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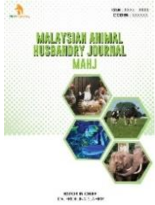

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RESEARCH ARTICLE

GROWTH PERFORMANCE OF THE NILOTIC CATTLE UNDER TRADITIONAL HUSBANDRY SYSTEM

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ABSTRACT

The Nilotic cattle of South Sudan support the socio-economic livelihoods of many rural and suburban communities, but their productive/reproductive characteristics are still poorly understood. This study investigated the growth performance of the Nilotic cattle under traditional husbandry system, by determining their live-body weight (BW), degree of maturity of weight (DM), absolute growth rate (AGR), relative growth rate (RGR), absolute maturing rate (AMR), and Kleiber ratio (KR), and how these traits change during postnatal development. The experimental procedure involved the measurement of heart girth (HG) and body length (BL) of 125 male and 136 female calves from birth up to the age of 16 months. Subsequently, the BW, DM, AGR, RGR, AMR, and KR of each calf were calculated. The results showed that on average, male calves weighed 4.68 kg, 7.98 kg, 2.23 kg, 10.23 kg, 2.21 kg, 2.24 kg, 3.97 kg, 10.38 kg, and 15.79 kg heavier (*$p<0.05$*) than females at birth, 2, 4, 6, 8, 10, 12, 14 and 16 months of age, respectively; and had the highest AGR (♂; 0.163 kg/day vs ♀; 0.139 kg/day) and KR (♂; 0.674 vs ♀; 0.591), while female calves had the highest (*$p<0.05$*) RGR (♀; 0.070%/day vs ♂; 0.065%/day), AMR (♀; 0.095% vs ♂; 0.056%), and DM (♀; 0.111~0.567 vs ♂; 0.072~0.340). Nevertheless, in both sexes, AGR, RGR, AMR, and KR values were higher (*$p<0.05$*) during the pre-weaning period than during the post-weaning period, though their respective declining rate was greater (*$p<0.05$*) in females (69.11%, 83.41%, 72.78%, and 75.09%) than in males (14.08%, 54.01%, 39.87%, and 41.94%). These results provide the first evidence for a fast growing and maturing pattern during the pre-weaning period in Nilotic cattle.

KEYWORDS

absolute growth rate, absolute maturing rate, degree of maturity, live-body weight, Kleiber ratio, relative growth rate

1. Introduction

Cattle are the most important livestock species in pastoral and agropastoral production systems worldwide. In South Sudan, in particular, cattle support the livelihoods of many rural and suburban communities, as the major source of milk and meat, besides their use for socio-economic purposes (de Mabior1981; Howell et al., 1988; Milla et al., 2012). The Nilotic cattle, which belong to the East Africa Sanga family, are some of the indigenous cattle of South Sudan that comprise of several strains, which differ in some body conformations, and known locally as *Dinka*, *Nuer*, *Shilluk*, and *Anuak* cattle after the tribes that own them; although much of their morphological distinctions are increasingly disappearing due to increasing tribal and cattle admixture, and the influence of breeds from elsewhere (Howell et al., 1988; Rege and Tawah 1999). The Nilotic cattle are typically reared under pastoral or agropastoral system, characterized by frequent feed shortage and prevalence of diseases; so they are subjected to constant migration and trekking for long distances, with tremendous energy expenditure, in search of places with plenty of pasture and water, and with less biting insects (Howell et al., 1988; Milla et al., 2012). Regarding their production capacity, the Nilotic cattle are believed to be poor producers of milk, even though there is currently insufficient evidence to suggest otherwise (Abdel-Rahman 2007; Mohammed et al., 2016). Furthermore, their growth performance is not yet fully elucidated, and prospects for improvement through institutional selective breeding or crossbreeding with exotic breeds are not feasible at the present time.

The knowledge of growth performance is an essential asset for designing breeding programs to improve production efficiency in livestock (Fitzhugh and Taylor 1971; Stobart et al., 1986). Moreover, there is a wealth of literature showing that information on growth parameters, such as that of live-body weight (BW), degree of maturity of weight (DM), absolute growth rate (AGR), relative growth rate (AGR), absolute maturing rate (AMR), and Kleiber ratio (KR) can be a useful means for selecting superior animals, assessing maternal ability, determining breeding and marketing age, and predicting farm productivity and profitability (Fitzhugh and Taylor 1971; Berg et al., 1992; Brown et al., 1988; Koster et al., 1994; Heinrichs et al., 1992; Van Marle-Köster et al., 2000, Ghafouri-Kesbi and Tari 2015; Rout et al., 2018; Shimada et al., 1988; Meyer 1992; Boro et al., 2016; Hayes et al., 2021; Williner et al., 2014; Shivley et al., 2017; Morris and Wilton 1976; Ozkaya and Bozkurt 2009; Frost et al., 1997; Portes et al., 2020).

Unfortunately, up to now, information on growth performance in Nilotic cattle is limited to BW and AGR, whereas the aspects of RGR, AMR, DM, or KR remained investigated (Zahlan et al., 1986; Howell et al., 1988; Milla and Mahjub 2013). One reason is the absence of weighing machines in

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rural and/or pastoral settings; since such studies require periodic measurement of BW. Thus, we recently established that even in the absence of weighing machines, BW in Nilotic cattle can be estimated with a substantial degree of accuracy from heart girth (HG), and body length (BL) measurements, as well as from body condition scores (Milla and Mahjub, 2013). Therefore, conducting extensive studies on the growth characteristics of the Nilotic cattle will increase our understanding of the yet unknown production potentials of these cattle; and such knowledge will be valuable for their improvement, which in turn will sustain food security and increase economic development opportunities in rural and suburban communities. The purpose of this study was to elucidate the growth performance of the Nilotic cattle under traditional husbandry system, by determining their BW, DM, AGR, RGR, AMR, and KR, and characterizing the dynamics of these traits during postnatal development.

