.01$) at birth, weaning and yearling ages. Moreover, live body weight and weight gain at six months and yearling ages were higher in midland and lowland agro-ecologies. However, three-month-old weight gain was nonsignificant ($p \geq 0.05$) among the environs. Kids born single were significantly higher ($p \leq 0.01$) at birth weight but no differences ($p \geq 0.05$) were observed across the rest of the ages on birth type. An increment in live weight and daily weight gain was higher in the females when aged due to sexual characteristics differences for early maturation. Thus, the effects of agroecology and sex was higher for performance variation under prolonged thermal pressure across seasons as well as sharing of dam milk for home consumption was an added factor in the lowlands. As a result, improvement of quality and quantity feeds and shelters for day-night thermal stress effects in routine seasonal changes can lead to a reasonable advance in yield of Arsi-Bale goat’s kids.

Key words: Agroecology, birth weight, body weight, daily weight gain, yearling weight

INTRODUCTION

Goat production is an integral part of livestock husbandry and affords significant contributions to sustaining the lives of poor farmers and pastoralists in challenging climate situations [1]. Central Statistics Agency [2] reported that Ethiopia has 52.5 million head goat populations; having a major role in the livelihoods of approximately 13.9% of urban and 22.7% of rural households and pastoralists, respectively, conferring to FAO, 2020 [3]. The study report of Debela *et al*. [4] indicated that the majority of goat flocks are kept under a nondescriptive production system with diverse and indeterminate genotypes, input-outputs, and flock sizes. Also, according to Mekuriaw [5], genetic performances are wide-ranging due to environmental backgrounds and unlimited additive variants. As a result, goat farming is more appreciated in dynamic climatic regions for keepers due to their tolerance to ecological changes, productive efficiency, and distinctive responsiveness to seasonal changes [6]. Moreover, genetic diversity also safeguards financial security for rural households and pastoralists during climatic catastrophic shifts [7]. Furthermore, their multipurpose use was seen as a benefit to the climate quiver in terms of yield diversification [8].

Despite this fact, the large populations and genetic diversity of goat genetic resources can be confronted with climatic and environmental changes combined with low genetic potential [9], absence and inefficiency of breed improvement interventions [10], and lack of access to quality and quantity feeds [11]. For the most part, climatic stresses have a major role in hurting production performance in outdated management practices [12], further unintentional genetic assimilations of eco-friendly varieties with incompatible genotypes under poor farming arrangements [10]. The above-mentioned problems come across with the impacts of reductions in yield, reproduction and adaptations [6]. Comprehensively, ecological, genetic and management difficulties interrupt the main goal of keepers to own high records of young's weaned per reproductive dam, per year as well as growth rate [13].

Largely, the additive effects mainly extreme climatic conditions, management and handling practices pressure affects performance at various intensities due to the differences in access to inputs and the extent of thermal radiation under different agro-ecological locations [14]. The effects also varied with seasons of the year, parity of the dam, sex of kids, and ages under ecological vicinities [15]. Moreover, the effects of persistent stress were more easily recognized on growth than that of other traits at early ages due to low adaptations to seasonal changes [16, 17]. Furthermore, the early-stage growth performances of kids are grossly influenced

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by their genotype and the milk yield of the dam [18]. Therefore, expressive growth rate and weight gain performance characterizations are important for output description as well as prerequisites for management and breeding programme interferences to improve performance [19]. Recently, several studies have been conducted on early age performance evaluations but limited to all ecotype breeds on ecological concern, particularly in currently proposed areas of the Bale zone endowed with ecological diversity from lowlands of drought-prone to the afro-alpine environment of Bale mountain [20]. As a result, live body weight and growth rate evaluations on kids from birth onwards up to yearling ages are essential to signify the performances demonstrated in a specific environment for their yield and adaptability [21]. Therefore, this study aimed to evaluate the on-farm growth performance of Arsi-Bale goat kids born at the three agro-ecologies of the Bale zone, southeastern Ethiopia.

MATERIALS AND METHODS

Study area

The study was conducted in Bale zone, southeastern part of Ethiopia from September 2020- August 2021. Astronomically, the area lies between $5^0$11’03’’N-$8^0$09’27’’N latitude and $38^0$12’04’’E-$42^0$12’47’’E longitude. The Santé Mountains area is broadly classified into highland, midland and lowland agroclimatic conditions, with altitudes ranging from ≥ 300 - 4,377 m.a.s.l. of afro-alpine ecology.

