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MORPHOMETRIC CHARACTERIZATION OF FOUR SHEEP BREEDS REARED IN SOUTH EAST OF ALBANIA

SUMMARY

Sheep are an important livestock species in Albania. The study was conducted at the Agricultural Technology Transfer Center of Korca in South East area of Albania. This study is focused in two local sheep breeds that have the status as endangered, Shkodrane and Lara e Polisit and two imported breeds Awasi and Il de France reared in this region under the care, responsibility and management of ATTC of Korca. Morphometric measurements and indices of a 190 unrelated and randomly selected animals were analyzed. Awasi have the largest wither height (70.31), rump height (73.56), body length (117.87), chest depth (36.16). Il de France is the largest breed related to rump width (24.89) chest circumference (90.978), cannon bone circumference (8.91), body weight (55.29). Shkodrane is the smallest breed regrading to body length (93.56), chest dept (30.98), chest width (15.91), chest circumference (76.31). All breeds have rectangular body frame, with an index of body frame ranging from 153.06 to 167.87. All morphometric traits were significantly positively correlated. The analysis indicated that body weight was highly correlated with all morphometric measurements. The highest correlation was with chest circumference (0.92) and the smallest (0.65) with cannon bone circumference. The PCA of all morphometric parameters indicated that the three components accounted 90.3% of the cumulative variance. The PCA and UPGMA indicated some admixture between two Albanian sheep breeds Shkodrane and Lara e Polisit and a pure differentiation of Ile de France and Awasi. A regression analysis was performed to predict the body weight from morphometric measurements.

Keywords: body measures, correlations, regression, PCA

INTRODUCTION

Sheep are an important livestock species in Albania, especially for the local community that manage them. They are an important source of milk, meat and wool. In 2020, (Instat, 2020) (Accessed 21 April 2022) the number of sheep was 1.55 million heads, where the milked sheep were 1.17 million heads representing

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75.39 % of the total herd. Meat production in 2020 was 33 thousand tones and milk production 75 thousand litra. The Albanian local sheep breeds (autochthonous) are approximately 40% of the sheep population. The local sheep breeds have a very good adaptation to the environment and the hard conditions of their breeding (Leka, 2019)

To increase milk and meat production, over the last twenty years the interest of the farmers has moved towards the crosses of their native sheep breeds with more exotic breeds. Some public Institutions such as Agricultural Technology Transfer Center in Korça have the responsibility to organize and implement the programes for the application of crosses schemes, as well as providing advice for farmers (Jani & Kume, 2018). In Korca are found 15.79 % of the total number of sheep heads (Instat, 2020).

Genetic diversity of some local sheep breeds is estimated by the use of molecular markers like microsatellites (Hoda *et al.,* 2009) a small number of SNP (Hoda *et al*., 2011).

But there are still many local sheep populations that are not yet characterized. In the present study we are focused in morphometric traits of some local sheep populations reared in South East of Albania, that are not previously characterized. Morphological characterization of livestock breeds is very important for developing a breeding strategy in a particular production system (Deribe *et al*., 2021). Body measurements that influence positively the body weight are evaluated as indirect selection criteria in sheep breeding strategy (Çelik *et al*., 2017). The aim of this study was morphometric characterization of two local sheep breed Shkodrane and Lara e Polisit that are defined to have the endangered status and two imported sheep breeds Awasi and Il de France that are reared at ATTC in Korca and are used for the improvement of the local breeds.

MATERIAL AND METHODS

Breeds description. Two local sheep breeds "Shkodrane" and "Lara e Polisit" and two imported sheep breeds Awasi and Il de France are included in this study. These breeds are reared in the Korca region which is located in South East of Albania under the care and supervision of Agricultural Technology Transfer Center (ATTC). The responsibilities of ATTC are the implementation of conservation programme for two local sheep breeds at risk of extinction "Shkodrane" and "Lara e Polisit", and the application of breed improvement of local populations at the region through the crossbreeding with imported sheep breeds Il de France and Awasi (Leka, 2019). The center was chosen also for the availability and accessibility of the data collection.