2. Materials and Methods

2.1 Location

This study was conducted in the rural villages of Tunga County in Upper Nile State, South Sudan. The area is situated at the flood plains along latitude 9°39' north and longitude 31° 39' east, about 390 meters above sea level. The climate is monsoon type with seasonal rainfall occurring mainly from June (990 mm) to late September (1207 mm), with an annual average monthly rainfall of about 719 mm. The minimum and maximum temperature in all seasons averaged 21.6°C (18.5°~26.1°C) and 35°C (30.9°~40.3°C), respectively. Relative humidity is the lowest (24.4%) in the dry season, mainly during February, but increases and remains high throughout the rainy season, with a peak rise of 76.2~76.9% from June to August.

2.2 Animals

Data for this study were extracted from the records of 158 male and 160 female calves owned by *Dinka*, *Nuer*, or *Shilluk* households from the year 2004 to 2007. However, partial records of calves that were sold, lost, or died during this period were excluded from the results. Note also that, because cattle in the study area frequently change hands through marriages, trade, or raids among the Nilotic communities, the initial distinctions between *Dinka*, *Nuer*, or *Shilluk* cattle subtype were not possible in this study. The cattle were freely grazed on natural pastures, which fluctuate between dry and wet season, in both quality and quantity. Moreover, owing to the unreliability of rainfall, pasture shortages are not uncommon, often causing considerable deterioration to the body condition of the animals (Milla and Mahjub 2013). Nonetheless, during the dry season, some households allowed their cattle to feed on crop residues, while brewery residues were occasionally fed to lactating cows. Calves were allowed to suckle their dams in the morning and evening, except for newborns, and weaned naturally when they were approximately 6~10 months old.

2.3 Estimation of Live—Body Weight (BW)

BW of calves was derived from linear heart girth (HG) and body length (BL) measurements by modifying the Schaeffer's formula (Wangchuk et al., 2018). The HG and BL measurements were taken using a tape-rule in centimeters, as previously described by Milla and Mahjub (2013). The HG and BL of each calf was measured at birth, 2, 4, 6, 8, 10, 12, 14, and 16 months of age; then the weight at each age was calculated from the corresponding HG and BL measurements as follows:

$$\boldsymbol{BW} = \frac{\boldsymbol{HG^2 \times BL}}{\boldsymbol{6600}} \quad \textit{(Schaeffer's formula standardized for Nilotic cattle)}$$

Where,

(***BW***) is the live-body weight in kg, (***HG***) is the chest girth (circumference) of the animal, and ***(BL)*** is the length of the animal from the point of shoulder to the pin bone, both in cm.

2.4 Determination of Growth Traits

The investigated growth; namely, DM, AGR, RGR, AMR, and KR for each were calculated from the estimated BW using formulas derived from the two-component equation-free model (Fitzhugh and Taylor, 1971):

$$\boldsymbol{y_t = u_t A}$$

Where,

(y_t) is the size at age (t) expressed as a function of the degree of maturity of weight (u_t), and mature size (A).

Hence,

$$\mathrm{DM} = u_t = \frac{y_t}{A}$$

$$\mathrm{AGR} = \frac{(y_{t_2} - y_{t_1})}{(t_2 - t_1)}$$

$$\mathrm{AMR} = \frac{1}{A}\frac{(y_{t_2} - y_{t_1})}{(t_2 - t_1)}$$

$$\mathrm{RGR} = \frac{\mathrm{AGR}}{\frac{1}{2}(y_2 + y_1)} \times 100$$

$$\mathrm{KR} = \frac{\mathrm{AGR}}{(y_{t_2})^{0.75}} \times 100$$

Where,

u_t = degree of maturity at age (t), y_t = weight at age (t), y_{t_1} = weight at age (t_1),

y_{t_2} = weight at age (t_2), and A = mature weight at age (t).

AGR was assessed as the proportion of weight gain in kilograms per day (kg/day). RGR was expressed as the percent gain in weight per day (%/day), while AMR, which is the rate of change in DM with respect to time was expressed as the percent (%) gain relative to mature weight over a given age interval ($t_1 \sim t_2$) (Fitzhugh and Taylor 1971). DM is equivalent to the economic degree of maturity (McWhir and Wilson 1986). Because there were no records of mature weight on individual calves used in the present study, the estimation of AMR and DM was performed by adopting an average mature weight (A) of 292.8 kg (males) or 146.4 kg (females) from our previous study (Milla and Mahjub 2013). KR was expressed as the percent ratio of AGR per kg metabolic weight ($BW^{0.75}$) at a given age (Bergh et al., 1992). To ease presentation, calf weaning weight (CWW) was adjusted to 8 months (240 days) by linear interpolation from birth weight, weaning weight, and age at weaning, using the below formula:

$$\boldsymbol{A} = \frac{\boldsymbol{B-C}}{\boldsymbol{D}} \times \boldsymbol{240\ days} + \boldsymbol{C} \quad \text{(Szabó et al., 2012)}$$

Where,

(A) is the CWW adjusted to 240-days (8 months) in kg, (***B)*** is the actual weaning weight in kg, (***C)*** is the birth weight in kg, and (***D)*** is the age at weaning in days.

Subsequently, AGR, RGR, AMR, and KR were estimated for pre-weaning period (birth~weaning at 8 months), post-weaning period (8~16 months), and the whole growth period examined (birth~16 months). Eventually, All RGR, AMR, and KR values were multiplied by 100 to avoid scaling problems.

2.5 Statistical Analysis

The data on BW, DM, AGR, RGR, AMR, and KR were analyzed for variance with respect to age or sex, using the One-way Analysis of Variance (ANOVA), with Fisher's Least Significant Difference (LSD) as the Post Hoc Test. All analyses were conducted using the *GB-Stat* statistical software version 10 (Dynamic Microsystems, Silver Spring, MD, USA), and $p<0.05$ was set as the level of significance.