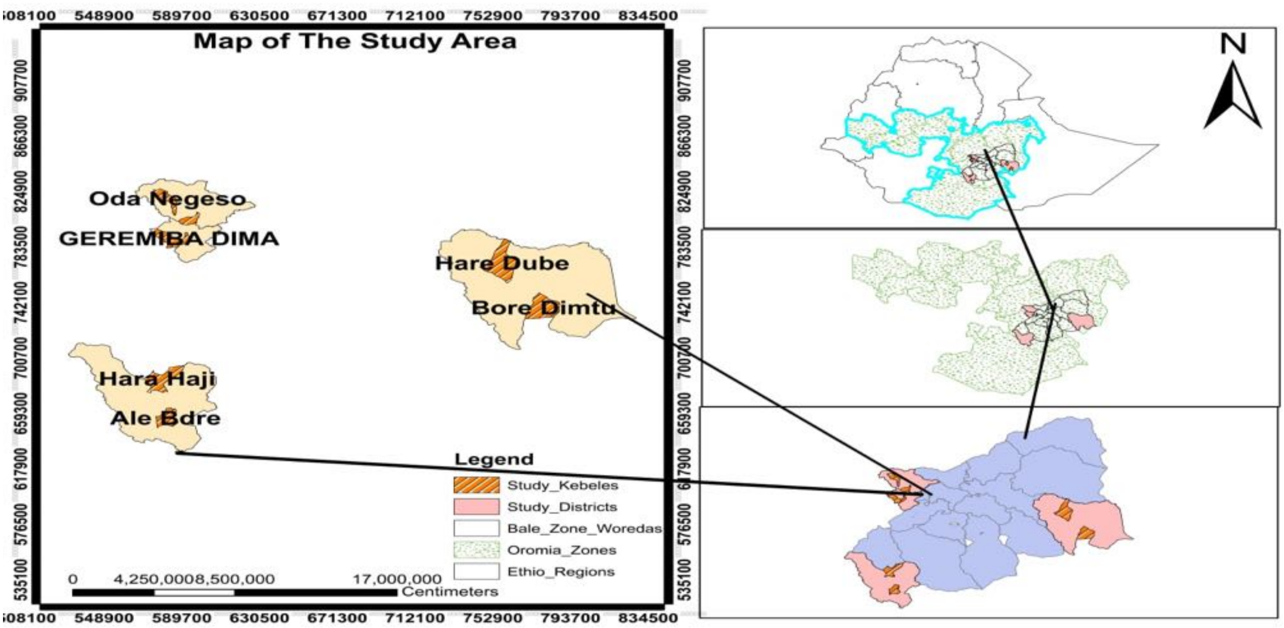

Figure 1: Map of the study area

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The area receives a bimodal rainfall with an average annual of 800 - 1150 mm. Thus, from March-August, there is high rainfall covering all agro-ecologies comprising of Agarfa, Gasera, Goba, Sinana, and Dinsho districts known for crop production. Moreover, from September-November and December-February, medium to low rainfall covers 20% of the areas of highland and midlands as well as the remaining 80% of the lowland districts of Rayitu, Sawena, Laga Hidha, Gura Dhamole, Mada Walabu, Goro, Ginir, Barbare, Delo-Mana, Harena, and Gololcha. The area has an average annual temperature in the range of 9-23 °C [22].

Sampling technique

Using multi-stage sampling procedures, four study districts were selected by considering their higher flock proportions and agroecology array size. Accordingly, from highland, Dinsho, from midland, Agarfa and from lowland, Mada Walabu and Rayitu districts were selected proportionally. In the same way, six *kebeles* (mini administrative class) were selected from all districts using purposive sampling. Thus, *kebeles* of *Granba Dima* from Dinsho district, *Oda Negeso* from Agarfa district, *Ela Bidire* and *Hara Haji* from Mada Walabu distrct and *Hare Dube* and *Bore Dimitu* from Rayitu district were selected, respectively, considering the flock size distributions. Before two months pregnant goats/dams at different parties were identified across study sites. Then, kids born from dams were registered from September 5/2020 across all agro-ecologies including previously unidentified dams. Thus, within 15-20 days of assessment, 24 (18 single, 3 twins), 22 (18 single, 2 twins), and 25 (19 single, 3 twins) kids were identified and registered in highland, midland and lowlands, respectively.