The "Shkodrane" sheep breed is a unique autochthonous breed reared in North of Albania (Shkodra region). This breed is crossed during the second half of the last century with exotic breeds such as Cigaya and Merino, but also with another local sheep breed "Bardhoka". The results were not satisfactory. However, the crossbreed processes did not lead to the complete disappearance of the sheep populations – pure breed "Shkodrane" (Leka, 2019). The data of

CAPRA Project (2017) indicate that the population size is 700 heads with a trend the population size increment. The "Shkodrane" breeding period starts in July and ends in August. The birth weight of "Shkodrane" breed reared at ATTC in Korca is 3.16 kg for males and 2.99 kg for females. The weaning weight is 10.39kg for males and 12.64 kg for females. Average body weight in adult individuals is 50-55 kg for males and 33-35 for females. "Shkodra" sheep can be classified in the population group as "Risk of extinction" and is being strongly affected by genetic erosion (Leka, 2019)

Awasi breed was introduced for the first time in Albania from Hungary, in 1987 at the ATTC in Korca region. The Local Awassi that is raised at this region is a triple-purpose breed for meat, milk, and wool production. It has a low profile and is well adapted to the unfavorable conditions of the Middle East, where it is managed under traditionally extensive to semiextensive conditions (Xhemo & Hajno, 2013). Ile de France is also an imported breed that is reared at this center with the aim to be used for improvement of local sheep populations through the crossbreeding. According to Leka, (2019) in the ATTC the population size of Awasi and Ile de France is 90 and 75 heads respectively.

Lara e Polisit is a local breed that is raised in the central part of Albania, at Elbasani, Polis and Librazhdi region. The average body weight is 30-45 kg. The average lamb birth live weight is 1.5—2 kg. The population size at 2019 was 427 with a decreasing trend (Leka, 2019). Milk production is 40 to 45 kg per year. Animals graze in the natural pasture of the area.

Data collection. Morphometric traits of a total of 180 indivuals from the four sheep breeds (45 individuals per each breed) were recorded. The individuals, older than one year, were randomly selected from different flocks. The measurements were performed according to the (FAO, 2012) guidelines, using Lydthin's stick and flexible measuring tape (Depison *et al.,* 2021). Data were collected in January - March 2022. The linear body measurements were taken such as Wither Height (WH), Rump Height (RH), Body Length (BL), Chest Depth (CD), Chest Width (CW), Rump Width (RW), Chest Circumference (CC), Cannon Bone Circumference (CBC) and Body Weight (BW). Based on the body linear measurements the following morphological indices were calculated as described by Dauda, (2018) and Marković *et al*., (2019):

Index of Body Frame (IBF) or index of length = (body length / wither height) x100

Chest index (CI) or thorax index: (chest width / chest depth) x 100;

Index of height (IH) or index of body proportion: (wither height / rump height) x 100;

Chest depth index (CDI): (chest depth / wither height) x 100;

Index of thorax development (ITD): (chest circumference / wither height) x 100.

Dactyl thorax index (DTI): (cannon bone circumference / chest circumference) x 100;

Baron-Crevat index (BCI) or Index of conformation: (chest circumference)^2 / wither height; the higher the index – the more robust is the animal;

Relative cannon bone index (RCBI): cannon circumference / wither height x 100

Index of body weight (IBW): body weight / wither height x 100. This index indicates how compact the animal is. Meat type animals have values above 3.15. Value close to 2.75 indicates dual purpose and close to 2.60 indicates that the animals are more suitable for milk purpose.

Body index (BI) = (Body length/Chest circumference) × 100. When this measure is greater than 0.90, the animal is longiline; between 0.86 to 0.88 is medigline; and less than 0.85, it is brevigline

Proportionality (Ipr) = (Height at withers/Body length) × 100.