3. Results

3.1 Body Weight (BW) and Degree of Maturity (DM)

Table 1 shows the estimated means ± standard deviation for calf BW and DM at birth, and at the age of 2, 4, 6, 8, 10, 12, 14 and 16 months. Analysis of variance revealed that BW in Nilotic calves is affected by sex, with males weighing heavier ($p<0.05$) than females, except at the age of 4, 8, and 10 months. An average weight difference of 4.68 kg, 7.98 kg, 2.23 kg, 10.23 kg, 2.21 kg, 2.24 kg, 3.97 kg, 10.38 kg, and 15.79 kg was recorded at birth, 2, 4, 6, 8, 10, 12, 14 and 16 months of age, respectively. Analysis of variance also demonstrated that DM varied with sex, with female calves being superior ($p<0.05$) to males at all ages examined.

Table 1: Estimates (mean ± standard deviation) for live-body weight (BW) and degree of maturity (DM) in Nilotic calves at successive ages

	Males (n = 125)		Females (n = 136)	
Age	BW	DM	BW	DM
Birth	21.2 ± 04.4 [a]	0.072 ± 0.015 [A]	16.3 ± 5.51 [a]	0.111 ± 0.040 [B]
2 months	41.3 ± 12.6 [a]	0.141 ± 0.043 [A]	33.5 ± 9.90 [b]	0.229 ± 0.068 [B]
4 months	45.2 ± 15.5 [a]	0.155 ± 0.053 [A]	42.9 ± 4.12 [a]	0.293 ± 0.028 [B]
6 months	61.4 ± 19.5 [a]	0.210 ± 0.067 [A]	50.8 ± 4.01 [b]	0.347 ± 0.027 [B]
8 months	70.0 ± 25.3 [a]	0.256 ± 0.081 [A]	67.7 ± 6.86 [a]	0.494 ± 0.034 [B]
10 months	79.5 ± 24.3 [a]	0.272 ± 0.083 [A]	77.1 ± 7.83 [a]	0.527 ± 0.053 [B]
12 months	86.0 ± 27.0 [a]	0.294 ± 0.092 [A]	81.8 ± 6.17 [b]	0.559 ± 0.042 [B]
14 months	92.6 ± 28.5 [a]	0.316 ± 0.097 [A]	81.8 ± 6.76 [b]	0.559 ± 0.046 [B]
16 months	99.5 ± 30.2 [a]	0.340 ± 0.103 [A]	83.0 ± 11.1 [b]	0.567 ± 0.076 [B]

Eight months-age corresponds to the adjusted weaning age. Values in the same row bearing different small superscript letters (ab) for BW or capital superscript letters (AB) for DM are different between sexes at $p<0.05$. n=number of animals.

Table 2: Average birth weight, weaning weight, and absolute growth rate (AGR) of some cattle breeds reared under traditional husbandry system elsewhere in Africa

Breed	Country	Birth weight (kg)	Weaning weight (kg)	Pre-weaning AGR (kg/day)	Post-weaning AGR (kg/day)	Reference	Breed	Country	Birth weight (kg)	Weaning weight (kg)	Pre-weaning AGR (kg/day)	Post-weaning AGR (kg/day)	Reference
Boran	Ethiopia	18.2(♂), 17.8 (♀)		0.14 (♂♀)		Cossins 1984	Malawi Zebu	Malawi	10.0~39.0 (♂♀)	45~170 (♂♀)	0.38 (♂♀)		Nandolo et al., 2016
	Ethiopia	25.4 (♂♀)	116.63 (♂♀)	0.4 (♂♀)	0.244 (♂♀)	Bayssa et al., 2020	Muturu	Nigeria	9.97 (♂♀)	45.38 (♂♀)	0.25 (♂♀)	0.21 (♂♀)	Nweze et al., 2012
EAZ	Kenya	16.0 (♂♀)		0.12 (♂♀)		Latif et al., 1995	N"Dama	Ghana	18.49 (♂), 17.69 (♀)	92.11 (♂), 82.72 (♀)	0.40 (♂), 0.36 (♀)	0.23 (♂), 0.18 (♀)	Tuah & Daso 1985
Fogera	Ethiopia	21.3 (♂), 20.4 (♀)	90.0 (♂), 87.5 (♀)	0.29 (♂), 0.29 (♀)		Melaku et al., 2011		Gambia	17.6 (♂), 16.2 (♀)	67.2 (♂), 61.3 (♀)	0.14 (♂), 0.13 (♀)		Agyemang et al., 1997
IAC	Mali	16.6 (♂♀)		0.19 (♂♀)	0.12 (♂♀)	Wilson 1987	WASH	Ghana	17.90 (♂), 17.00 (♀)	83.99 (♂), 73.41 (♀)	0.36 (♂), 0.31 (♀)	0.21 (♂), 0.14 (♀)	Tuah & Daso 1985
Masai	Kenya	19.2~25.9 (♂♀)	64.4~89.8 (♂♀)	0.27~0.31 (♂♀)	0.13~0.25 (♂♀)	Kibiru 2007	Sheko	Ethiopia	17.25 (♂), 15.83 (♀)	106.13 (♂), 113.62(♀)	0.22 (♂), 0.21 (♀)	0.13 (♂), 0.12 (♀)	Bayou et al., 2015

EAZ (East African Zebu); IAC (Indigenous African Cattle); WASH (West African Short horn); ♂= males; ♀= females; ♂♀= both sexes

