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Structural indices of Boer, Central highland and their F_1 Crossbred goats reared at Ataye farm, Ethiopia

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Abstract

The study was conducted to assess the structural indices of Boer (B), Central Highland (CH) and their F_1 crossbreds (CB) goats reared at Ataye farm, Amhara region. Twenty morphometric measurements and live weight (LW) were assessed on both sexes of the three genotypes totaling to 125 goats. Structural indices were calculated for the different genotypes to collaborate with the breeding objectives of Amhara Agriculture Research Institute, i.e developing meat type goats. The average values of structural indices were compared between genotypes (sex and age) while the correlation between structural indices was studied. The results of the structural indices indicated higher value for proportionality (IPr) among the CB, while weight 1 (W1), transverse pelvic index (IPT), relative body index (RBI), dactyl thoracic index (DTI), body ratio (BR) and compact index (CI) were higher for the B bucks. Among the does the values for IPr, Weight (2, 3, 4) were higher ($p<0.05$) among the CB and CH while IPr were similar among the B and CB. However, most of the indices showed more or less similar variation among the three genotypes. The results of the correlation for structural indices were both positively and negatively correlated among some indices. Thus, it can be concluded that the CB goats exhibit meat type traits.

Key words: Structural indices, Boer goats, Crossbreds, Central Highland goats

Introduction

Structural indices are combinations of several linear measurements or morphometrical measurement, the results of which are expressed as a percentage and indicate the type and function of a particular breed (Maciejowski and Zieba, 1982). Indices offer accurate estimation of an animal's conformation when compared to individual measurements alone (Salako, 2006). Structural indices also provide tested empirical values which are limited in the use of single measurements. They are also used for the assessment of type, weight and function as well as enhance the ability of breeders to select potential breeding stock (Salako, 2006).

Studies on structural indices are very scanty and the information of structural indices on goats is only limited to the study by Chacon *et al.*, (2011) for Cuban Creole goats and their crossbreds. However the importance of indices is because of their superiority over single measurements. Structural indices are calculated from morphometric traits and provide evaluation of animals to buyers since the morphometric measurements are related with production characteristics (Mohammed and Amin, 1997). Assessment of animal weight (due to its association with desirable conformation such as length and balance) are better done using indices (Salako, 2006). The index system for assessment of type and function in cattle was developed by Alderson (1999) who suggested that the application can be used to other species of animals. This observation extends and also supported the possibility use of structural indices in exploitation beyond within farm to within-herd comparisons and as a determinant factor of type and function between breeds within a particular species (Salako, 2006). Therefore, the objective of this study was to assess the structural indices of Boer, Central highland and their F_1 crossbred goats so as to assess their type and function.

Materials and methods

Description of the study area

The study was conducted in Ataye farm of Debre Berhan Agricultural Research Center, Ethiopia. Ataye is the administrative center of the Efratana Gidim woreda. It is known as Effison on the map

and is located in the central highlands of Ethiopia about 290 km north of Addis Ababa at an altitude of 2780 m above sea level and at a longitude of 39° E and latitude 10° N. Nearby cities to Ataye are Debre Berhan, Dessie, Hirna (Amhara region agricultural research institute).

Experimental animals and their management

A total of one hundred and twenty-five goats which comprised of Boer, crossbred and indigenous goats of Central highland reared at the farm. The flock comprised of 35 bucks and 90 does age 2 years. The Boer goats and crossbreds were supplemented with concentrates and received newly cultivated *Pennisetum purpureum* (Napier) grass while the native goats were given concentrates and allowed to graze on natural pasture. The concentrate feed were provided three times per day and the goats were taken to water source two or three times a day depending on the season. The animals were vaccinated against commonly occurring disease in the area viz. anthrax, black leg and pasturelosis. The animals were regularly dewormed against commonly occurring parasites using antihelmenthics viz. albendazole, tetraclozole and ivermectin in rotation.

Data collection procedures

Quantitative morphometrical characters:

Data were collected on twenty morphometrical traits from the bucks and does. The study lasted for 9 months and was divided into three seasons: February to March; July to August followed by October to November in the year 2014. During each of the period all the animals were measured for the morphometrical traits and were weighed using a spring balance. All the measurements were taken by the researcher in order to avoid any measuring error. For the assessment of morphometrical traits, only those bucks and does aged 2 years were considered. The FAO (2012) qualitative and quantitative goat/sheep breed descriptor list was followed to characterize the goat types phenotypically and morphologically.

The morphometrical parameters were obtained using self-devised equipment and according to the method suggested by Maciejowski and Zieba (1982). All measurements were taken early in the morning prior to feeding and were taken to an up-right plane during measurement. Pregnant and lactating animals were avoided in the sampling. Live weight was measured using suspended spring balance with 100 kg capacity with ±200 g error margin (for heavier animals) and 25 kg capacity

with ±50g error margin (for lighter ones). The age of the animals were obtained from the farm records.

Index calculations

The structural indices were assessed from the morphometric measurements and according to standard calculation as presented in Table 1. To construct indices; measurements anatomically related to each other were paired. From these measurements, 20 conformation indices were calculated according to Agraz García (1981), Martin–Rosset (1983), Ribeiro (1988) and Salako (2006).