Area index (AI) = Height at withers × Body length

Descriptive statistics for the morphometric traits were obtained using Minitab software (Minitab, LLC, 2021). The following values were calculated: the mean, standard error (SE), coefficient of variation (CV) and minimum (Min) and maximum (Max) values. In addition, the Pearson's correlation coefficients were calculated between the morphometric traits of investigated sheep breeds and morphometric indices as well. Live weight was regressed on each of the body measurements and the best fitted regression model was assessed.

Prediction models

The full regression model of the body measurements was defined as:

$Y = a + b1X1 + b2\ X2 + b3X3 + b4X4 + b5X5 + b6X6$, where:

Y = dependent variable (body weight),

a = intercept,

b (s) = regression coefficients,

X's = independent variables (WH, RH, BL, CD, CW, RW, CC, CBC).

RESULTS AND DISCUSSION

Least square means (LSM) and standard errors (SE) for morphometric measures and body weight are shown in table 1. For all traits significant differences ($p<0.01$) were found between all breeds. The wither height (WH) ranged from 59.689 (Lara e Polisit) to 70.312 (Awasi), with an average of 64.478 at the level of whole sheep population with significant differences ($P < 0.01$) among all studied breeds. Similar order of breeds exists related to the average values of other morphometric traits such as rump height (RH), cannon bone circumference (CBN). The lowest values of the body length (BL) and chest depth (CD) are found in Shkodrane and the highest values in Awasi breed, meanwhile the lowest values for the chest width (CW), rump width (RW) and chest circumference (CC) are found also in Shkodrane and the highest values are found in Il de France. All breeds have greater rump heights than wither heights.

The Coefficient of Variation (CV) values range from 7.07 (RH) to 25.01 (BW). Coefficient of variation of BW was 2-3 times greater than other body measurements. The same order was observed also by Sabbioni *et al*., (2020) in Cornigliese sheep breed. The higher the coefficient of variation the more heterogenous in nature are the traits therefore possess more room for genetic improvement through selection (Abbaya & Dauda, 2018). The selection that exists in the morphometric traits can be exploited for the breed improvement.

Table 1. The descriptive statistics, least square means (LSM) with standard errors (SE), coefficient of variation (%), minimum and maximum values of of body measurements (cm) and body weight (kg) of four sheep breeds

Variable	Awasi	Il de France	Shkodrane	Lara e Polisit	Whole population	CV (%)	Min	Max
WH	70.32±0.50	66.67±0.41	61.25±0.37	59.69±0.35	64.47±0.38	7.84	53	79
RH	73.56±0.45	70.2±0.35	64.25±0.29	63.65±0.36	67.91±0.36	7.07	56	81
BL	117.87±0.63	104.65±0.5	93.56±0.82	98.87±0.64	103.73±0.75	9.7	81	127
CG	36.16±0.34	35.58±0.43	30.98±0.3	32.89±0.35	33.89±0.23	9.25	26	42
CW	19.09±0.25	21.23±0.23	15.92±0.22	17.12±0.19	18.33±0.19	13.58	13	25
RW	22.54±0.26	24.89±0.22	19.27±0.3	19.69±0.18	21.59±0.21	12.94	15	28
CC	86.47±0.61	90.98±0.57	76.32±0.57	76.72±0.65	82.62±0.56	9.04	68	99
CBC	7.14±0.06	8.92±0.10	6.96±0.06	6.89±0.06	7.472±0.071	12.77	6	10
BW	54.12±0.70	55.29±0.99	33.63±0.61	35.89±0.61	44.73±0.83	25.01	25	68

WH – wither height, RH – rump height, BL – body length, CD – chest depth, CW – chest width, RW – rump width, CC –chest circumference, CBC – cannon bone circumference, BW – body weight.

The morphometric indices are helpful for describing the proportions among body parts of animals. Index of Body Frame (IBF) indicate how compact the animal is (Dauda, 2018). IBF values (table 2) range from 153.062 (Shkodrane) to 167.87 (Awasi) which indicate that all breeds have rectangular body frame. Rectangular body frame have also some Pramenka sheep breeds such as Bela Krajina, Istrian Pramenka, and the Sjenicka breed (Marković *et al*., 2019).