Data collection techniques

Data were recorded to include weights of birth (BWT), three-month (TMWT), six-month (SMWT), and yearling age (YWT) on 71 kids starting from 24 hours of kidding period. Live body weights (kg) were measured using a suspended spring balance of 50 kg with ±200 g precision. Measurements were taken weekly once per 7 days until three months of age. Then, data were recorded once per 15 days from 4-6 months of age. Lastly, after 6 months of age, once per 30 day (month) records were taken to yearling age. In total, 25 days of measurements were recorded. Kids were kept in the home for 5-15 days after kidding depending on the production ecology and rearing practices. On average after 10-15 days of age, dams and kids were kept together day and night during the experimental period. No supplementary feed was provided for kids or dams. Days before measurement, kids were separately penned overnight. Then, weights were taken in the morning before suckling. Finally, daily weight gain was computed starting from colostrum feeding day weight = 1-3 days, preweaning = 4-90 days, weaning = 91-180 days to

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yearling weight = 181-365 days. The rate of gain per day was calculated by subtracting the initial live weight from the final weight and then dividing the total live weight gain by the total number of days across the experimental period (g/day).

Statistical analysis

Kids' live body weight and weight gain data were analysed using the general linear model (GLM) procedure of SAS, 2012 version 9.4 to evaluate the effects of agroecology, birth type, and sex of kids starting from birth period to yearlings. Duncan's multiple range tests was used to separate mean differences when the F test declared significant for each fixed effect. The model used for analyses was as follows:

$Y_{ijk} = \mu + S_i + B_j + G_k + e_{ijk}$

Y_{ijk} = the growth rate and daily weight gain of the n^{th} kid

M = the overall mean

S_i = Fixed effects of the i^{th} sex (i: 1 = male, 2 = female)

B_j = Fixed effects of the j^{th} birth type (j: 1= single, 2 = twins, 3 = triplet)

G_k = fixed effect of k^{th} agroecology (k: 1 = highland, 2 = midland and 3 = lowland)

e_{ijk} = Random error

RESULTS AND DISCUSSION

Live body weight of kids

The aforementioned focus in developing countries was on the sustainability and enhancement of livelihoods of rural and pastoral communities. For that reason, goat farmers place a lot of emphasis on improving the performance of their flocks [23]. Undoubtedly, monitoring performances across ages is essential for management plans to verify eco-friendly effects [17] and genetic advance approaches [19]. As per the findings, the average body weight (BWT) (kg), birth type and sex of kids born from Arsi-Bale goats in agro-ecologies are presented in Table 1. The average weights of kids at the ages of birth, three months, six months and yearling was 2.0, 7.6, 13.0, and 19.3 kg, respectively.

The study revealed that the effect of agroecology was highly significant ($p \leq 0.001$) on the live body weight of the birth period. Thus, kids born in the midland and lowlands had higher birth weights than those born in the highlands (Table 1). This was mostly caused by immunological variations across dams due to cold stress acquaintance and a scarce supply of feed during pregnancy in the highlands. This upshot also remains for year-round performance differences due to repeatedly encountering stress. The current study's finding of average birth weight of 2.0 kg was consistent with Deribe and Taye [24], who reported a 1.9 kg for Abergele goat populations and Zergaw [25], who reported a 2.0 kg for Woyto Guji goats. In contrast, Demissie [26] reported much less weight than the reports for central highland goats of 2.4 kg, Deribe *et al.* [19] for crossbred Boer and Central Highland goats 2.7 kg, Zergaw *et al.* [25] for central highland goats and crossbred Woyto Guji goats 2.7 kg. This was less than the weight reported by Hyera *et al.* [27], who reported for blended, Pare White, and Sonjo Red goat kids that were born weighing 3.1, 2.5, and 2.3 kg, respectively. These differences might have been due to seasonal changes in feed availability during the pregnancy and parturition periods via the interaction of agroecology and genetics [28]. On the other hand, the recent findings were much greater than the report of Tucho *et al.* [29], who stated 1.5 kg for mid-rift valley goat kids. This demonstrated that the dam's genotype and additive interaction had an impact on the birth weight of kids [30].