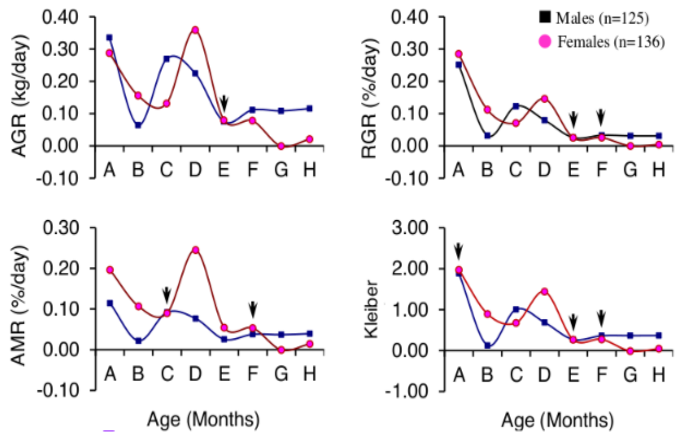
3.2 Growth and Maturing Rates

Table 3 shows the AGR, RGR, AMR, and KR estimates for male and female Nilotic calves from birth up to the age of 16 months, while Figure 1 depicts their profiles in the same period. Analysis of variance demonstrated that AGR, RGR, AMR, and KR varied between sexes; AGR and KR values were higher (*$p<0.05$*) in males, while RGR, and AMR values were higher in females. Analysis of variance further revealed that AGR, RGR, AMR and KR values fluctuate in a generally similar pattern during aging, with rates being higher in the pre-weaning period (birth~8 months) than in the post-weaning period (8~16 months). Interestingly, when there was a steep increase or decrease in AGR, there was a simultaneous steep increase or decrease in RGR, AMR, or KR during the same period, suggesting that these traits are inter-correlated, and confirmed the report that animals ranking high for one growth trait also rank high for others (Brown et al., 1988).

Table 3: Estimates (means ± standard deviation) for AGR, RGR, AMR, and KR in Nilotic calves

	Age interval	AGR (kg/day)	RGR (%/day)	AMR (%/day)	KR
Males n=125	Birth~8 M	0.204 ± 0.110	0.105 ± 0.034 ^{a}	0.070 ± 0.038 ^{a}	0.791 ± 0.242 ^{a}
	8~16 M	0.123 ± 0.043 ^{b}	0.038 ± 0.024 ^{b}	0.035 ± 0.015 ^{b}	0.377 ± 0.272 ^{b}
	Birth~16 M	0.163 ± 0.065 ^{c}	0.065 ± 0.013 ^{c}	0.056 ± 0.022 ^{c}	0.674 ± 0.176 ^{c}
		(14.08%) ^{d}	(54.01%) ^{d}	(39.87%) ^{d}	(41.94%) ^{d}
Females n=136	Birth~8 M	0.214 ± 0.034	0.128 ± 0.019 ^{a}	0.146 ± 0.024 ^{a}	0.906 ± 0.105 ^{a}
	8~16 M	0.064 ± 0.45 ^{b}	0.021 ± 0.014 ^{b}	0.015 ± 0.013 ^{b}	0.221 ± 0.154 ^{b}
	Birth~16 M	0.139 ± 0. 026 ^{c}	0.070 ± 0.010 ^{c}	0.095 ± 0.018 ^{c}	0.591 ± 0.108 ^{c}
		(69.11%) ^{d}	(83.41%) ^{d}	(72.78%) ^{d}	(75.09%) ^{d}

AGR =Absolute growth rate; RGR =Relative growth rate; AMR =Absolute maturing rate; KR =Kleiber ratio. Values in parenthesis denote percentage decrease in AGR, RGR, AMR, or KR from the pre-weaning to the post-weaning period, and values with the same superscript letters (a~d) within the same column are different between sexes at p<0.05. n = number of animals; M=month.



Changes in absolute growth rate (AGR), relative growth rate (AGR), absolute maturing rate (AMR), and Kleiber ratio from birth up to the age of 16 months. Each point represents the age range from which mean ± standard deviation values were calculated; A=birth to two months, B=two to four months, C=four to six months, D=six to eight months, E=eight to ten months, F=ten to twelve months, G=twelve to fourteen months, H=fourteen to sixteen months. Arrows (↓) indicate means that are not different between sexes at p<0.05; n = number of animals.

4. Discussion

This study is the first to report a comprehensive investigation of growth traits; namely, BW, DM, AGR, RGR, AMR, and KR in Nilotic cattle under traditional husbandry system, and to characterize the dynamics of these traits during postnatal development. Although very limited studies have attempted to investigate the growth of the Nilotic cattle in the past, the growth performance of these cattle remains poorly understood (Zahlan et al., 1986; Howell et al., 1988; Milla and Mahjub 2013). One reason is that the data reported by those studies were derived from sporadic surveys that were limited in scope, and therefore lack comprehensiveness. Moreover, subsequent attempts to pursue similar studies have been hampered by the absence of weighing machines for determining BW. We recently established an accurate alternative method for estimating BW in Nilotic cattle from HG and BL measurements (Milla and Mahjub 2013). Using this method in the present study, we have determined the BW of male and female Nilotic calves from birth up the age of 16 months, and report the following findings.

First, on average male Nilotic calves weigh heavier (p<0.05) than females, although individually, some female calves were heavier than some male calves at various ages, which is fundamentally consistent with the results of our previous study (Milla and Mahjub 2013). Specifically, the present mean birth weight of male and female Nilotic calves were very close to the 26.8 kg (males) and 15.5 kg (females) reported by us (Milla and Mahjub 2013). Also, the 26.8 kg (males), corresponded closely to the 20 kg recorded by another group (Zahlan et al., 1986). The present mean yearling weight 86.0 kg (males) and 81.8 kg (females), respectively corresponded to the 88 kg and 78 kg recorded previously by others (Howell et al., 1988). Interestingly, our estimates of BW were comparable to those of other African cattle breeds reared under traditional husbandry system (Table 2). For example, the present mean CWW, as well as birth weight are very close to those of the Masai, N`Dama, and West African Shorthorn cattle, but lower than those of the Boran, Forgera, and Sheko cattle, and higher than those of the Muturu cattle. These discrepancies were not unexpected, since BW in cattle varies according to breed type and other factors (Assan 2013).