Table 1: Methods used for assessing structural indices

Indices	Formula	Description
Cephalic index (IC)	Head width × 100 / Head length	
Body index (IB)	Body length × 100 / Chest girth	When this measure is greater than 0.90, the animal is *longiline*; between 0.86 and 0.88 is *medigline*, and less than 0.85, it is *brevigline*
Proportionality (IPr)	Wither height × 100 / Body length	
Pelvic index (IP)	Rump width × 100 / Rump length	
Weight 1 (W1)	Body length × chest depth × (hip width + chest width)/2) /1050	
Weight 2 (W2)	(W2) = CG^3*80.	Weight above 45 kg correspond to large or hypermetric animals, between 35 and 55 kg medium or *eumetric* animal and less than 35 kg, small or elipometric animals;
Weight 3 (W3)	W3 = 0.5 × CG) – 14.87	Mohammed & Amin (1996)
Weight 4 (W4)	W4 = (0.63 × CG) – 19.5	Singh & Mishra (2004)
Width slope (WS)	rump width/chest width;	
Balance	(rump length × rump width)/ (chest depth × chest width)	
Transverse pelvic (IPT)	rump width × 100 /rump height	
Longitudinal pelvic index (IPL)	rump length × 100 / rump height	
Relative depth of thorax (RDT)	chest depth × 100 / wither height	
Relative body index (RBI) or length index	BL × 100/wither height.	

Dactyl thorax index (DTI)	CC /CG.	The DTI may not be more than 10.5 in light animals, up to 10.8 in intermediary; up to 11.0 in light meat animals and up to 11.5 in heavy meat type.
Pectoral Index (PI)	((HW + HR)/2)/(HW-CD))	This index also indicates thoracic development; when the back height is less than the sternum height, the animal is considered "far from ground"
Thoracic development (TD)	CG/HW	This indicates thoracic development of the animal, with values above 1.2 indicating animals with good TD
Body ratio (BR)	HW/HR	If the withers are lower than the rump, the animal is low in front and vice versa.
Baron & Crevat (BC)	CG^2/HW	
Compact index (CI) or Conformation Index	(W/HW)/100	It indicates how compact the animal is. Meat type animals have values above 3.15. Values close to 2.75 indicate dual purpose and close to 2.60 indicate animals more suitable for milk

Statistical Analysis

The data were analyzed using SPSS version 19 for Windows. The goats were classified according to genotype and sex and age within a genotype. The average means of the structural indices were compared according to genotype (sex and age) using Independent T-test and Duncan's multiple range test. The correlation of structural indices was also assessed.

Results Structural indices of Boer (B) and Crossbred (CB) bucks aged 2 years

The results indicating the comparison of structural indices of the Boer and crossbred bucks aged 2 years are presented in Table 2. It transpires from the table that the CB have a higher value ($p<0.05$) for proportionality index (IPr) while weight 1 (W1), transverse pelvic index (IPT), relative body index (RBI), dactyl thorax index (DTI), body ratio (BR) and compact index (CI) values were ($p<0.05$) higher among the Boer bucks.

Table 2: Average values of structural indices (Means ±SD) for Boer (B) and crossbred (CB) bucks aged 2 years

Structural indices	Boer N= 15	Crossbred N =20
IC	44.71±2.57	45.77±1.11
IB	89.76±1.96	83.96±1.40
IPr	94.40±1.61[b]	104.93±1.18[a]
IP	132.87±7.55	123.80±3.11
W1	27.54±2.72[a]	22.08±0.67[b]
W2	27.85±3.35	23.78±1.00
W3	20.04±1.36	18.21±0.48
W4	24.48±1.71	22.18±0.60
WS	0.76±0.03	0.70±0.01
BI	0.31±0.02	0.27±0.01
IPT	23.30±0.89[a]	20.14±0.23[b]
IPL	17.71±0.87	16.66±0.41
RDT	46.27±0.67	46.96±0.61
RBI	1.06±0.02[a]	0.96±0.01[b]
DTI	12.84±0.42[a]	11.24±0.21[b]
PI	1.91±0.02	1.98±0.03
TD	1.18±0.02	1.15±0.02
BR	0.95±0.01[a]	0.92±0.00[b]
BC	82.71±3.89	76.36±1.83
CI	5.36±0.38[a]	4.65±0.10[b]

[a,b] *Means on the same row are significantly different (P<0.05) Cephalic index (IC), Body index (IB), Proportionality index (IPr), Pelvic index (IP), Weight 1(W1), Weight 2(W2), Weight 3 (W3), Weight 4 (W4), Width slope (WS), Balance index (BI), Transverse pelvic index (IPT), Longitudinal pelvic index (IPL), Relative depth of thorax (RDT), Relative body index (RBI) or length index, Dactyl thorax index (DTI), Pectoral index (PI), Thoracic development (TD), Body ratio (BR), Baron & Crevat (BC), Compact index (C1)*

Structural indices of Boer (B), Crossbred (CB) and Central highland (CH) does aged 2 years

