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Exploring the Link Between Insulin-like Growth Factor-1 (IGF-1) and Body Trait Measurements in Prepubertal Goat Kids in a Humid Subtropical Climate

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ABSTRACT

Background: Insulin-like growth factor 1 (IGF-1) is produced throughout life and contributes to the growth of nearly all the organs in the body. Current study investigated the relationship between IGF-1 concentrations with body trait measurements in prepubertal period of male and female Assam Hill Goat kids.

Methods: Twenty-four (24) goat kids (12 male + 12 female) were used for the experiment for a period of 7 months (March-September, 2022). Climatic data points were obtained from the State Meteorological Department, Meghalaya and the temperature-humidity index (THI) was calculated. The experimental months was grouped into fourteen (14) periods (Period 1-14) based on the severity of heat stress as indicated by the THI values. Blood samples were collected at every 15 days interval for determination of serum IGF-1 levels and on the same day of collection the phenotypic growth trait measurements were recorded.

Result: Results showed that the IGF-1 concentration in the experimental kids significantly ($P<0.05$) increased until Period 6; then a steady non-significant ($P>0.05$) decline till Period 14. Correlations between IGF-1 concentrations and the phenotypic body trait measurements were significant ($P<0.05$). In conclusion, serum IGF-1 level increases with increase in THI which may be attributed to its thermos-protective effect against environmental stressors.

Key words: Climatic variables, Correlation, Goat kids, Heat stress, Insulin-like growth factor (IGF-1), Phenotypic body traits.

INTRODUCTION

Goat being a small ruminant animal plays an important role in uplifting the socio-economic condition of the farmers and assures a continuous source of income. Assam Hill Goat is a native breed of Assam and is found in the hilly tracts of North-eastern region of India. Highly prolific and well adapted to the local climatic conditions, this breed is mainly reared for meat purpose. So, in this regard growth related traits have always attracted much interest in the production of meat animals as it is the most common trait used for evaluating the economic value of farm animals.

Physiologically, growth is the effect of a complex process that regulates neuroendocrine pathways, among which the somatotrophic axis (growth hormone (GH)/*IGF-1* plays a fundamental part in postnatal growth and metabolism in mammals (Ashpole *et al*., 2015). IGF-1, also called somatomedin C, is a hormone structurally similar to insulin and the most potent mitogenic peptide with 70 amino acids (Pehlivan, 2019). Although IGF-1 is produced throughout life and involved in the growth and function of almost every organ in the body, their highest rates of production occur during the pubertal growth spurt. During the prepubertal period, IGF-1 are determinants of longitudinal bone growth, skeletal maturation, acquisition of bone mass and cell proliferation, whereas in adults they have anabolic effects and help in the maintenance of bone mass (Baroncelli *et al*., 2003). The secretion of IGF-1 is non-pulsatile and the secretion level is phenotypically correlated with the live weight and growth rate in cattle, pigs, sheep and chickens (Bishop *et al*., 1989). According to Sarko *et al*. (1994), IGF-1 concentrations in farm animals are significantly affected by environmental factors. This was followed by Spicer *et al*. (2007) and Dahl *et al*. (1997) who reported that photoperiod and IGF-1 concentration were positively correlated. On the other hand, Richards *et al*. (1995) reported a negative correlation between environmental temperature and IGF-1 concentration. Squires, (2003) reported that short-term stress reduced IGF-1 secretion. So, in purview of the reported studies, there seems to be a knowledge-gap regarding the influence of IGF-1 with phenotypic growth traits in farm animals especially goat kids under existing seasonal temperature/

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humidity fluctuations. In this regard, it was hypothesized that serum IGF-1 levels are altered by fluctuations in environmental temperature/humidity in a particular topographic region, which in turn is reflected on the growth-related parameters of the animal species. Therefore, this study aimed to identify the relationship between IGF-1 concentrations with some body trait measurements in prepuberty period of male and female Assam Hill Goat kids.