The effect of altitude arrays was nonsignificant ($p \geq 0.05$) on three-month weight. Accordingly, 7.6 kg body weight was recorded among the three agro-ecologies. From this time, the highland ecology's warm stress influence at the period was much more conducive to kids reaching their peak weight at a time. Additionally, sharing of dam milk for home consumption was practiced in the lowlands, which made a minimal difference to ecology influence. Moreover, a recent report was higher than Deribe and Taye [24], who reported 6.8 kg for Abergele goats under identical management conditions of dry seasons. Conversely, the recent report was lower than 9.1 kg and 9.4 kg for breeds of Central Highland and Woyto-Guji goats, respectively [25], and 9.8 kg for crossbreed of Boer and Central Highland goats [19]. This discrepancy may be due to genetic and seasonal impacts on feed resource quantity and quality [31]. So, the dam's milk yield potential had an impact on the preweaning return [30]. Thus, the study indicated production environments, and kids' adaptability for self-feeding following the dam-suckling period, have an influence on growth rate inconsistencies among goat breeds [21].

The weaning weight of the kids was significant ($p \leq 0.05$) across agro-ecologies. The differences were mainly due to rangeland output variations from December to March, making the feed deficit severe in midland and lowlands. As a result, kids performed worse towards the end of the preweaning dry seasons. The period was when kids switched from milk feeding to self-feeding while remaining at an equal stage for browsing and grazing on prevailing feed supplies. Further, midlands were intensively utilized for cropland preparations, leading to reductions in rangeland size [31]. Still, the reported weaning weight of 13.0 was higher than the values of 9.1 and 11.5 kg reported by Deribe and Taye [24] for Abergale goats and Zergaw *et al.* [25] for Woyto-Guji goats. On the other hand, the weaning weight of 16.3 kg reported by Gatew *et al.* [23] for Bati goats was higher than the recent but comparable to 13.8 kg and 13.9 kg, respectively, as reported for Short-eared Somali and Borana goat flocks by the same author. For that reason, genotypic and adaptability perspective were key points to determine performances in production environments [32].

The effect of agroecology on yearling body weight was highly significant (p≤0.001) (Table 1). The differences might be due to ecology and season interactions boosting feed resource accessibility [33]. Thus, several scholars agreed that production area, genetic variability, and weather patterns affect the growth rate [5, 14]. The recent study report of 19.3 kg was higher than the 14.2 kg reported by Deribe and Taye [24] for Abergale goats. As well, when compared to lowland- and highland-born, midlands performed supreme at the end of yearlings (Fig 2). These variations were made for midlands by cutting-edge feeding and watering practices around water basins and access to water proximity at the end of dry seasons. However, highland kids resumed lowest due to limited feed resource availability, cold stress and short feeding period seasonally. As a result, kids in highlands required a longer period for maturation than the rest agro-ecologies.