Second, in Nilotic cattle, the AGR, RGR, AMR, KR, and DM varied between sexes, with AGR and KR values being higher in male calves, while RGR, AMR, and DM were the highest in female calves. From this finding, we speculated that male Nilotic calves are better off in both growth and food utilization efficiency than females, which are in turn better off in attaining mature weight earlier than males. This speculation is based on reports that high AGR indicates faster growth, high RGR, AMR and DM denotes faster maturity, and high KR indicates better food conversion efficiency (Fitzhugh and Taylor 1971; Stobart et al., 1986; Savar-Sofla et al., 2011; Talebi 2012; Supakorn and Pralomkrn 2012; Hojjati and Hossein-Zadeh 2018; Khadda et al., 2018; Mohd-Hafiz et al., 2019; Tesema et al., 2021). This finding could also explain why male Nilotic calves weighted heavier than females, as discussed earlier, although physiological and hormonal differences between sexes are also known to play a part; in that, males produce androgens, which enable them to develop more muscles, while females produce estrogens, which effectively promote fat deposition rather that muscle development (Alemneh and Getabalew 2019).

Third, in Nilotic cattle, AGR, RGR, AMR and KR values also varied between growth phases; being higher in the pre-weaning period and lower in the post-weaning period, thus, confirming reports that growth and maturing rates decrease as animals grow older (Fitzhugh and Taylor 1971; Schoeman 1996; Jeichitra et al., 2014; Khadda et al., 2018; Tesema et al., 2021). This finding suggest that Nilotic calves grow and mature faster during the pre-weaning period, and might therefore, reach puberty at a young age, especially when their high pre-weaning RGR or AMR is considered. In fact, RGR is equivalent to AMR, and animals with high pre-weaning RGR but low post-weaning RGR tend to reach puberty at an early age (Laster et al., 1976; Schoeman 1996; Fitzhugh and Taylor 1971). In support for the possibility of early maturity in Nilotic calves is the report which showed that Nilotic heifers, especially the small size Shilluk subtype calve for the first time at the age of 2 years (Howell et al., 1988).

This is early by comparison with the average age (3.7 year) at first calving for *Bos indicus* cattle under tropical conditions (Dadhich et al., 2017), although the large size Dinka and medium size Nuer subtype were presumed to calve for the first time around 3~4 years (Howell et al., 1988). The faster growth during the pre-weaning period could be attributed to claves` accessibility to their mother's milk, and to their ability to gain weight, unlike during the post-weaning period, when they are exposed to various stress conditions, including the stress of finding feed by themselves, especially during the dry season when feed resources are scarce; thereby resulting in low growth performance (Weary and Chua 2000; Mgbere and Olutogun 2003; Place et al., 1998; Shivley et al., 2017; Kisac et al., 2011). Indeed, we and others have previously observed that growing Nilotic calves, as well as adult cows and bulls often lose weight, exhibit poor body condition, and even die in large numbers during the dry season (Milla and Mahjub, 2013; Howell et al., 1988).

On the other hand, the reason why female Nilotic calves had lower post-weaning growth and maturing rates compared to males is unclear, but it could be because females are more sensitive to the stress of weaning, such that they tend to eat less and vocalize more compared to male calves (Sweeney et al., 2010; Lambertz et al., 2014). Concerning KR in particular, its decline during the post-weaning period could be because this trait is correlated with feed conversion efficiency and energy requirement for maintenance, both of which are also known to decline with increasing age and body mass (Roshanfekr 2014; Harper 1998; Thompson et al., 2010; Nie et al., 2015; Jeichitra et al., 2014). Numerous studies have also reported variation in AGR, RGR, AMR and/or KR between growth phases and/or sexes in various domestic animals (Ghafouri-Kesbi and Tari 2015; Supakorn and Pralomkrn 2012; Zuñiga-Galindo et al., 2018; Khadda et al., 2018; Chakraborty et al., 2020; Bansal et al., 2021; Tesema et al., 2021).

Finally, while there are currently no literature records for RGR, AMR, or KR in neither male nor female Nilotic cattle for comparison with the results of this study, the present average AGR estimates for males (0.163 kg/day) and females (0.139 kg/day) from birth~16 months of age (Table 3) compared favorably with values previously recorded for *Dinka* (0.143 kg/day), *Nuer* (0.156 kg/day), and *Shiulluk* (0.160 kg/day) male calves from birth~12 months (Howell et al., 1988). These values are also very close to those of the East African Zebu cattle and Sheko cattle, but somewhat inferior to those of the Boran, Fogera, Masai, Malawi Zebu, Muturu, N`Dama, and West African shorthorn cattle (Table 2). From these comparisons we can suggest that Nilotic cattle grow at their best in their environment, as other cattle breeds do in other parts of Africa, although growth rates differ among cattle breeds (Baker et al., 1981).

5. CONCLUSION

The present study provided the first evidence that Nilotic calves grow faster in terms of AGR, RGR, AMR, and KR during the pre-weaning period, and even attain mature body weight at earlier ages; with males gaining weight faster than females, and females maturing faster than males, like some indigenous African cattle breeds, elsewhere. These findings represent a significant step towards elucidating the production potential of the Nilotic cattle. Therefore, determination of whether BW, DM, AGR, RGR, AMR, and KR traits are inter-correlated would help in the development of an institutional scheme for selecting superior animals for use in selective breeding.

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REFERENCES

Abdel-Rahman, I.M.K., 2007. Sudanese cattle resources and productivity. A review. Agricultural Reviews, 28 (4), Pp. 305–308.