MATERIALS AND METHODS

This study was carried out on twenty-four (24) Assam Hill Goat kids (12 male + 12 female) raised in the Goat Farm (25.6768°N, 91.9270°E) under the Division of Animal and Fisheries Sciences, ICAR Research Complex for NEH Region, Umiam, Meghalaya. The experimental trial was carried between March, 2022 to September, 2022. The goat kids were clinically healthy and were raised under semi-intensive system. The goat kids were allowed to receive milk from their dams during the experimental period, along with concentrates and hay fed ad libitum from 2 weeks of age. Fresh water was always available to the goat kids. Management of experimental goat kids did not interfere with the general operation of the station and the study was conducted within standard ethical norms for a period of 7 months (March-September, 2022).

Blood samples were taken at 15 days interval during the experimental period. Samples for Period 1 were collected 30-33 days after birth; and subsequent sampling (Period 2-14) was carried out at 15 days interval. On sampling days, blood samples were collected from the vena jugularis of each goat kid using Clot Activator. The blood samples were centrifuged at 4000 × g for 5 minutes and the serum was stored at -20°C until further analysis was carried out. IGF-1 concentrations were determined in the blood serum using a commercial ELISA kit (ELK Biotechnology Goat IGF-1 Cat. No. ELK8708). The intra-and inter-assay coefficients of variation were <8% and <10%, respectively. The least detectable concentration was 1.57 ng mL^{-1}.

The sampling interval for phenotypic body trait measurements were kept consistent with the blood sampling. With respect to body trait measurements, the body weight (BW), heart girth (HG), body length (BL), withers height (WH), shin circumference (SC), rump length (RL), chest depth (CD), rump height (RH) and head length (HL)of each kid were regularly measured on the same sampling days. BW was measured using a commercial hanging scale (±10 g). A measuring tape was used to record the phenotypic body trait measurements of the goat kids. All measurements were taken by the same operator and followed the methodology of Herrera *et al*. (1996) and the observations were recorded in centimetres (cm).

Climatic values *viz*., temperature (°C) and humidity (%) fluctuations were obtained from State Meteorological Department,Meghalaya in order to estimate the comfortable temperature and severity of heat stress during the experimental period. The temperature-humidity index (THI) was calculated using the following equation, reported by Marai *et al*. (2001) for sheep and goats.

$$THI = db°C - \{(0.31 - 0.31\ RH/100)\ (db°C - 14.4)\}$$

Where,
db°C = Dry bulb temperature (°C).
RH = Relative humidity (RH %)/100.

The values obtained indicate the following: <22.2 signifies the absence of heat stress; 22.2 to <23.3 represents moderate heat stress and 23.3 to <25.6 represents severe heat stress (Marai *et al*., 2007; Pehlivan, 2019).

The experimental data obtained were analysed by Statistical Package for Social Sciences (SPSS) software version 23. IGF-1 concentration differences within and between groups and their interactions were evaluated. The effect of period and sex on serum IGF-1 levels were assessed by Analysis of Variance (ANOVA). Multiple comparisons were made using a Tukey test if significance was indicated by ANOVA. Correlation coefficients (Pearson) between IGF1 concentrations and body trait measurements were calculated. Results are shown as the mean ± standard error (X±S.E) and the significance level was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The goal of this research was to measure the levels of serum IGF-1 in male and female prepubertal Assam Hill Goat kids and explore the correlation between the levels of IGF-1 and growth measurements, considering the seasonal temperature and humidity fluctuations. A few previous studies analysed IGF-1 levels in some breeds, but were primarily targeting other investigational goals. A priori data, therefore, including serum IGF-1 measurements in this unique goat germplasm, have not previously been available. The lack of data prompted the investigators to examine IGF-1 concentrations and relate it to physical growth characteristics, as a clear understanding of these levels could contribute to a better understanding of the aging process in farm animals. By doing so, it may shed light on efforts to improve production efficiency by manipulating physiological systems, as the GH-IGF-1 pathway has been shown to be crucial in extending lifespan in certain organisms, such as worms, flies and mice, but its effect on the growth of farm animals, particularly goats, is still unknown.