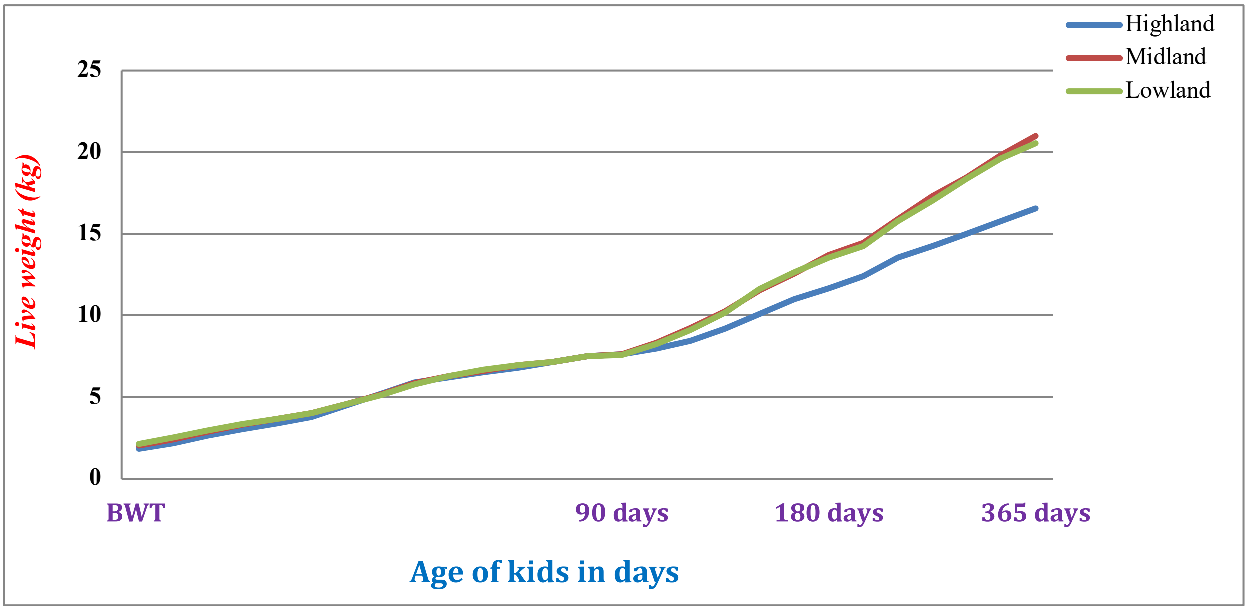

Figure 2: Trends of the growth performances of kids born from Arsi-Bale goats in the three agro-ecologies

In addition, the birth type had a highly significant effect (p≤0.01) on birth weight and a nonsignificant (p≥0.05) effect for later ages. Thus, the study indicated that single-born kids weighed higher than twins from birth to half of the preweaning ages. This was due to less competition for feeding during pregnancy and after kidding which was similarly reported by Deribe *et al.* [19] for Central Highland and Boer goat offspring and Zeleke [34] for Somali goats, indicating twins were relatively lighter at earlier preweaning. However, the live weight trend was nearly equal at the end of preweaning to yearling among the agro-ecologies (Table 1).

The effect of sex on the weight of kids from birth to preweaning ages was nonsignificant ($p \geq 0.05$). However, the effect was highly significant ($p \leq 0.01$) at the ages of weaning and yearling due to sexual influences on females to attain puberty until yearlings (Table 1).

Daily weight gain of kids

The weight gain (g/day) performances of Arsi-Bale-born kids for the effects of agro-ecology, birth type, and sex are presented in Table 2. The average weight gain performance of kids at the ages of birth period (1-3 days), preweaning (4-90 days), weaning (91-180 days) and yearling (181-365 days) was 125.3, 60.4, 70.1 and 40.2 g/day, respectively. The average daily weight gain at earlier ages was higher than the elderly (Table 2). Moreover, adequate moisture and flora availability from September to November offered access to plenty of feed resources for sustainability. In fact, the high rainfall seasons from the end of March to August contributes sufficiently to feed resource availability which stimulates goat flock for reproductive hormones, which in response initiates breeding seasons. As a result, many kids are born of favorable climatic circumstances [35]. Ecologically, seasonal rainfall had a more positive impact on lowlands and midlands. However, in the highlands, dams had less advancement due to cold thermal stress and the absence of extra supplements. Because of this, the effect was highly significant ($p \leq 0.01$) during the first three days of colostrum feeding. In addition, the study found that lowland-born kids had the highest daily weight gains (140.1 g), followed by midland kids (123.5 g) while, the lowest weight gains were reported in the highlands (111.7 g/day), which continued for a month. Comparably, the average (125.3 g/day) reported weight gain was higher than the 86.2 g/day reported by Gatew *et al.* [23] for the three ecotype goat breeds. However, the effect was nonsignificant ($p \geq 0.05$) at the end of preweaning ages. This was due to feed-related constraints in highlands being resolved and equally comparable to midland and highlands for cold stress season effects that limit feeding durations. But weight gain was reduced from 125.3 to 60.4 g/day due to age effect requirements, which was highly consistent with 61.3 g/day reported by Zeleke [34] for extensively kept Somali goats. On the other hand, the recent study report was lower than those reported by Zergaw *et al.* [25] for crossbreeds of Woyto-Guji and Central Highland goats of 77.7 g/day, Demissie *et al.* [26] for Western Highland goats of 72.7 g/day at the same age. However, overall, the weight gains of kids decreased from birth

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period to pre-weaning age during the period by approximately 35%, due to feed shortages across the agro-ecologies.