All breeds displayed low values of chest index (CI) ranging from 52.109 (Lara e Polisit) to 59.957 (Il de France) and significantly different between breeds. These results are comparable with the values of this index found in Zeta Zuja (Marković *et al*., 2019).

ITD values range from 123.178 (Awasi) to 136.558 (Il de France). CDI values were higher than 50 in all breeds. These both indices obtained in this study indicate a good thorax development of all breeds. These breeds are reared in Korca region, which has an elevation of approximately 1400 m, therefor a high ITD indicate a better fitness and capacity of the respiratory system (Marković *et al*., 2019). The values of BCI range from 95.32 (Shkodrane) to 136.59 (Ile de France) with an average 106.3 ate the level of whole population. These values

indicate that all the breeds are not robust. The results are similar with the results found in Albanian Bardhoka breed (Hoda & Hajno, 2021). DTI also indicates thoracic development. DTI in light animals is lower than 10.5. These values range from 8.26 (Awasi) to 9.799 (Ile de France), with significant differences between populations ($p<0.01$). These values indicate that all breeds consist of light individuals and are more appropriate for milk production than for meat production (Marković *et al*., 2019). These breeds are adapted to waking longer distance, since they graze in natural pasture almost during the year and are managed under traditionally extensive to semiextensive conditions. These findings are very similar with the results obtained for some Pramenka sheep breeds by Marković *et al*., (2019). Body index (BI) values are higher than 90 in each population, indicating that the animals are longiline (Dauda, 2018).

Table 2. The least square means (LSM) with standard errors (SE) of morphometric indices of four sheep breeds

Variable	Awasi	Il de France	Shkodrane	Lara e Polisit	Whole population
IBF	167.87±1.09	157.14±0.95	153.07±1.72	165.79±1.15	160.96±0.77
CI	52.94±0.77	59.96±0.87	51.46±0.65	52.11±0.44	54.11±0.43
IH	95.58±0.27	94.97±0.34	95.34±0.4	93.8±0.25	94.92±0.17
CDI	51.48±0.47	53.41±0.63	50.58±0.36	55.09±0.43	52.63±0.27
ITD	77.06±1.04	82.94±1.42	54.9±0.93	60.09±0.9	128.35±0.61
DTI	118.33±0.97	117.49±0.74	121.23±1.32	115.23±0.7	9.04±0.06
BCI	123.18±1.08	136.59±0.9	124.71±0.94	128.57±0.93	106.29±1.09
RCBI	8.26±0.07	9.8±0.1	9.13±0.08	9±0.08	11.61±0.101
IBW	10.17±0.09	13.38±0.15	11.37±0.1	11.55±0.09	68.74±1.02
BI	34.16±0.47	31.09±0.5	30.27±0.29	26.8±0.28	125.89±0.76
Ipr	241.29±2.68	233.1±3.03	252.56±4.01	223.71±2.3	62.39±0.32
AI	410.16±2.83	391.23±2.95	406.62±4.98	390.5±2.41	6726.49±83.69

IBF – Index of body frame, CI – chest index, IH – Index of height, CDI – Chest depth index, ITD - Index of thorax development, DTI – dactyl thorax index, BCI – Baron-Crevat index, RCBI – Relative cannon bone index, IBW – Index of body weight, PI-Pelvi index, BI-Body index, Ipr-Proportionality, AI -Area index

The total phenotypic correlations among all morphometric measures for all animals is presented in the Table 3. All correlations were positive, statistically significant ($p<0.001$). The lowest value of correlation was found between CBC and BL (0.21). The strongest correlation was between WH and RH (0.957). The correlation coefficients observed within each breed (Tables S3a, b, c) were also positive, and statistically significant ($p<0.001$). All breeds individually are characterized by a high correlation between WH and RH. Awasi was characterized by a very low correlation of RW and CW (0.174). Il de France displayed the lowest correlations between CW and CBC (0.263). In Shkodrane