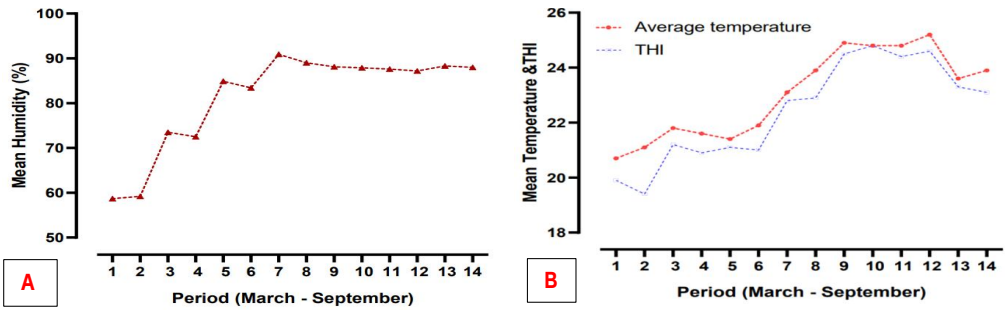
Pattern of climatic variables during the study period

Patterns of climatic values *viz*., mean humidity (%) and mean temperature and THI (units) has been presented in Fig 1A-B. As evident from the graphs, the THI and temperature values increased from Period 2 to Period 9 and a sharp decline after period 12. Similarly, the mean humidity levels increased from Period 2 to Period 7; then a steady decline from Period 8 to Period 14. It can be derived from the Fig that Period 1-2 were devoid of heat stress, Period 3-6 represents moderate heat stress and Period 7 and beyond represents severe heat stress.

Serum IGF-1 concentration

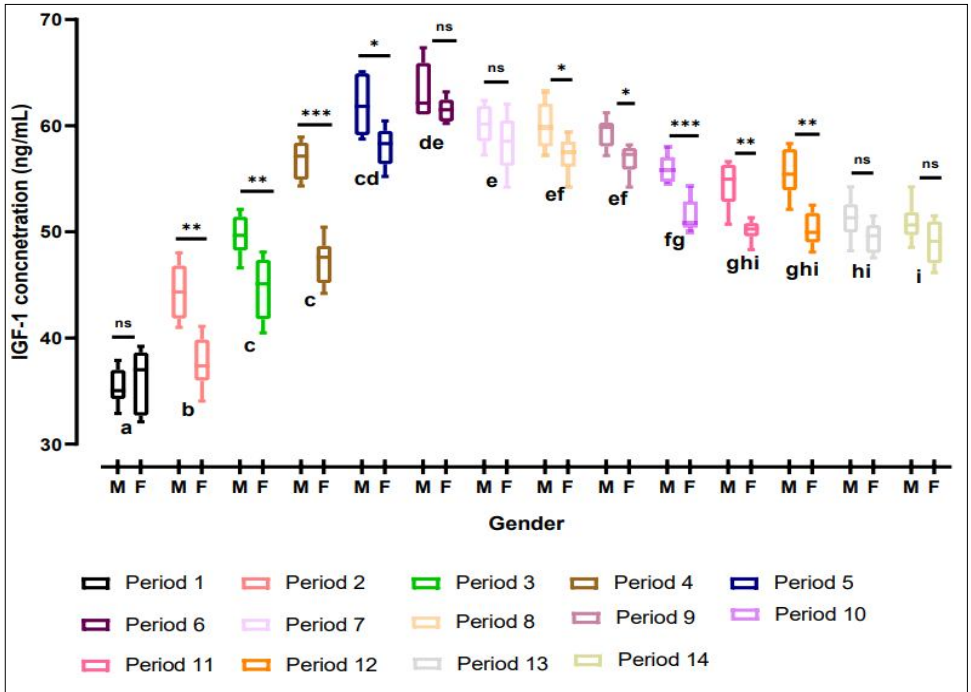
The IGF-1 concentration in theexperimental kids of both sexes in the different periods (Period 1-14) has been depicted in Fig 2. As per our findings, the IGF-1 concentration in the experimental kids significantly (P<0.05) increased until Period 6; then a steady non-significant (P>0.05) decline till Period 14. Significant (P<0.01) differences were recorded in the said parameter between male and female kids in Periods 2,3,11,12. A highly significant (P<0.001) difference existed in Period 4 and 10.

