The Analysis of Morphometric Index of Four Buffaloes Populations in Southeast Sulawesi, Indonesia

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ABSTRACT
The objective of this study is to analyze the morphometric index of four buffalo populations in Southeast Sulawesi. Swamp buffaloes samples in this study were 271 head, from Bombana Island, Bombana Mainland, Kolaka, and Konawe populations. The observed morphometric index variables included height slope, length, width slope, depth, balance, and cumulative index. Morphometric index value comparison between populations was tested using the Duncan Multiple Range test at 5% probability. The results showed that the height slope index between four buffalo populations was not significantly different. The depth index of Bombana Island buffalo was higher significant difference than Konawe and Kolaka buffaloes, but not significant difference from Bombana Mainland buffalo. The length index value of Konawe buffalo was higher significant difference than Bombana mainland and Bombana Island Buffalo, but not different from Kolaka buffalo. The width slope index between the four populations was not different. The balance index of Bombana islands buffalo was significantly higher than the other three populations. The cumulative index value of Kolaka buffalo was higher significant difference than Bombana Mainland buffalo, but not different with Bombana Island and Konawe buffaloes, Bombana Island and Konawe buffaloes were also not significantly different. In conclusion, four buffalo populations in Southeast Sulawesi were classified as excellent types of meat with the characteristics of a fat body, wide and long, short legs, and have a relatively flat backline. The results can be used in the selection program of meat-type buffalo in Southeast Sulawesi.

Keywords: *Swamp Bufallo, morphometric index, local livestock, Southeast Sulawesi.*

1. INTRODUCTION

Buffalo (*Bubalus bubalis*) has a strategic role as a source of food (meat and milk) for many countries in the world, especially in Southeast Asia. In addition, it has a strategic role in people's lives in Indonesia, namely as a source of draft power on agricultural land, savings, biogas, and organic fertilizer, and also used in cultural rituals and tourist attractions [1, 2]. On the other hand, the growth trend of buffalo populations in Indonesia drastically declined in the last two decades.

Statistical data recorded that the buffalo populations in Indonesia amounted to 1,999,604 heads in 2010, while in 2020 it was 1,154,226 heads or declined 42.28% [3, 4]. The trend of decline in buffalo population also occurs in various areas, including in Southeast Sulawesi. The buffalo population in Southeast Sulawesi in 2010 amounted to 5,291 heads and in 2020 amounted to 2,374 or declined 55.16% in the last ten years [5, 6]. The trend of the Buffalo population decrease was a threat to the sustainability of buffalo in Indonesia. Therefore, it needs efforts to improve the population measurement, productivity, and genetic quality of buffalo in Indonesia included in Southeast Sulawesi.

There are two types of buffalo in Indonesia, namely river buffalo and swamp buffalo. About 99% swamp buffalo spread in various regions in Indonesia [2]. The buffalo populations in Southeast Sulawesi which spread in various regions is swamp types while river type is not found.

Bombana, Kolaka, and Konawe districts are source regions of buffalo breeding stock in Southeast Sulawesi. The quantitative traits of local buffalo in Southeast Sulawesi are relatively diverse. The buffalo with the highest quantitative traits is found in Konawe, namely body weight of male and female, rump length of male, and rump width of female. The results of phylogenetic analysis based on morphology traits identified is that the local buffaloes of Southeast Sulawesi is grouped into three clusters, namely Kolaka and Konawe clusters, Bombana Island cluster, and Bombana mainland cluster [7]. The diversity of animal genetic resources (AnGR) of buffalo in Southeast Sulawesi is needed in the selection program to produce superior breeding stock.

Information of production traits of buffalo is needed in programs of AnGR conservation to improve the productivity of local buffalo of Indonesia. Bodyweight and body measurements are known as morphometric traits. It is one of the important production traits in animal breeding programs. The morphometric conduce to explore breed structure and inter-breed variability [8]. In addition, the morphometric approach can be used to identify breed differences with a minimum error rate without having to concentrate only on genotypic traits [9]. The morphometric index is the alternative to assessment livestock as an indicator of type (meat type, dairy type, or dual-purpose) and function of animal [10, 11, 12]. The morphometric index is used to estimate the body weight and animals type because it includes several important variables, namely body conformation, body length, and animal balance. This system has a neutral correlation with age, which can be used without any age restrictions. The application of morphometric indexes to the assessment of the type and function of animals can improve the ability of farmers to evaluate and select potential breeding stock of animals [10].

The study on morphometric indexes has been carried out in various livestock animals types such as goats [13], sheep [10, 14, 11, 15], horses [16], and cattle [17, 18, 19], but it is rarely reported in buffalo. Previous studies report that the difference in the value of quantitative variables between North Kalimantan, East Kalimantan, South Kalimantan, and Thai Phatthalung buffaloes could affect their morphometric index values.