The results pertaining to the comparison of structural indices of B, CB and CH does at age 2 years are presented in Table 3. It transpires from the table that the CB does have higher values for most of the indices indicating effect of heterosis. The values for proportionality (IPr), weight 2 (W2), W3 and W4 were higher ($p<0.05$) among the CB and CH does while IPr value was similar among the B and CB. The result further indicates that pectoral index (PI) and thoracic development (TD) were higher ($p<0.05$) among the CB does. The result also indicated higher values ($p<0.05$) longitudinal pelvic index (IPL), relative depth of thorax (RDT), relative body index (RBI), thoracic development (TD) and compact index (CI) among the B and CB does. However, width slope (WS) and Balance index values were higher ($p<0.05$) among the CH does. Similarity existed in the average mean values of Body ratio (BR) among B and CH. Furthermore, transverse pelvic index (IPT) was higher ($p<0.05$) for the B does.

Table 3: Average values of structural indices (Means ±SD) for Boer, Crossbred and Central highland does aged 2 years

Structural indices	Boer N =20	Crossbred N=25	South Wollo N= 45
IC	42.62±3.13	43.83±1.29	46.58±0.63
IB	89.44±1.81	85.61±0.97	86.83±0.65
IPr	$99.61±1.74^{b}$	$103.83±1.19^{ab}$	$108.12±0.75^{a}$
IP	122.92±7.64	112.59±1.86	122.74±1.41
W1	19.33±2.04	21.05±0.47	19.80±0.31
W2	$18.19±2.07^{b}$	$20.78±0.69^{a}$	$22.02±0.32^{a}$
W3	$15.19±1.36^{b}$	$16.88±0.33^{a}$	$17.54±0.16^{a}$
W4	$18.37±1.72^{b}$	$20.51±0.42^{a}$	$21.34±0.20^{a}$
WS	$0.77±0.04^{b}$	$0.71±0.01^{c}$	$0.91±0.01^{a}$
BI	$0.34±0.04^{b}$	$0.29±0.01^{c}$	$0.38±0.01^{a}$
IPT	$22.87±0.52^{a}$	$20.62±0.34^{b}$	$20.55±0.10^{b}$
IPL	$19.48±1.88^{a}$	$18.38±0.25^{ab}$	$17.03±0.19^{b}$
RDT	$46.99±1.25^{a}$	$48.25±0.47^{a}$	$43.80±0.18^{b}$
RBI	$1.01±0.02^{a}$	$0.97±0.01^{ab}$	$0.93±0.01^{b}$
DTI	$11.94±0.33^{a}$	$11.19±0.19^{b}$	$10.64±0.05^{c}$
PI	$1.93±0.05^{b}$	$2.01±0.02^{a}$	$1.84±0.01^{c}$
TD	$1.13±0.03^{a}$	$1.13±0.01^{a}$	$1.08±0.01^{b}$
BR	$0.96±0.01^{a}$	$0.93±0.01^{b}$	$0.94±0.00^{ab}$
BC	68.28±4.43	72.22±1.41	69.86±0.62
CI	$4.48±0.32^{a}$	$4.44±0.06^{a}$	$3.91±0.05^{b}$

[a,b,c]Means on the same row are significantly different (P<0.05) Cephalic index (IC), Body index (IB), Proportionality index (IPr), Pelvic index (IP), Weight 1(W1), Weight 2(W2), Weight 3 (W3), Weight 4 (W4), Width slope (WS), Balance index (BI), Transverse pelvic index (IPT), Longitudinal pelvic index (IPL), Relative depth of thorax (RDT), Relative body index (RBI) or length index, Dactyl thorax index (DTI), Pectoral index (PI), Thoracic development (TD), Body ratio (BR), Baron & Crevat (BC), Compact index (C1)

Correlation of structural indices for Boer (B) and crossbred (CB) bucks

The results pertaining to the correlation among structural indices for Boer and crossbred bucks are presented in Table 4. The findings indicate that most of their indices are poorly correlated and some had negative association with each other. The results for the structural indices among the B indicated that the cephalic index (IC) was correlated ($p<0.05$) with relative body index (RBI) and compact index (CI), while the body index (IB) was negatively correlated ($p<0.05$) with thoracic development (TD). Similarly the body weight (W1) was observed to be correlated ($p<0.05$) with transverse pelvic (IPT), relative body index (RBI) and CI. The findings further indicated that the Balance index (BI) of the bucks was correlated ($p<0.05$) with the values of longitudinal pelvic index (IPL) while it was negatively correlated ($p<0.01$) with body ratio (BR). The IPL values were negatively correlated ($p<0.05$) with BR, while pelvic index (IP) and relative depth of thorax (RDT) were positively correlated ($p<0.05$), also RBI was positively correlated with CI. The study further indicated that TD values were correlated positively ($p<0.01$) with Baron and Crevat (BC) values, while BC and CI were positively correlated ($p<0.05$).