Previous studies have indicated that the levels of IGF-1 in farm animals are significantly influenced by environmental factor (Sarko *et al*., 1994). We reported decrease in IGF-1 concentration in goat kids during periods of heat stress (Period 7-14) but significantly elevated levels (Period 1-6) during ambient THI (without heat stress). Such results corroborate with the findings of Pehlivan (2019) whereby it was documented that IGF-1 release in prepubertal goat kids increases due to increase in photoperiod and environmental temperature. Previous studies, particularly those focused



NB: THI values <22.2 signifies the absence of heat stress; 22.2 to <23.3 represents moderate heat stress and 23.3 to <25.6 represents severe heat stress.

Fig 1: Climatic variables during the experimental periods. A. Mean humidity (%). B. Mean temperature and THI (Units).



Notes: a, b, c, d, e, f, g, h, i - different letters indicate significant (P<0.05) differences between the different sampling periods. **- P<0.01; ***- P<0.001; ns- non-significant. Samples for Period 1 were collected 30-33 d after birth; and subsequent sampling (Period 2-14) was carried out at 15 days interval.

Fig 2: Box and whisker plots of mean IGF-1 concentration (ng/mL) in the experimental kids of both sexes during different sampling periods.

Table 1: Periodic mean values (Mean±S.E) of few phenotypic body trait measures.