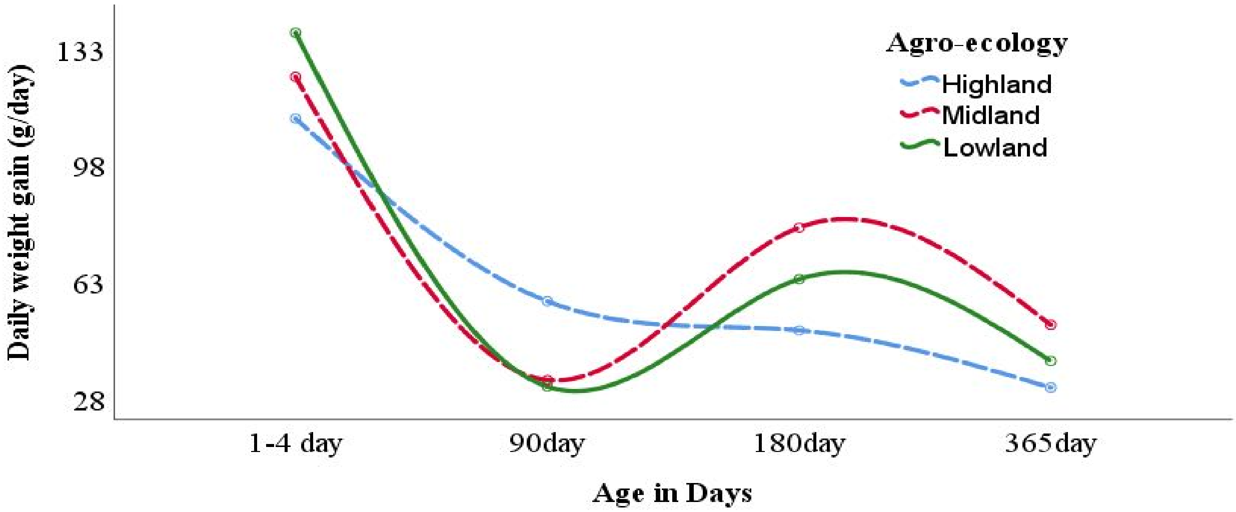

Figure 3: Pattern of daily weight gain of Arsi-Bale goat kids in the three studied agro-ecologies

Per results, weight gain at weaning of 70.1 g/day showed a modest increase after adapting to the end of milk feeding. This was due to goats' rearing practices being more advanced around water basins after midlands' stubble feeds became saturated. Also, a season-based outcome from the hills or highland eco-region was promoted and appreciable. Thus, a significant difference ($p \leq 0.05$) was determined. More, the finding was greater than 31.9 g/day reported by Zergaw *et al.* [25] for Woyto-Guji crossed Central Highland goats and 37.3 g/day reported by Deribe *et al.* [19] for crossbred Boer and Central Highland goats. As well, the recent study report was higher than Gatew *et al.* [23], who reported 55.5 and 47.2 g/day for Bati, and short-eared Somali goats, respectively.

At the yearlings, the ecology influence was highly significant ($p \leq 0.001$) across seasonal changes. Moreover, weight gain dropped to 40.2 g/day (Table 2). This was due to year-round seasonal fluctuations and season-based feeding regimes which amassed impacts on growth performance [36]. As well, midland and lowland agro-ecologies saw rapid gain at the end of the rainy season, but highlands were slow due to cold stress exposure from April to the end of August [22]. Yet, the reported 40.2 g/day was higher than the study report of 33.01 g/day by Deribe *et al.* [19] for crossbred Boer and Central Highland goat kids. This was due to the periodic fluctuation effects on performance that were collective across the ages of weaning and yearling as well as genetic expressions to additives.

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The effect of birth type was nonsignificant (p≥0.05) within age groups except at the earlier ages. However, weight gain decreased slowly with increasing age. Thus, weight gain from parturition to yearling age showed significant disparities while the results were almost consistent within ages (Table 2). In contrast, Demissie *et al.* [26] reported for singletons (82.8 g/day) and twins (68.2 g/day). This variation was due to the exhaustion of dams on enhancing nutrients for the twins' resistance during the pregnancy. Furthermore, the effect of sex was nonsignificant (p≥0.05) across the ages of preweaning, weaning, and yearling. However, the females gained slightly higher than males (Table 2). Also, female kids gained more at weaning (70.4 vs. 59.7 g/day) due to their fast growth to attain puberty earlier than males. In contrast, Zeleke [34] reported a 55.9 vs. 61.6 g/day female-to-male ratio at the same age from postweaning to yearlings, respectively. Generally, the overall average daily weight gains immediately after birth were the highest in comparison to elderly ages. Thus, daily weight gain variations were higher due to year-round seasonal fluctuations across the ecology (Fig 2).