Agyemang, K., Dwinger, R.H., Little, D.A., Rowlands, G.J., 1997. Village N'Dama cattle production in West Africa. Six years of research in The Gambia. Nairobi, Kenya: International Livestock Research Institute.

Alemneh, T., Getabalew, M., 2019. Factors influencing the growth and development of meat animals. International Journal of Animal Science, 3, 1048. https://doi.org/10.1016/B978-0-08-100694-8.00002-9

Baker, J.H., Kropp, J.R., Turman, E.J., Buchanan, D.S., 1981. A comparison of different breeds for growth rates, performance traits and scrotal circumference in young beef bulls. Animal Science Research Reports, Pp. 15-18.

Bansal, G., Kumar, V., Nagda, R., Hada, R., 2021. Genetic investigation on Kleiber ratio in Sonadi sheep. Journal of Entomology and Zoology Studies, 9, Pp. 1038–1041.

Bayou, E., Haile, A., Gizaw, S., Mekasha, Y., 2015. Evaluation of non-genetic factors affecting calf growth, reproductive performance, and milk yield of traditionally managed Sheko cattle in Southwest Ethiopia. Springer Plus, 4, Pp. 568.

Bayssa, M., Yigrem, S., Betas, S., Tolera, A., 2020. Production, reproduction, and adaptation characteristics of Boran cattle breed under changing climate: A systematic review and meta-analysis. PLoS ONE, 16 (5). https://doi.org/10.1371/journal.pone.0244836

Bergh, L., Scholtz, M.M., Erasmus, G.J., 1992. Identification and assessment of the best animals: The Kleiber ratio (growth rate/ metabolic mass) as a selection criterion for beef cattle. Proceedings of the Association for the Advancement of Animal Breeding and Genetics, 10, Pp. 338–340. http://www.aaabg.org/livestocklibrary/1992/ab92078.pdf

Boro, P., Naha, B.C., Madkar, A.R., Saikia, D.P., Prakash, C., Godara, A.S., Sahoo, S.P., Patel, J., Chandrakar, J., 2016. The effects of heifer growth on milk production and efficiency. International Journal of Science and Nature 7, Pp. 220–227. https://doi.org/10.1016/j.animal.2020.100169

Brown, A.H., Johnson, Z.B., Chewning, J.J., Brown, C.J., 1988. Relationships among absolute growth rate, relative growth rate and feed conversion during post-weaning feedlot performance tests. Journal of Animal Science, 66, Pp. 2524–2529. DOI: 10.2527/jas1988.66102524x

Chakraborty, D., Zaffer, V., Gupta, P., Khajuria, P., Singh, V.P., Taggar, R., 2020. Genetic studies on growth rate traits and Kleiber ratios in Rambouillet Sheep. Journal of Pharmaceutical Innovations, 9, Pp. 23–26.

Cossins, N.J., 1985. The productivity and potential of pastoral systems.

Dadhich, S.R., Pandey, H.N., Gupta, A., Raghav, R.S., 2017. Effect of Green fodder on milk production and age at first calving in Gir cows. International Journal of Advanced Multidisciplinary Research, 6, Pp. 190–192.

de Mabior, J.G., 1981. Identifying, selecting, and implementing rural development strategies for socio-economic development in the Jonglei Projects Area, Southern Region, The Sudan: Retrospective Theses and Dissertations, Iowa State University, USA. Pp. 7413. https://lib.dr.iastate.edu/rtd/7413

Fitzhugh, H., Taylor, C.S., 1971. Genetic analysis of degree of maturity. Journal of Animal Science, 33, Pp. 717–725. DOI: 10.2527/jas1971.334717x

Frost, A.R., Schofield, C.P., Beaulah, S.A., Mottram, T.T., Lines, J.A., Wathes, C.M., 1997. A review of livestock monitoring, and the need for integrated systems. Computers and Electronics in Agriculture, 17, Pp. 139–159. https://doi.org/10.1016/S0168-1699(96)01301-4

Ghafouri-Kesbi, F., Tari, A.R., 2015. Relative growth rate in sheep: Heritability and relationship with absolute growth rate and body weight. Songklanakarin Journal of Science and Technology, 37, Pp. 21–27.

Harper, E.J., 1998. Changing perspectives on aging and energy requirements: Aging and energy intakes in humans, dogs, and cats. Journal of Nutrition, 128, Pp. 2623–2626. https://doi.org/10.1093/jn/128.12.2623S

Hayes, C.J., McAloon, C.G., Kelly, E.T., Carty, C.I., Ryan, E.G., Mee, J.F., O'Grady, L., 2021. The effect of dairy heifer pre-breeding growth rate on first lactation milk yield in spring-calving, pasture-based herds. Animal, 15 (3). https://doi.org/10.1016/j.animal.2020.100169

Heinrichs, A.J., Rogers, G.W., Cooper, J.B., 1992. Predicting body weight and wither height in Holstein heifers using body measurements. Journal of Dairy Science, 75, Pp. 3576–81. https://doi.org/10.3168/jds.S0022-0302(92)78134-X

Hojjati, F., Hossein-Zadeh, N.G., 2018. Comparison of non-linear growth models to describe the growth curve of Mehraban sheep. Journal of Applied Animal Research, 46, Pp. 499–504 https://doi.org/10.1080/09712119.2017.1348949

Howell, P., Lock, M., Cobb, S., 1988. The Jonglei Canal: Impact and opportunity. Cambridge University Press. https://www.cambridge University Press.

Jeichitra, V., Ramanujam, R., Karunanithi, K., Rahumathulla, P.S., 2014. Genetic Analysis of Relative Growth Rates in Mecheri Sheep. Indian Journal of Animal Science, 91, Pp. 12–15.

Khadda, B.S., Singh, B., Singh, D.V., Singh, S.K., Singh, C.B., Singh, J.L., 2018. Genetic and non-genetic parameters of Kleiber ratio in Pantja goat under field conditions of Tarai region of Uttarakhand. Indian Journal of Animal Science, 88, Pp. 1370–1373.