The correlation between the structural indices for the crossbred bucks indicate that there is a positive correlation ($p<0.05$) with balance index (BI) and IC, while negative correlation ($p<0.05$) was observed between BI and IP. The correlation between IPL and IP was negative ($p<0.01$). The correlation values between DTI and Balance was significant ($p<0.01$). While the correlation values with RDT was negative ($p<0.05$) correlated with Balance and the values were ($p<0.01$) for DTI. The TD and BC values were positively correlated ($p<0.05$) with IPT. The study further indicates that the value of CI was positively correlated ($p<0.01$) with W1, W2 and BC.

Table 4: Correlation of structural indices for Boer buck and their Crossbreds

	IC			IP	W1				IPT	IPL	RDT	RBI						
		IB	IPr			W2	WS	BI					DTI	PI	TD	BR	BC	CI
IC		0.31	-0.07	-0.08	0.60	0.55	0.51	0.40	-0.09	0.02	-0.46	0.04	0.64	-0.52	-0.34	0.02	0.34	0.57
W1	0.71	-0.80	-0.90	-0.21		0.96	0.35	0.42	0.33	0.23	-0.19	-0.01	0.37	-0.16	0.02	-0.37	0.81	.901*
W2	0.68	-0.83	-0.91	-0.30	0.99		0.20	0.51	0.46	0.42	-0.22	-0.13	0.34	-0.18	0.16	-0.40	0.90	.904*
WS	0.98	0.03	-0.76	0.40	0.56	0.52		0.15	-0.62	-0.60	-0.47	-0.34	0.38	-0.45	-0.91	-0.30	-0.24	0.22
BI	0.22	-0.67	-0.65	-0.86	0.56	0.63	0.12		0.22	0.66	-.79*	-0.46	.814**	-.709*	-0.16	-0.70	0.36	0.43
1PT	0.68	-0.63	-0.83	-0.18	.904*	0.89	0.59	0.58		0.64	0.15	0.10	-0.01	0.13	.780*	0.07	.708*	0.28
IPL	-0.14	-0.78	-0.38	-0.96	0.44	0.52	-0.28	.902*	0.42		-0.15	-0.13	0.34	-0.10	0.60	-0.39	0.61	0.35
RBI	.884*	-0.52	-0.99	-0.16	.881*	0.89	0.80	0.63	0.88	0.34	0.16		-0.26	0.29	0.39	0.64	0.09	0.01
DTI	0.31	0.11	-0.42	-0.43	0.05	0.11	0.37	0.66	0.24	0.35	-0.59	0.46		-.673*	-0.41	-0.48	0.11	0.33
IB	-0.17		-0.63	0.53	0.00	-0.24	0.49	-0.30	-0.58	-0.65	-0.12	0.60	0.08	-0.17	-0.50	0.33	-0.39	-0.06
IPr	-0.86	0.59		-0.21	0.00	0.13	0.30	0.46	-0.08	0.16	-0.37	-.99**	0.23	-0.29	-0.36	-0.63	-0.07	-0.03
IP	0.29	0.62	0.21		-0.05	-0.21	0.48	-.69*	-0.34	-.93**	0.26	0.20	-0.47	0.20	-0.38	0.43	-0.36	-0.23

RDT	0.42	0.06	-0.11	0.78	0.32	0.22	0.44	-0.56	0.34	-0.58	0.38	.713*	.983**	0.56	0.41	0.06	-0.13
PI	0.52	-0.24	-0.34	0.57	0.58	0.49	0.48	-0.30	0.58	-0.32	.952*	0.38	-0.53	0.54	0.25	0.07	-0.07
TD	0.49	-.936*	-0.83	-0.51	.937*	0.96	0.31	0.73	0.78	0.69	0.01	0.78	0.10	0.31	0.28	0.57	0.12
BR	-0.17	0.77	0.63	0.86	-0.63	-0.69	-0.04	-.97**	-0.65	-.945*	0.45	-0.61	-0.51	0.17	-0.79	-0.19	-0.38
BC	0.64	-0.87	-0.90	-0.35	0.99	1.00	0.47	0.66	0.86	0.56	0.17	0.86	0.11	0.45	.980**	-0.72	.823**
CI	.879*	-0.60	-0.94	0.02	.956*	0.94	0.77	0.42	0.88	0.21	0.43	.934*	0.12	0.64	0.82	-0.45	.913*

*P< 0.05 **P< 0.01 *Note: The values in the upper diagonal indicate the values for Crossbred bucks while in the lower diagonal the Boer bucks. Cephalic index (IC), Body index (IB), Proportionality index (IPr), Pelvic index (IP), Weight 1(W1), Weight 2(W2), Width slope (WS), Balance index (BI), Transverse pelvic index (IPT), Longitudinal pelvic index (IPL), Relative depth of thorax (RDT), Relative body index (RBI) or length index, Dactyl thorax index (DTI), Pectoral index (PI), Thoracic development (TD), Body ratio (BR), Baron & Crevat (BC), Compact index (C1)*