the lowest positive correlations were found between RW and CC (0.167) In this breed were found two negative correlations between WH and Bl, RH respectively. Meanwhile in Lara e Polisit the lowest correlations were between WH and BL (0.364). BW is highly positively correlated with all measurements. A strong positive correlation between BW and body measurements were found in different sheep breeds worldwide like in Cornigliese (Sabbioni *et al*., 2020), Arsi Bale ((Worku, 2019), Karaya ((Yilmaz *et al*., 2013) etc. Tadesse *et al*. (2014) have suggested that all the phenotypic traits that showed high positive correlation with the body weight are good estimators of body weight. The high correlations values of BW with morphometric measurements can be indirectly used for the improvement of BW (Salamon *et al* 2015). The positive correlations between body morphometric traits and body weight can be exploited for the breed improvement, since the improvement in one trait will improve also the other trait. Positive correlations values between morphometric measurements indicate a balanced physical development and adaption of the sheep breed to the environmental conditions through the process of evolution (Stojiljkovic *et al*., 2015). These finding indicate that these breeds are well adapted to the environment and climate of South East Albania that is different from the environment of their origin.

Table 3. Pearson's correlation coefficients between the morphometric traits of investigated sheep breeds

	RH	***BL***	***CD***	***CW***	***RW***	***CC***	***CBC***	***BW***
WH	0.957*	0.752*	0.683*	0.591*	0.601*	0.705*	0.379*	0.773*
RH		0.82*	0.708*	0.613*	0.647*	0.723*	0.408*	0.808*
BL			0.661*	0.55*	0.582*	0.608*	0.21*	0.756*
CD				0.624*	0.594*	0.736*	0.407*	0.749*
CW					0.915*	0.852*	0.703*	0.816*
RW						0.846*	0.739*	0.826*
CC							0.727*	0.923*
CBC								0.645*

WH – wither height, RH – rump height, BL – body length, CD – chest depth, CW – chest width, RW – rump width, CC –chest circumference, CBC – cannon bone circumference, BW – body weight. *Statistically significant correlation ($P < 0.001$)

Principal component analysis (PCA) based on the average values of all morphometric parameters for the studied sheep breeds was performed by Minitab software using varimax normalized rotation option. The analyses showed that the first two PC contributed 86 % of the total variance, while the first three factors accounted for 90.4% of the total accumulated variance, which satisfactorily explained the differences expressed in the evaluated traits. All traits that were contributing to PC1 have positive value. The most contributing were RW, CC and BW (0.346-0.375). Positive values of the first PC are found by other authors as well (Deribe *et al*., 2021; Marković *et al*., 2019). (Jolliffe, 2002) have explained that the first PC almost always has positive coefficients for all variables and

simply reflects overall ‘size’ of the individuals but the later PCs usually contrast some of the measurements with others, and can often be interpreted as defining certain aspects of ‘shape’ that are important for the breeds. The most contributing trait to PC2 was CBC (0.575). The plot of principal components is shown in figure 1.

The first component classified local sheep breeds from imported breeds. The second component clearly discriminates Awasi and Ile de France, meanwhile between Shkodrane and Lara e Polisit overlaps are observed, which indicate admixture between these Albanian local breeds.

Table 4. Eigenvalue, the proportion of variance, eigenvectors and cumulative variance of morphometric measurements and body weight in the four sheep populations

Variable	PC1	PC2	PC3
WH	0.331	-0.351	0.383
RH	0.343	-0.346	0.344
BL	0.305	-0.435	0.008
CG	0.316	-0.179	-0.81
CW	0.342	0.296	-0.07
RW	0.346	0.293	0.089
CC	0.365	0.176	-0.123
CBC	0.264	0.575	0.224
BW	0.375	0.015	-0.032
Eigenvalue	6.5276	1.2158	0.389
Proportion	0.725	0.135	0.043
Cumulative	0.725	0.86	0.904

UPGMA analysis was performed based on morphometric measurements and body indices and the dendrograme was constructed (Figure 2). The smallest distance was between Shkodrane and Lara e Polisit. The UPGMA tree dendrograme show two clusters. The first cluser include Shkodrane and Lara e Polisit. Ile de France and Awasi are grouped in the second cluster. The clusters displayed in the tree are in line also with the results of PCA. This tree structure can be related with the breeds origin. Shkodrane and Lara e Polisit are native Albanian breeds and Awasi and Ile de France are imported and reared at ATTC in Korca region for the local breed improvement reasons. Shkodrane and Lara e Polisit are raised at ATTC in Korca with the aim of conserving these local sheep breeds, therefore avoiding the mixture of breeding animals.