The morphometric index values are highly variable in each sub-population region in both males and females buffaloes [12]. However, study on the morphometric index of buffalo in various provinces in Indonesia, such as in Southeast Sulawesi, has not yet been reported. Based on those backgrounds, the objective of this study is to analyze the morphometric index of four buffalo populations in Southeast Sulawesi as a base for the assessment of the type and function of buffalo morphology.

2. MATERIALS AND METHODS

2.1. Data Collection

The animals observed were 271 swamp buffaloes from four populations. 70 heads were from Bombana island (20 males: 50 females), Bombana Mainland were 70 heads (20 males: 50 females), Kolaka were 60 heads (15 males: 45 females), and Konawe were 71 heads (21 males: 50 females). This study use survey and exploration methods. The sample size was 10 – 15% of the total population in each study location. The morphometric data consists of body weight, body length, hip height, hip width, chest depth, chest width, and rump length. Measurement of morphometric variables: body weight and body measurements done when the animal was in an upright position on flat media based on SNI for measuring the quantitative traits of swamp buffalo [20, 21]. The equipment consists of restraining cage, digital scales, measuring tapes and sticks, calipers, and digital cameras.

2.2. Data Analysis

Data collected from morphometric variables were corrected based on age 3 – 4 years and female sex [22, 23]. Correction of age used the following formula:

$$X_{\text{i-corrected}} = \frac{X_{\text{standard age}}}{X_{\text{observed age}}} \text{ x } X_{\text{observed to-i}}$$

Note:
$X_{\text{i-corrected}}$: The average of size corrected to-i
$X_{\text{standard age}}$: The average of many most age
$X_{\text{observed age}}$: The average of observed age
$X_{\text{observed to-i}}$: The average of size observed to-i

Correction of sex using the formula:

$$X_{\text{i-corrected}} = \frac{X_{\text{female}}}{X_{\text{male}}} \text{ x } X_{\text{observed to-i}}$$

Note:
X_{female} : The average of female sample size
X_{male} : The average of male sample size

The morphometric data were calculated based on the mean value (X), standard deviation (s), and coefficient of variances (CV) [24], with the formula:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n} \qquad s = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$$

$$CV = \frac{s}{X} \; x\, 100\%$$

Furthermore, six morphometric indexes calculated in this study included height slope, length index, width slope, depth index, balance, and cumulative index [17, 10], with the formula:

1. Height slope (HeS) : rump height - wither height
2. Length index (LI) : body length/chest (thorax) depth
3. Width slope (WiS) : hip width - chest width
4. Depth index (DI) : chest depth/withers height
5. Balance (B) : (hip width x rump length)/(chest depth x chest width)
6. Cumulative index (CI): (weight/breed average weight) + length index + balance.

The differences in morphometric indexes between buffalo populations were calculated by Duncan Multiple Range test at 5% probability [24]. Processing and data analysis used SAS package ver. 9.2.

3. RESULTS AND DISCUSSION

The average of six morphometric indexes variables of four buffalo populations in Southeast Sulawesi is presented in Table 1.

Height Slope (HeS)

The results showed that the HeS index between buffaloes populations was not significantly different (P>0.05). All buffalo populations have a positive HeS index value ranging from 0.08±4.00 (Kolaka) to 0.47±3.26 (Bombana Island). The value of the HeS index in this study is low or close to zero. It indicates that all buffalo populations in Southeast Sulawesi have a relatively flat back-line marked by the position of the shoulders to the hips forming a flat straight line same tall [11]. The buffaloes with a flat back indicate a fat body condition and have a carcass of good quality, while the buffaloes with a curved back have a thin body [25].

HeS indexes value of Southeast Sulawesi local buffaloes in this study is lower than that of the buffalo from North Kalimantan, East Kalimantan, South Kalimantan, and Phatthalung Thailand ranging from 1.80 (Phatthalung Thailand) to 3.11 (North Kalimantan) for males, and 1.45 (Phatthalung Thailand) to 3.25 (North Kalimantan) for females [12]. The differences in the animal population, breeds, and variable of quantitative possible could affect the morphometrics index values. Several local Indonesian cattle breeds such as Pasundan, Bali, Madura, and PO cattle have various HeS indexes value. Their HeS indexes values range from 1.31±0.91 (Madura cattle) to 2.84±2.17 (Pasundan cattle) for males and 1.29±0.86 (Bali) to 2.82±2.21 (Pasundan) for females [19]. Those HeS indexes value is not much different from the HeS index values of the Boran bulls from Southern Ethiopia ranged from 1.6 – 2.8 [18].