Table 5: Correlation of structural indices for Boer doe and their Crossbreds

	IC	IB	IPr	IP	W1	W2	WS	BI	IPT	IPL	RDT	RBI	DTI	PI	TD	BR	BC	CI
IC		0.05	0.16	0.32	-.74**	-0.55	-0.03	-0.29	-0.31	-0.57	-0.20	-0.16	0.02	-0.20	-0.26	0.07	-0.52	0.03
IB	-0.03		-0.56	0.02	0.35	-0.53	-0.10	-0.11	0.05	0.00	0.13	0.55	0.38	0.13	-.782**	-0.29	-.678*	-0.16
IPr	0.05	-.412**		-0.16	-0.31	0.15	-0.36	-0.28	-0.54	-0.25	-0.51	-.99**	0.32	-0.49	-0.07	0.36	0.08	-0.02
IP	0.10	-0.21	0.00		-0.47	-0.53	0.30	-0.34	0.48	-.69*	.727**	0.13	0.18	.701*	0.04	-0.41	-0.39	0.34
W1	0.08	0.11	-.674**	-0.01		0.52	-0.29	0.04	-0.02	0.49	-0.06	0.32	-0.06	-0.13	-0.12	0.23	0.35	0.25
W2	0.08	-.430**	-.493**	0.14	.769**		-0.06	0.26	-0.18	0.44	-0.32	-0.13	-.62*	-0.40	.583*	0.56	.952**	0.30
WS	0.27	-0.01	-0.16	0.06	0.27	0.22		.762**	.650*	0.15	0.37	0.35	-0.33	0.43	0.39	-0.45	0.11	-0.29
BI	0.22	0.21	-0.12	-.69**	0.15	0.01	.564**		0.43	.689*	-0.03	0.29	-0.39	0.05	0.38	-0.24	0.35	-0.46
IPT	.322*	0.01	-.465**	0.06	.555**	.435**	.550**	.459**		0.29	.825**	0.53	0.01	.826**	0.35	-0.48	0.00	-0.05
IPL	0.11	0.19	-0.24	-.85**	0.30	0.11	0.23	.867**	.464**		-0.11	0.27	-0.20	-0.10	0.25	0.10	0.43	-0.30
RDT	-0.13	-0.09	-.550**	0.19	.673**	.524**	.380*	-0.10	.412**	0.02		0.51	0.11	.977**	0.22	-.579*	-0.16	0.22
RBI	-0.04	.411**	-.996**	0.00	.685**	.501**	0.14	0.11	.468**	0.24	.553**		-0.34	0.48	0.09	-0.35	-0.06	0.02
DTI	0.04	.373*	-0.12	-.39**	-0.10	-0.27	-0.07	0.28	-0.10	.317*	-0.19	0.14		0.17	-.708**	-0.28	-.71**	-0.25
PI	-0.16	-0.04	-.565**	0.17	.642**	.471**	.381*	-0.08	.341*	0.01	.982**	.566**	-0.13		0.21	-.726**	-0.22	0.09
TD	-0.01	-.412**	-.654**	0.21	.579**	.852**	0.17	-0.06	.476**	0.07	.613**	.657**	-0.18	.585**		0.09	.800**	0.19
BR	0.20	-0.21	.430**	0.02	-0.21	-0.05	-0.11	0.00	0.17	0.07	-.39**	-.41**	-0.20	-.54**	-0.22		0.44	0.25
BC	0.06	-.436**	-.586**	0.17	.712**	.971**	0.21	-0.01	.474**	0.10	.582**	.593**	-0.24	.538**	.951**	-0.12		0.27
CI	-0.03	0.00	-.705**	0.23	.797**	.760**	.300*	-0.01	.405**	0.01	.637**	.716**	-0.12	.637**	.701**	-.317*	.760**	

*P< 0.05 **P< 0.01 *Note: The values in the upper diagonal indicate the values for Crossbred does while in the lower diagonal the Boer does. Cephalic index (IC), Body index (IB), Proportionality index (IPr), Pelvic index (IP), Weight 1(W1), Weight 2(W2), Width slope (WS), Balance index (BI), Transverse pelvic index (IPT), Longitudinal pelvic index (IPL), Relative depth of thorax (RDT), Relative*

body index (RBI) or length index, Dactyl thorax index (DTI), Pectoral index (PI), Thoracic development (TD), Body ratio (BR), Baron & Crevat (BC), Compact index (C1)

Table 6: Correlation of structural indices for Central highland does

	IC	IB	IPr	IP	W1	W2	WS	BI	IPT	IPL	RDT	RBI	DTI	PI	TD	BR	BC	CI
IC																		
IB	0.03																	
IPr	-0.06	-.73**																
IP	0.01	0.13	-0.13															
W1	0.02	0.17	-.40**	.211*														