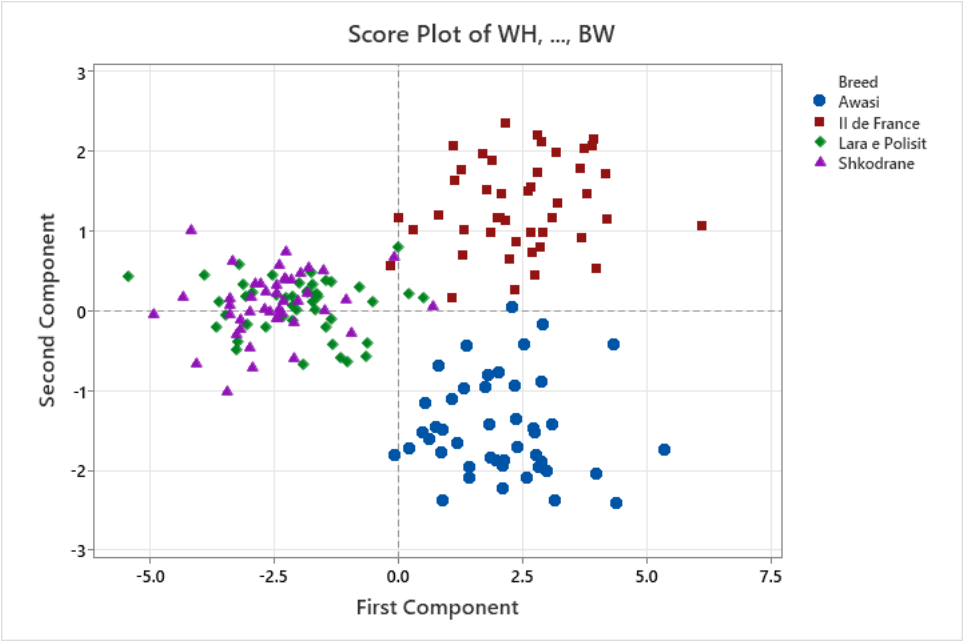

Figure 1. Scatter plot of the principal component analysis, based on morphometric measurements and body weight.