Periods¥	Gender	BW	WH	HG	CD	BL	RL	RH	SC	HL
1	M	12.62±1.85	40.13±2.17	56.10±2.40	22.63±1.27	44.40±1.70	14.73±1.19	44.40±1.70	7.53±1.58	12.70±1.88
	F	12.23±1.02	38.33±1.66	56.02±3.75	21.33±0.66	43.66±1.52	13.01±0.33	43.09±0.88	6.59±2.18	11.33±1.20
2	M	13.10±1.47	42.47±2.30	56.13±2.40	22.70±1.46	45.63±2.00	14.90±1.50	45.13±2.62	7.60±2.47	12.87±1.09
	F	12.66±1.20	38.79±2.26	56.09±1.69	21.45±2.72	44.16±2.48	13.33±4.90	44.21±2.89	6.78±3.11	11.46±4.48
3	M	13.50±1.80	43.50±1.89	56.27±3.09	23.13±1.27	46.90±2.80	15.13±0.93	46.73±3.58	7.77±0.29	12.99±0.88
	F	13.15±1.21	39.16±1.17	56.13±3.05	21.83±1.84	44.91±0.88	13.91±0.45	45.5±1.66	6.90±0.41	11.59±0.57
4	M	14.22±1.01	43.97±1.53	56.53±2.78	23.83±0.79	47.10±2.40	15.27±0.64	47.22±2.91	7.90±0.31	13.03±0.88
	F	13.53±1.44	39.98±2.02	56.33±2.90	22.06±0.88	45.66±1.20	14.13±0.33	46.33±0.33	7.16±0.44	11.73±0.88
5	M	14.89±1.39	44.00±1.73	56.60±1.60	24.20±1.11	47.80±2.31	15.43±0.65	47.93±2.50	8.07±0.44	13.17±1.01
	F	14.30±1.44	40.24±1.62	56.54±2.64	22.96±0.33	46.66±1.45	14.52±0.32	47.05±1.52	7.31±0.52	12.03±0.33
6	M	15.65±1.50	45.17±1.13	57.13±1.85	24.90±0.58	48.20±3.61	15.87±1.17	48.33±2.74	8.22±0.31	13.27±1.13
	F	14.81±0.78	41.33±1.85	56.67±2.60	23.43±0.52	46.98±2.02	14.99±1.74	48.8±0.64	7.54±1.27	12.23±1.26
7	M	16.10±1.45	46.43±0.81	57.33±1.99	25.32±1.04	49.77±2.74	16.13±0.73	48.88±2.18	8.34±0.62	13.34±1.27
	F	15.13±1.16	42.00±1.01	56.93±1.79	23.76±0.88	47.66±0.34	15.13±0.84	49.6±0.30	7.80±0.21	12.43±0.17
8	M	16.99±1.25	47.00±1.73	57.67±1.49	25.80±1.14	50.67±2.03	16.60±0.60	50.30±2.01	8.65±0.45	13.49±1.16
	F	15.78±1.33	43.66±1.33	57.27±2.40	24.01±0.33	48.02±1.52	15.83±0.33	50.23±1.15	8.06±0.41	12.61±0.58
9	M	17.52±1.21	47.67±1.21	57.94±1.67	26.11±0.97	51.22±2.10	17.02±0.67	50.93±1.22	8.89±0.44	13.61±1.09
	F	16.02±0.97	44.13±0.99	57.53±1.23	24.59±0.86	48.90±1.45	16.32±1.11	51.22±1.09	8.25±0.56	12.79±1.22
10	M	17.99±1.12	48.12±1.10	58.11±0.78	26.76±1.22	51.93±1.56	17.86±0.98	52.33±1.01	9.21±0.22	13.79±0.81
	F	16.56±0.78	44.90±0.87	57.90±1.24	25.12±1.34	49.75±1.21	16.61±0.89	52.31±0.93	8.57±0.41	12.98±0.78
11	M	18.22±1.01	48.91±0.98	58.23±1.56	27.12±2.31	52.71±0.98	18.24±0.82	54.21±1.43	9.30±0.51	13.91±0.66
	F	16.89±0.76	45.87±1.22	58.21±2.04	25.98±1.31	50.22±0.76	17.21±1.33	52.89±2.01	8.79±0.39	13.18±0.29
12	M	18.58±0.98	49.76±1.23	58.39±2.21	27.53±0.89	53.40±0.55	18.91±1.21	54.98±2.31	9.45±0.41	13.99±1.13
	F	17.12±0.84	46.22±0.94	58.45±1.89	26.45±0.99	50.89±1.23	17.88±0.77	54.77±1.94	9.02±0.55	13.29±0.78
13	M	18.97±0.99	50.12±0.82	58.42±1.45	27.98±2.01	54.33±0.88	19.32±1.22	55.67±1.49	9.56±0.40	14.09±0.29
	F	17.56±0.79	46.69±1.23	58.89±0.88	26.99±2.22	51.72±0.91	18.11±1.25	55.60±1.72	9.23±0.38	13.41±0.54
14	M	19.21±0.87	51.20±2.01	58.76±0.76	28.23±1.43	55.76±1.49	19.59±0.81	56.62±1.40	9.79±0.37	14.27±0.77
	F	17.91±1.21	47.69±1.67	59.21±2.32	27.54±1.32	52.22±1.80	18.70±0.99	56.12±0.80	9.46±0.55	13.60±0.51

M: Male; F: Female; BW: Body weight; WH: Withers height; HG: Heart girth; CD: Chest depth; BL: Body length; RL: Rump length; RH: Rump height; SC: Shin circumference; HL: Head length.

¥ The first samples (Period 1) were taken 30-33 d after birth and subsequent sampling (Period 2-14) was done at 15 days interval.

Table 2: Pearson's correlation (r) values between IGF-1 concentration and few phenotypic body trait measurements in experimental kids.