W2	-0.02	-.37**	-0.08	0.00	.746**												
WS	-0.06	0.19	-0.02	.242*	-.237*	-.265*											
BI	-0.11	0.10	0.01	-.35**	-.32**	-.244*	.758**										
IPT	-0.12	0.07	-.238*	.538**	.424**	0.21	.480**	.274**									
IPL	-0.12	-0.10	-0.03	-.76**	0.06	0.15	0.08	.630**	0.13								
RDT	0.16	-0.03	-.47**	0.12	.475**	.413**	-0.19	-.31**	.272**	0.06							
RBI	0.06	.812**	-.97**	0.12	.378**	0.02	0.02	-0.02	0.18	0.00	.416**						
DTI	-0.10	.217*	-0.07	-0.02	-0.10	-.258*	.296**	.337**	0.12	0.12	-.226*	0.04					
PI	0.20	-0.02	-.52**	0.05	.346**	.328**	-.211*	-.235*	0.18	0.08	.943**	.464**	-.22*				
TD	0.05	-0.19	-.49**	0.01	.377**	.615**	-.256*	-0.18	0.21	0.16	.742**	.415**	-.26*	.811**			
BR	-0.18	-0.03	.413**	0.12	0.09	0.02	0.13	-0.05	0.09	-0.1	-.46**	-.38**	0.12	-.72**	-.60**		
BC	0.01	-.32**	-.31**	0.00	.624**	.899**	-.29**	-.243*	.225*	0.17	.646**	.232*	-.3**	.636**	.896**	-.32**	
CI	0.06	-0.17	-.36**	0.05	.715**	.831**	-.27**	-.259*	.217*	0.11	.557**	.264*	-0.16	.525**	.709**	-.221*	.859**

*P< 0.05 **P< 0.01. *Cephalic index (IC), Body index (IB), Proportionality index (IPr), Pelvic index (IP), Weight 1(W1), Weight 2 (W2), Width slope (WS), Balance index (BI), Transverse pelvic index (IPT), Longitudinal pelvic index (IPL), Relative depth of thorax (RDT), Relative body index (RBI) or length index, Dactyl thorax index (DTI), Pectoral index (PI), Thoracic development (TD), Body ratio (BR), Baron & Crevat (BC), Compact index (CI)*

Correlation of structural indices for Boer and Crossbred does

The results as presented in Table 5 indicate the correlation between most of the structural indices for Boer does were significant. It indicates from the Table that IC was correlated ($p<0.05$) with IPT. The result further indicates that the correlation between IB and IPr, W2, TD, and BC was negative ($p<0.01$) while positive correlation was observed with DTI ($p<0.05$).

The correlation between IPr was mostly negative ($p<0.05$) while W1, W2, IPT, RDT, RBI, PI, TD, BC and CI, positive ($p<0.01$) correlation was observed with BR. Similarly IP was correlated negatively ($p<0.01$) with Balance, IPL and DTI. The results further indicate that W1 value was negatively ($p<0.01$) correlated with IPT, RDT, RBI, PI, TD, BC and CI. The correlation values between width slope (WS) was negative ($p<0.01$) with Balance and IPT, while positive correlation ($p<0.05$) was observed with PI and CI. The result of correlation between Balance index and IPT and IPL was positive ($p<0.05$). Furthermore, the correlation studies between IPT and IPL; RDT; RB; TD; BC and CI were positive ($p<0.01$). IPT was also ($p<0.05$) positively correlated with PI and DTI. The correlation between RDT and RBI; PI; TD; BR; BC and CI was positive ($p<0.01$). The Table also indicates that RBI is ($p<0.01$) correlated with PI; TD; BR; BC and CI. While PI was ($p<0.01$) positively correlated with TD; BR; BC and CI. TD was also positively correlated ($P<0.05$) with BC and CI while BR and CI were ($p<0.05$) positively correlated.

The correlation values between the structural indices for the crossbreds indicated that W1 value was negatively correlated ($p<0.01$) with IC. The correlation values between Balance and WS was positively ($p<0.01$) correlated. The IPT was negatively ($p<0.05$) correlated with WS. The correlation results between IPL and IP was ($p<0.05$) but negative, on the other hand IPL was also positively ($p<0.05$) correlated with Balance. The study further indicates that RDT was positively correlated ($p<0.01$) with IP and IPT. The correlation between RBI and IPr was observed to be significant ($p<0.01$) but in a negative manner. Negative but significant ($p<0.05$) correlation was observed between DTI and W2. The correlation between PI and IP was positive ($p<0.05$) while IPT and RDT were also positively correlated ($p<0.01$) with PI. The correlation between TD, IB and DTI was significant ($p<0.01$) but in a negative manner while the values were significantly correlated ($p<0.05$) with W2. The study further indicates that BR was correlated negatively

(p<0.05) with RDT and PI. While BC was correlated (p<0.05) negatively with IB, it was also positively (p<0.01) correlated with W2 and TD.

Correlation of structural indices for Central highland does

The results for correlation of structural indices for the does of Central highland breed are presented in Table 6. The results indicate that IB value was negatively correlated (p<0.01) with W2 and BC, while the IB value was observed to be positively correlated (p<0.01) with RBI and (p<0.05) with DTI. The study further indicates that IPr value was negatively correlated (p<0.01) with W1, RDT, RBI, TD and BC. IPr value was also (p<0.05) negatively correlated with IPT. The study further indicates that IP was correlated (p<0.05) with W1 and WS. IP was also correlated negatively (p<0.05) with Balance. The correlation values between IP; IPT and IPL was (p<0.01), while it was positively correlated for the former and the values were negatively correlated with the later. The study further indicated that W1 was positively correlated (p<0.01) with W2; IPT; RDT; RBI; PI; TD; BC and CI. However, W1 was negatively correlated (p<0.05, with WS and (p<0.01) Balance. The results further indicated that W2 was correlated negatively (p<0.05) with WS, Balance and DTI. Value of W2 was correlated (p<0.01) with RDT; PI; TD; BC and CI. WS was correlated (p<0.01) with Balance and DTI, while WS was negatively correlated (p<0.01) with BC. The correlation values between WS with CI; PI and TD was positive (p<0.05). The correlation between Balance with PI, BC and CI was negative (p<0.01).