Kibiru, S.K., 2007. Calf health and production under Massai pastoral system in Kajodo District of Kenya. PhD Thesis, University of Nairobi.

Kisac, P., Broucek, J., Uhrincat, M., 2011. Effect of weaning calves from mother at different ages on their growth and milk yield of mothers. Czech Journal of Animal Science, 56, Pp. 261–268. DOI: 10.17221/1287-CJAS

Koster, E., van der Westhuizen, J., Erasmus, G.J., 1994. Heritability estimates for different Kleiber ratios obtained from growth performance data in a Hereford herd. South African Journal of Animal Science, 24 (2).

Lambertz, C., Farke-Röver, A., Gauly, M., 2014. Effects of sex and age on behaviour and weight gain in beef calves after abrupt weaning. Animal Science Journal, 86, Pp. 345-350. https://doi.org/10.1111/asj.12285

Laster, D.B., Smith, G.M., Gregory, K.E., 1976. Characterization of biological types of cattle. IV Post-weaning growth and puberty of heifers. Journal of Animal Science, 43, Pp. 63–70. https://doi.org/10.2527/jas1976.43163x

Latif, A.A., Rowlands, G.J., Punyua, D.K., Hassan, S.M., Capstick, P.B., 1995. An epidemiological study of tick-borne diseases and their effects on productivity of zebu cattle under traditional management on Rusinga Island, western Kenya. Preventive Veterinary Medicine, 22, Pp. 169–181. https://doi.org/10.1016/0167-5877(94)00408-B

Melaku, M., Zeleke, M., Getinet, M., Mengistie, T., 2011. Pre-weaning growth performances of Fogera calves at Metekel cattle improvement and multiplication ranch, Northwest Ethiopia. Livestock Research for Rural Development, 23 (182).

McWhir, J., Wilton, J.W., 1986. Prediction of traits at constant finish for performance-tested beef cattle. Journal of Animal Science, 63, Pp. 1108-1118. DOI: 10.2527/jas1986.6341108x

Meyer, K., 1992. Variance components due to direct and maternal effects for growth traits of Australian beef cattle. Livestock Production Science, 31, Pp. 179–204. https://doi.org/10.1016/0301-6226(92)90017-X

Mgbere, O.O., Olusegun, O., 2003. Genetic aspects of growth and maturing rate in trypan tolerant beef cattle: N'Dama. Nigerian Journal of Animal Production, 30, Pp. 149–156. https://doi.org/10.51791/njap.v30i2.1461

Milla, A.P., Mahagoub, M.M., Bushara, I., 2012. Analysis of pastoral livelihood strategies among displaced Nilotics in Tunga County; Upper Nile State-South Sudan. Journal of Animal Science Advancement, 2, Pp. 458–466.

Milla, A.P., Mahjoub, M.M., 2013. Estimation of live body weight from heart girth, body length, and condition score in Nilotic cattle, Southern Sudan. Agricultural Technology Transfer Society Magazine, 1, Pp. 15–19.

Mohammed, R.M., Fager, I.M., Abu-Neikhaila, A.M., Abdelwahid, H.H., Abu-Shulukh, E.S., 2016. Milk yield and milk composition of Nilotic cattle breed supplemented with different levels of concentration. Journal of Applied Industrial Science, 4 (1), Pp. 38–42.

Mohd, H.A.W., Marini, A.M., Rosly, S.M., Hifzan, M.R., Izuan, B.A.J., Shanmugavelu, S., 2019. Describing growth pattern of selected Kedah-Kelantan cows using non-linear regression models. Malaysian Journal of Animal Science, 22, Pp. 47–54.

Morris, C.A., Wilton, J.W., 1976. Influence of body size on the biological efficiency of cows: A review. *Canadian Journal of Animal Science,* 56, Pp. 613–647. (https:www.cdnsciencepub.com)

Nandolo, W., Gondwe, N., Banda, M., 2016. Phenotypic and genetic parameters of calf growth traits for Malawi Zebu. Livestock Research for Rural Development, 28 (2).

Nie, H.T., Wan, Y.J., You, J.H., Wang, Z.Y., Lan, S., Fan, Y.X., Wang, F., 2015. Effect of Age on Energy Requirement for Maintenance and Growth of Dorper and Hu Crossbred F1 Ewes Weighing 20 to 50 kg. Asian-Australian Journal of Animal Science, 28, Pp. 1140–1149. doi: 10.5713/ajas.14.0403

Nweze, B.O., Ekewe, O.O., Alaku, S.O., Omeje, S.I., 2012. Productivity of two indigenous Nigerian cattle breeds and their crossbred under range grazing management. World Journal of Life Science and Medical Research, 2 (1). https://www.academia.edu

Ozkaya, S., Bozkurt, Y., 2009. The accuracy of prediction of body weight from body measurements in beef cattle. Archiv Fur Tierzucht Dummerstorf, 52, Pp. 371–377.

Place, N.T., Heinrichs, A.J., Erb, H.N., 1998. The effects of disease, management, and nutrition on average daily gain of dairy heifers from birth to four months. Journal of Dairy Science, 81, Pp. 1004–1009. https://doi.org/10.3168/jds.S0022-0302(98)75661-9

Portes, J.V., Menezes, G.R.O., MacNeil, M.D., da Silva, L.O.C., Gondo, A., Neto, J.B., 2020. Selection indices for Nellore production systems in the Brazilian Cerrado. Livestock Science, 242, Pp. 104309. https://doi.org/10.1016/j.livsci.2020.104309

Rege, J.E.O., Tawah, C.L., 1999. The state of African cattle genetic resources II. Geographical distribution, characteristics, and uses of present-day breeds and strains. Animal Genetic Resource Information, 26, Pp. 1–26.