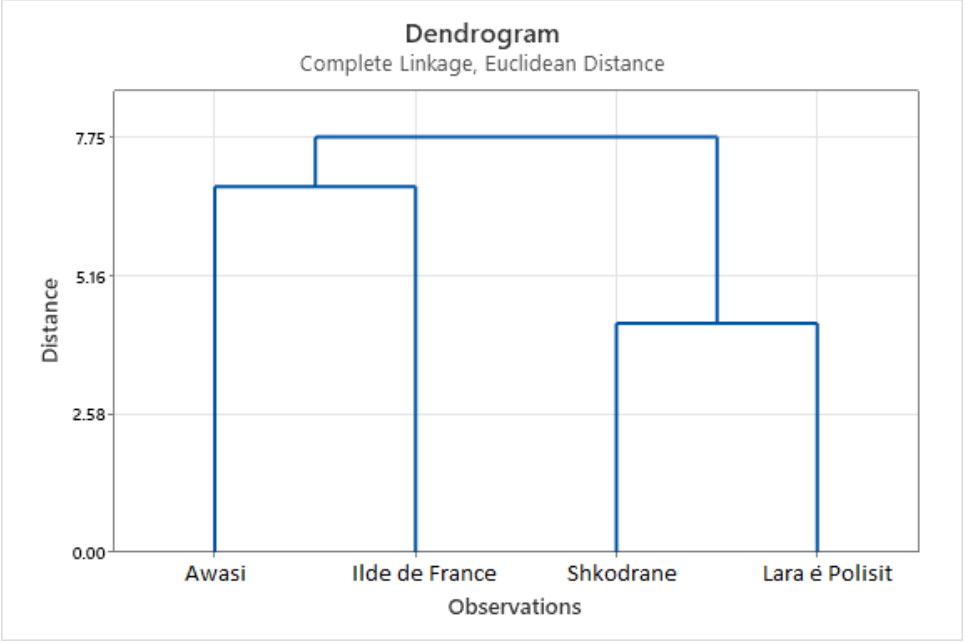

Figure 2. UPGMA tree diagram of distances sheep breeds obtained based on means for morphometric parameters and body weight

Four sheep breeds grouping based on discriminant analysis is shown in table 5. 97.8% of animals were placed in the correct group Awasi and Ile de France by the model. 93.3% of individuals were placed correctly in group Lara e Polisit. The group of Shkodrane has the lowest proportion of correct placement, 86.7%, with 39 out 45 animals were placed correctly. The results of Discriminant analysis support the PCA and UPGMa analysis, indicating admixture in the Albanian local sheep breeds, but not in the imported breeds. High level of admixture is found previously in small ruminants and is explained with the lack of herd book and with the management of these species by the farmers (Hoda *et al*., 2012).

Table 5. Breed grouping based on discriminant analysis

	True Group			
Put into Group	Awasi	Il de France	Lara e Polisit	Shkodrane
Awasi	44	0	0	0
Il de France	0	44	0	1
Lara e Polisit	1	0	42	5
Shkodrane	0	1	3	39
Total N	45	45	45	45
N correct	44	44	42	39
Proportion	0.978	0.978	0.933	0.867

There is lack of published information on prediction of BW using body measurements in Albanian sheep breeds except of Bardhoka (Hoda & Hajno, 2021). The breeds under this study are characterized here for the first time by morphological measurements. The results are shown in table 6. The analysis indicates that all predicted variables, except of WH have p-values that are less than the significance level of 0.05, which indicate that these predictors have a statistically significant effect on body weight.

Table 6. Stepwise Multiple Regression Analysis for different body linear measurements in four sheep breeds

Model	**S**	**R^2**	**R^2 (adj)**	**Mallows' Cp**	**P-value**
-69.48+1.382CC	4.32832	85.12%	85.03%	138.83	0.000
-81.88+1.101CC+0.343BL	3.35151	91.13%	91.03%	13.7	0.000
-83.36+0.9327CC+0.392BL+1.394CBC	3.25559	91.67%	91.53%	4.11	0.001
-86.93+0.886CC+0.351BL+1.426CBC+0.161WH	3.22996	91.85%	91.66%	2.36	0.053