The correlation results between IPT and RDT was positive (p<0.01). IPT was also positively correlated (p<0.05) with BC and CI. The study further indicates that RDT was positively (p<0.01) correlated with RBI; PI; TD; BC and CI while RDT was negatively correlated with DTI (p<0.05) and BR (p<0.01). The correlation findings with RBI and other structural indices indicated that it was positively correlated (p<0.01) with PI; TD; RBI was also positively correlated (p<0.05) with BC and CI. RBI was negatively correlated (p<0.01) with BR.

The correlation values with DTI and the other traits is mostly negative with (p<0.05) values assessed with PI and TD. While, DTI was positively (p<0.01) correlated with BC. The study further indicates that PI was positively (p<0.01) correlated with TD and CI while negative correlation was observed with PI and (p<0.01) BR. The findings also indicate that PI was positively (p<0.05) correlated with BC. The correlation between TD with BC and CI was observed to be positive

($p<0.01$). TD was also negatively correlated ($p<0.01$) with BR. The study also indicated that BR was negatively correlated ($p<0.01$) with BC while, CI was positively correlated ($p<0.01$) with BC

Discussion

Structural indices calculation for Boer (B) and Crossbred (CB) bucks aged 2 years

The value of the proportionality index (IPr) for the CB was higher than the B bucks. The result for IPr obtained in this study is comparable to the observation made by Chacon *et al.,* (2011) for adult Cuban Creole goats and their crossbreds. The IPr bespeaks that withers were slightly lower than the rump in both genetic groups which is an important trait correlated with the good health and better disease resistance of the animals (Chacon *et al.,* 2011). The IPT values for the B and CB are comparable with those reported by Chacon *et al.,* (2011) in Cuban Creole and their crossbred goats. The results for the IPT values of both genotypes are indicative of narrow hips with animals having potential for good carcass traits (Cerqueira *et al.,* 2011). The result related to the RBI or length index showed differences ($p<0.05$) among the genetic groups, the values assessed for B was higher than the CB bucks. Salako (2006) suggested that the indices that are derived from measurements that are more closely associated with bone growth (fore limb length, height slope and RBI or length index). These are more appropriate for assessment of type for which the breed/genotype was developed. While the RBI and balance indices bespeak of the carcass yield in live animals. The RBI value for the B is comparable to those reported by Chacon *et al.,* (2011) but lower value for RBI was observed in the present study among the CB indicating that the carcass yield of the CB is expected to be lower than those of the B. DTI values indicate the shape of the animal which shows the establishment of relationship between the mass of goat and the limbs that sustain it, so as to determine whether the body volume suits the osseous or bone development (Cerqueira *et al.,* 2011). Studies by Bravo and Sepulveda (2010) indicated that the value of the DTI is correlated with the muscular development/strength of the animal. It also provides an idea for the degree of fineness of the skeleton (Bravo and Sepulveda, 2010). The results from the DTI bespeak that the B and CB have the true traits of a meaty type animal. The DTI value for the B indicated heavy built animals while the CB indicated a slightly light but meat type. According to Pena *et al.,* (1990) higher values of DTI correlate with medium sized legs which are important for grazing animals. Pena *et al.,* (1990) also reported that an increment in CC presupposes an increase in body size.

Furthermore, the result for BR indicated that both B and CB genotypes were slightly lower at withers when compared to the rump. The result pertaining for CI value was higher in B. This study indicated that the CI values of both genotypes are closer to those of the meat type animals (Chacon *et al.,* 2011). The CI is a useful indicator of the overall value of the animals because it combines morphology and structure; and provides an accurate picture of type and function. The value for CI is relatively constant during the lives of an animal and can be used in young animals to estimate the adults merit (Alderson, 1999). In line with the observation made by Alderson, (1999), Salako, (2006) also reported CI values of different age groups in WAD and Yankasa sheep in Nigeria and concluded that CI has the potential to be applied in the study of types and functions in livestock breeds.