Roshanfekr, H., 2014. Estimation of genetic parameters for Kleiber ratio and trends for weight at birth and weaning in Arabi sheep. International Journal of Advanced Biological and Biomedical Research, 2 (11), Pp. 2830–22836.

Rout, P.K., Matika, O., Kaushik, R., Dige, M.S., Dass, G., Singh, M.K., Bhusan, S., 2018. Genetic analysis of growth parameters and survival potential of Jamunapari goats in semiarid tropics. Small Ruminant Research, 165, Pp. 124–130. https://doi.org/10.1016/j.smallrumres.2018.04.002

Savar-Sofla, S., Nejati-Javaremi, A., Abbasi, M.A., Vaez-Torshizi, R., Chamani, M., 2011. Investigation on Direct and Maternal Effects on Growth Traits and the Kleiber Ratio in Moghani Sheep. World Applied Science Journal, 14, Pp. 1313–1319.

Schoeman, S.J., 1996. Characterization of beef cattle breeds by virtue of their performances in the National Beef Cattle Performance and Progeny Testing Scheme. South African Journal of Animal Science, 26 (1). http://hdl.handle.net/10019.1/9395

Shimada, K., Izaike, Y., Suzuki, O., Oishi, T., Kosugiyama, M., 1988. Milk yield and its repeatability in Japanese Black cows. Asian-Australian Journal of Animal Science, 1, Pp. 47–53. (https://www.nimbiosci.org)

Shivley, C.B., Lombard, J.E., Urie, N.J., Kopral, C.A., Santin, M., Earleywine, T.J., Olson, J. D., Garry, F.B., 2017. Preweaned heifer management on US dairy operations: Part VI. Factors associated with average daily gain in preweaned dairy heifer calves. Journal of Dairy Science, 101, Pp. 9245–9258. https://doi.org/10.3168/jds.2017-14022

Stobart, R.H., Bassett, J.W., Cartwright, T.C., Blackwell, R.L., 1986. An Analysis of body weights and maturing patterns in Western Range Ewes. Journal of Animal Science, 63, Pp. 729–740. https://doi.org/10.2527/jas1986.633729x

Supakorn, C., Pralomkarn, W., 2012. Genetic parameter estimates for weaning weight and Kleiber ratio in goats. Songklanakarin Journal of Science and Technology, 34, Pp. 165–172.

Sweeney, B.C., Rushen, J., Weary, D.M., de Passillé, A.M., 2010. Duration of weaning, starter intake, and weight gain of dairy calves fed large amounts of milk. Journal of Dairy Science, 93, Pp. 148-152. https://doi.org/10.3168/jds.2009-2427

Szabó, F., Szabó, E., Bene, S., 2012. Statistic and genetic parameters of 205-day weaning weight of beef calves. Archiv Fur Tierzucht Dummerstorf, 55, Pp. 552–561. (https://aab.opernicus.org)

Talebi, M.A., 2012. Feed intake, feed efficiency, growth, and their relationship with Kleiber ratio in Lori-Bakhtiari lambs. Archiva Zootechnica, 15, Pp. 33–39.

Tesema, Z., Deribe, B., Lakew, M., Getachew, T., Tilahun, M., Kefale, A., Shibesh, M., Asres, Z., Yizengaw, L., Alebachew, G.W., Ali, S. T., Kiros, S., Asfaw, M., Bishaw, M., 2021. Phenotypic and genetic parameters estimation for growth traits and Kleiber ratios in Dorper x indigenous crossbred sheep. Proceedings of the 13th Annual Regional Conference on Completed Livestock Research Activities, Vol 1.

Tuah, A.K., Danso, Y.N., 1985. Preliminary studies on the performance and productivity indices of N'Dama and West African Shorthorn in Ghana. Tropical Animal Health and Production, 17, Pp. 114–120. https://link.springer.com ›

Van Marle-Köster, E., Mostert, B. E., Van der Westhuizen, J., 2000. Body measurements as selection criteria for growth in South African Hereford cattle. Archiv Fur Tierzucht Dummerstorf, 43, Pp. 5–15. DOI: 10.5194/aab-43-5-2000

Wangchuk, K., Wangdi, J., Mindu, M., 2018. Comparison and reliability of techniques to estimate live cattle body weight. Journal of Applied Animal Research, 46, Pp. 349–352.

Weary, D.M., Chua, B., 2000. Effects of early separation on the dairy cow and calf 1. Separation at 6 h, 1 day, and 4 days after birth. Appl. Animal Behavior Science, 69, Pp. 177–188. DOI: 10.1016/s0168-1591(00)00128-3

Williner, V., Torres, M.V., Carvalho, D.A., König, N., 2014. Relative growth and morphological sexual maturity size of the freshwater crab Trichodactylusborellianus (Crustacea, Decapoda, Trichodactylidae) in the Middle Paraná River, Argentina. Zoo Keys, 25, Pp. 159–170. DOI: 10.3897/zookeys.457.6821

Wilson, R.T., 1987. Livestock production in central Mali: factors influencing growth and live weight in agro-pastoral cattle. Tropical Animal Health and Production, 19, Pp. 103–114. DOI: 10.1007/BF02297328

Zahlan, A.B., Magar, W.Y., Shuman, A.M., 1986. Agricultural sector of Sudan: policy and system studies. Published for the Abdul Hameed Shoman Foundation, Amman, Jordan by Ithaca Press. ebook.pdfbookslibs.com

Zuñiga-Galindo, I.C., Navarro-Hernandez, J.A., Carlin-Valderrabano, S.C., Sanchez-Lemus., J.C, Juarez-Rodriguez, I., Vargas-Estrada, D., 2018. Effect of ractopamine hydrochloride on growth promotion in guinea pigs (Cavia porcellus). Turkish Journal of Veterinary and Animal Science, 42, Pp. 103–109. DOI:10.3906/vet-1709-9