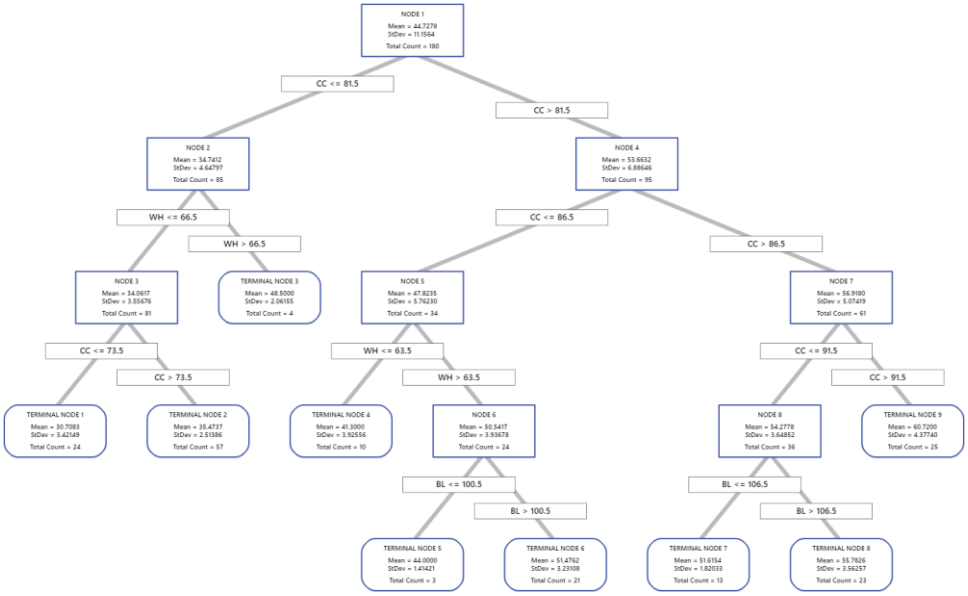

Figure 3. Regression tree diagram constructed by CART algorithm

Figure 3 shows the regression tree diagram constructed by CART algorithm in MINITAB software for the prediction of body weight from morphometric measurements. The algorithm has produced an optimal tree structure of six terminal nodes, with a Root mean squared error (RMSE) 3.207, Mean square error (MSE) 10.286, Mean absolute deviation 2.426, Mean absolute percent error (MAPE) 0.056. In figure 4, is shown the relative variable importance, which is defined as percentage of improvement related to the top predictor.

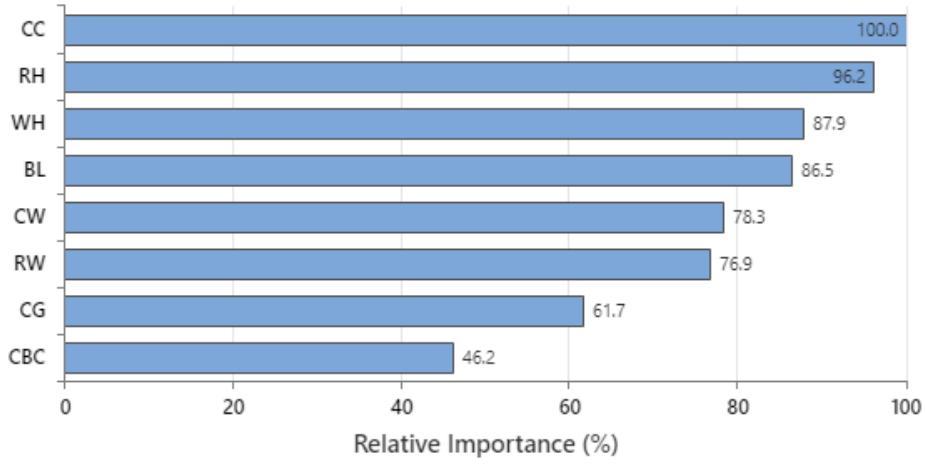

Figure 4. Relative variable importance

Assessment of body weight is important both for commercial purposes and also from the veterinary point of view where the dosages of the medicines are usually provided based on the body weight (Worku, 2019). The detection of the body measurements that are positively linked with the increment of BW in sheep breeding is vital for helping countryside economy and improving selection schemes (Faraz *et al*., 2021). This might be very helpful in the case of ATTC in Korca, whose main mission is the designing of breeding programmes for conservation of local breeds that are at risk of extinction, or the improvement programs by the crossbreeding with the imported breeds.

CONCLUSIONS

Sheep are an important livestock species of triple purpose that contribute for the development of rural economy under extensive and semiextensive conditions of Albania. The data on morphometric measurements and indices of sheep breeds raised at ATTC of Korca, in South East of Albania are used for the characterization of these breeds and the obtained results might be used in the designing of conservation and breeding programme which are the main objectives of this center. PCA, UPGMA and discriminant analysis based on body measurements could differentiate Albanian local breeds from the imported breeds. The imported sheep breeds Awasi and Ile de France are clearly distinct groups, meanwhile Shkodrane and Lara e Polisit show some level of admixture.

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