CONCLUSION

The influences of agro-ecosystem and sex had a major impact on live body weight and day-to-day gain from the time of birth period to yearlings on kids born and kept under free-ranging conditions. Moreover, daily weight gain declined, as the kids became older. This might be due to the high nutritional imbalances needed for development and year-round feed scarcity. Thus, the effectiveness of backyard farming practices for accelerating weight acquisition was minimal, and seasonal changes did not significantly enhance weight gains. As a result, it is advised to increase nutrient-rich feeding, adopt feed conservation practices, and use optional supplementary feed resources when the environment is negatively influenced. As well, undertaking environmental rehabilitations for sustainability may be crucial for livestock and human being.

Author contributions

MG: Data collection facilitator, data analysis and paper write-up; AM: Major advisor made journalistic comments on the final manuscript, MT: Co-advisor made editorial comments on the draft manuscript. All authors read and approved the final manuscript.

Availability of data

The data analyzed for the current study is ready when requested from corresponding author.

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Conflict of interest
The authors declared no conflict at all.

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Table 1: The average weight (kg) of Arsi-Bale goat kids at birth, three months, six months, and yearling ages

		BWT	TMWT	SMWT	YWT
	Overall LSM±SE	2.0±0.2	7.6±0.6	13.0±1.3	19.3±2.3
Agro - ecology	p value	0.000	0.989	0.050	0.000
	Highland	1.8±0.1[c]	7.6±0.8[a]	11.7±1.1[b]	16.6±1.4[b]
	Midland	2.0±0.1[b]	7.6±0.5[a]	13.7±0.7[a]	21.0±1.1[a]
	Lowland	2.1±0.2[a]	7.6±0.5[a]	13.6±0.7[a]	20.6±1.1[a]
Birth type of kids	p value	0.005	0.910	0.585	0.583
	Single	2.0±0.2[a]	7.6±0.5[a]	13.0±1.3[a]	19.4±2.4[a]
	Twins	1.8±0.1[b]	7.6±0.8[a]	12.8±1.2[a]	19.1±2.3[a]
Sex of kids	p value	0.226	0.343	0.019	0.013
	Male	2.0±0.2[a]	7.5±0.6[a]	12.4±2.8[b]	18.8±2.8[b]
	Female	2.0±0.2[a]	7.7±0.6[a]	13.1±1.0[a]	19.7±2.0[a]

[a, b, c]Means bearing different superscript letters are significant at $p<0.05$; BWT: birth weight; TMWT: three-month weight; SMWT: six-month weight; YWT: yearling weight; LSM: least square mean; SE: standard error

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Table 2: The average daily weight gain (g/day) of Arsi-Bale goat born kids at birth, preweaning, weaning, and yearling ages reared in various agro ecologies

		1-3 days	Preweaning	Weaning	Yearling
	Overall LSM±SE	125.3±4.0	60.4±3.9	70.1±2.6	40.2±1.6
Agro-ecology	p value	0.011	0.844	0.024	0.000
	Highland	111.7±5.8[c]	62.5±5.4[a]	64.1±4.1[c]	32.2±2.1[c]
	Midland	123.5±7.9[b]	61.7±9.8[a]	73.6±5.4[a]	49.7±1.6[a]
	Lowland	140.1±6.2[a]	57.3±5.1[a]	72.8±4.2[b]	39.4±3.0[b]
Birth type of kids	p value	0.175	0.785	0.746	0.834
	Single	122.4±4.3[b]	59.8±4.7[a]	69.7±3.2[a]	40.0±1.9[a]
	Twins	135.5±9.8[a]	62.4±6.8[a]	71.7±4.1[a]	40.8±2.9[a]
Sex of kids	p value	0.188	0.247	0.908	0.647
	Male	118.3±7.2[a]	56.9±3.8[a]	69.7±4.6[a]	39.6±1.7[a]
	Female	129.4±4.7[b]	66.4±8.6[a]	70.4±3.2[a]	41.1±3.2[a]

[a, b, c]Means bearing different superscript letters are significant at $p<0.05$; LSM: least square mean; SE: standard error

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