Variable	Gender	BW	WH	HG	CD	BL	RL	RH	SC	HL
IGF-1 concentration	M	0.541*	0.691**	0.812**	0.788**	0.518*	0.711**	0.662**	0.144	0.772**
	F	0.310*	0.549*	0.431*	0.670**	0.612*	0.540*	0.519*	0.112	0.610*

**-P<0.01; *- P<0.05.

IGF-1: Insulin-like growth factor 1; M: Male; F: Female; BW: Body weight; WH: Withers height; HG: Heart girth; CD: Chest depth; BL: Body length; RL: Rump length; RH: Rump height; SC: Shin circumference; HL: Head length.

on ruminants, indicate that the alterations in IGF-1 levels during different seasons are largely influenced by the length of daylight (Dahl *et al*., 2000). Furthermore, it has been documented that the photoperiod plays a crucial role in determining the concentration of IGF-1 in goats (Flores *et al*., 2015; Hernández *et al*., 2016; Flores *et al*., 2018). In a separate study, it was noted that environmental temperature has a direct impact on plasma GH levels in rainbow trout, a regulator of the IGF system, independent of the nutritional status (Gabillard *et al*., 2003).

Phenotypic body trait measurements

The periodic mean values of few phenotypic body trait measurements for the goat kids have been presented in Table 1. An almost linear increase was observed in all the body trait measures in the goat kids of both the sexes during the experimental period.

The IGF-I gene influences many vital processes in an organism, including growth (Akers 2006; Burgos and Cant, 2010). The level of IGF-I in circulation affects the size of foetuses and new-borns as well as postnatal growth in various species (Zapf and Froesch, 1999; Duclos *et al*., 1999; Yakar *et al*., 2002). In our study, all phenotypic body trait measures increased linearly in the experimental kids under study. However, there were differences between genders as male kids grew faster than the female counterpart along with increased phenotypic body measurements. It has been established through previous research that the secretion of growth hormones in females is less stable than in males in both human and rat populations (Pincus *et al*., 1996). Such might be the case for increased growth and phenotypic body measures in males than in females. Nonetheless, the exact mechanism should be investigated in further trails so as to uncover the molecular mechanism involved in the growth and aging process.

Correlation between IGF-1 concentration and few phenotypic body trait measures

The Pearson's correlation between IGF-1 concentration (ng/mL) and body measurements (cm) has been presented in Table 2. Correlations between IGF-1 concentrations and the phenotypic body trait measurements were significant (P<0.05) expect for SC in both the sexes under study.

It has been established that there is a positive relationship between IGF-1 levels and protein accumulation, skeletal development and growth rate in farm animals (Bishop *et al*., 1989). Positive connections between IGF-1 levels and both live weight and weight increase have been documented in farm animals such as pigs, sheep, cattle and poultry (Bishop *et al*., 1989; Davis and Simmen, 1997). In our study, statistically significant positive correlations were also found between IGF-1 concentrations and all the phenotypic body trait measures in kids; except for SC in both the sexes. The existence of positive, significant correlations between IGF-1 and growth traits in young goat kids is a predictable outcome due to the growth and development process. In contrary, the connection between IGF-1 levels and body mass in 36 species of mammals has been reported to be negative and elevated IGF-1 levels are known to contribute to the growth of cancer and shorten the life span of the animal (Stuart and Page, 2010). In this regard applying a standardized IGF-1 measurement technique to goat serum samples may uncover the actual relationship between serum IGF-1 levels and physical body characteristics.

CONCLUSION

In conclusion, from our findings there is a significant relationship between IGF-1 concentrations and phenotypic body measurements in goat kids. Serum IGF-1 concentration increases with increase in THI which may be attributed to its thermos-protective effect against environmental stressors. Since, the insulin like activity of IGF-1 may be an important role in intermediate metabolism affecting glucose homeostasis to relieve the detrimental effects of hyperthermia in goats.

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Conflict of interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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