Structural indices calculation for Boer (B), Crossbred (CB) and Central Highland (CH) does aged 2 years

Most of the indices showed variation ($p<0.05$) among the genotypes. Results of IPr indicated that withers were slightly lower than the rump among the genotypes which correlates with the health and disease resistance of the animals (Chacon *et al.,* 2011). The results of width slope (WS) and Balance were higher among the CH followed by B and CB does. The considerable difference between the WS among the genotypes is related to both type and function, the CH being a typical tall animal, the width at hip is relatively higher to that of shoulder where the leg is longer indicated by higher fore leg length index than B and CB. The value of WS for CH obtained from this study is comparable to the report by Chacon *et al.,* (2011). The findings also indicate that the CB does were having lower values for the trait. The variation for WS value among the CB to that reported by Chacon *et al.,* (2011) may be attributed to genotypic differences of the buck used in their crossbreeding program. However, the Balance index (BI) values had the similar trend as that of the WS value across the genotypes. The values for the BI for CH is comparable to the values reported by Salako, (2006) for WAD and Yankasa sheep. The relative trend between the heights at withers and rump in these genotypes support the reports by Agaviezor *et al.,* (2012) which indicates the adaptability of the breed to the mountainous region. It is necessary for an animal to have a proper "Balance" which is an important adaptive feature and it is a criterion to be looked into in developing a suitable breed for the ecological zone since improperly balanced animal may have difficulties in grazing on hilly topography (Agaviezor *et al.,* 2012). The result pertaining for IPT values are comparable (across all the genotypes) to the observations of Chacon *et al.,* (2011)

but IPL values of all the three genotypes were lower to the findings of Chacon *et al.*, (2011). Lower values for IPT and IPL correlate to animals with high incidence of dystocia. The IPT would be a favorable characteristic in selection of animals for crossbreeding because it determines ease of parturition (Ribeiro *et al.*, 2004; Araújo and Silva, 1996). The effect of IPL among the CB showed that the hip width of crossbreds is improved indicating less chances of dystocia. This supports the suggestions of Chacon *et al.*, (2006) as the contributing factor for introducing exotic breeds to improve productive and reproductive traits of indigenous goats.

The result for W2 among the genotypes was higher in CB and CH. The lower values for the weights obtained as against the B may be attributed to these formulae of weights which were formulated for animals in the tropics and their crossbreds (Mohammed & Amin, 1997).

However, the results pertaining to RDT was higher among the B and CB. The RDT values showed an indirect measure of leg length, whereby higher indices for this trait correspond to animals with longer legs (Sastre, 2003). Salako (2006), reported lower values for the trait in Yankasa sheep while the values assessed in this study are comparable with those of Chacon *et al.*, (2011). According to Sastre (2003), animals with higher RDT values have higher kinetic capacity, being more adapted to plains and long treks with bodies further from the ground to avoid heat radiation. The value for relative body index (RBI) for the B was higher than CH while the values for CB were intermediate between the two parents. This indicates that the B had longer body than CH. The RBI for CH does were comparable with the findings of Salako, (2006) in WAD and Yankasa sheep while the values for B and CB are in accordance to the report of Chacon *et al.*, (2011). Higher DTI value observed in B, indicates that B is a heavy meat animal followed by their CB and CH does were intermediary meat type animals. The pectoral index (PI) value was found to be highest among the CB. PI values among the genotypes indicated that the sternum was almost half the back height of the animal (Chacon *et al*., 2011). These values are comparable with the findings of Chacon *et al.*, (2011). The three genotypes also have good thoracic development (TD) but the values were higher in B and CB. The results pertaining to the TD correlates with the fitness of the animals, the values as assessed in the study indicate that all the three genotypes are endowed with a higher lung capacity and hence have the ability to graze for long hours and can also travel long distance (Chacon *et al*., 2011). The result pertaining to the BR indicated that the B and CH does have similar values for the trait and are comparable to the findings of (Chacon *et al.*, 2011). However, the animals were lower in front *i.e* at withers than rump. The results pertaining to

compact index (CI) was higher in B and CB does. The trait indicates the true conformation of a breed; values above 3.15 are usually associated with meat type animals (Agraz García, 1981; Martin–Rosset, 1983; Ribeiro, 1988; Salako, 2006; Chacon *et al.*, 2011).

Correlations of structural indices for Boer (B) and Crossbred (CB) for both sexes

The results of the correlation among the structural indices for Boer and crossbred buck are presented in Table 4 (bucks) and 5 (does). The findings indicated that most of the indices are poorly correlated and some were negatively and positively correlated with each other. Those indices which used the same linear measurement as a base tended to have higher correlations as expected. Similar correlations between indices have been reported for sheep in Belgium (Janssens and Vandepitte, 2004). Salako, (2006) reported similar result for West African Dwarf and Yankasa sheep. The observations are also in accordance with the findings by Chacon *et al.*, (2011). The correlation ($p<0.05$) between CI with W1 are in accordance with those of Chacon *et al.*, (2011).

Correlation of structural indices for Central Highland doe

The results pertaining to the correlation of structural indices for Central Highland goats are presented in Table 6. The high correlation values between CI and W2; BC and W2 are in accordance with the observations of (Chacon *et al.*, 2011).

Summary and conclusion

This study was carried out to assess structural indices of Boer, Central Highland and their F_1 Crossbred (Boer X Central Highland goats) raised at Ataye farm in Amhara region. The structural indices for the B and CB for both sexes and CH does indicate that the crossbreds so developed were meat type animal but the overall effect of heterosis was not significant as the B outperformed the CB in most of the parameters. The result for the correlation of structural indices for the three genotypes of different sexes indicated low correlation among most of the indices except for those which had similar traits.

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