Length Index (LI)

The length index (LI) can explain whether the animal is tall or long type. If the value of LI is positive <1 it can be said that the animal has a tall body type, and if it is positive >1, it has a long body type [11]. The results show that the LI value of Konawe buffalo (1.13±0.07) is significantly higher (P<0.05) than Bombana Mainland buffalo (1.08±0.11) and Bombana Island (1.04±0.09), but not significantly different (P>0.05) from Kolaka buffalo (1.11±0.11), while the LI value between Bombana Mainland buffalo and Bombana Island show a significant difference (P<0.05). This indicates that the local buffalo of Southeast Sulawesi is included in the long body type because it has a positive LI value >1, which the highest value of LI was found at the Konawe buffalo (1.13±0.07). The value of LI of all buffaloes populations in Southeast Sulawesi in this study is relatively higher than that of the buffaloe from North Kalimantan, East Kalimantan, South Kalimantan, and Phatthalung Thailand ranging from 0.96 (North Kalimantan) to 1.00 (East Kalimantan) for males, and 0.96 (North Kalimantan) to 1.02 (East Kalimantan) for females [12]. In addition, the average LI value of local buffaloes in Southeast Sulawesi found in this study is higher than the LI value for local horses in North Sulawesi, ranging from 0.65±0.03 (South Minahasa horse) to 0.97±0.05 (Minahasa horse) [16]. Meanwhile, the average LI value in Indonesian local cattle such as male and female Madura cattle is 1.11+0.03 and 1.12+0.02, respectively, which are higher than that of PO cattle (1.01+0.03 and 1.10+0.02), Bali cattle (1.02 +0.02 and 1.01+0.01), and Pasundan cattle (1.01+0.02 and 1.01+0.07) [19].

Width Slope (WiS)

The width slope index (WiS) describes the dimensions of the body width because it is the difference between the width of the chest and the width

Table 1. The average of morphometric index from four buffalo populations in Southeast Sulawesi

No.	Variable	Population			
		Bombana Island (n=70)	Bombana Mainland (n=70)	Kolaka (n=65)	Konawe (n=71)
1	Height Slope	0.47±3.26	0.08±4.00	0.35±3.72	0.46±5.22
2	Length Index	1.08±0.11^{b}	1.04±0.09^{c}	1.11±0.1^{a}	1.13±0.07^{a}
3	Width Slope	6.32±3.66	5.47±4.27	6.29±3.17	5.14±4.49
4	Depth Index	0.60±0.02^{a}	0.59±0.04^{a}	0.57±0.02^{b}	0.57±0.05^{b}
5	Balance	0.71±0.08^{a}	0.62±0.08^{c}	0.68±0.08^{b}	0.65±0.08^{c}
6	Cumulative Index	2.78±0.28^{a}	2.67±0.26^{b}	2.79±0.31^{a}	2.78±0.33^{a}

of the hips. The results show that the WiS index between populations is not significantly different (P>0.05) and has a positive value. The WiS index values of the Bombana Mainland buffalo, Bombana Islands, Konawe, and Kolaka populations are 5.47±4.27, respectively; 6.32±3.66; 5.14±4.49; and 6.29±3.17. This means that the local Sulawesi buffaloes belong to the wide-body type. The WiS index value of buffalo in this study is higher than that of North Sulawesi local horse (1.33–1.45) [16], and male Boran bulls in Southern Ethiopia (-21.8 to -25) [18].

Depth Index (DI)

The results show that the average DI index value of the Bombana Island buffalo (0.60±0.02) is significantly different (P<0.05) in which it is higher than that of the Konawe buffalo (0.57±0.05) and Kolaka buffalo (0.57±0.02), but no difference (P>0.05) from the Bombana Mainland buffalo (0.59±0.04). Likewise, there is not difference between Bombana Island and the Bombana mainland buffalo (P>0.05). The animals can be classified in the fat type with short-legged if they have a DI value greater than 0.5 (> 0.5), while the fat type with long-legged has a DI index value of lower than 0.5 (<0.5) [11]. Based on these DI index values, all buffalo populations in Southeast Sulawesi in this study can be claimed as fatty buffalo types with short-legged because they have the DI index value greater than 0.5 (> 0.)5. This study identifies that the Bombana island buffalo has a relatively higher DI index value than other populations. It is relevant to the previous study that the bodyweight of female buffalo in the population of Bombana Island (465.22 ± 103.25 kgs) is significantly higher than the population of Bombana mainland (358.96 ± 66.54 kgs), Kolaka (372.00 ± 81.41 kgs), and Konawe (355.95 ± 78.49 kgs), while the male buffaloes are not significantly different from the three populations. However, quantitatively the bodyweight of male buffalo in the population of Konawe (419.82 ± 148.46 kgs) is relatively higher than the population of Bombana Island (407.09 ± 74.43 kgs), Bombana mainland (373.75 ± 71.23 kgs), and Kolaka (396.18 ± 107.34 kgs) [7].

Balance (B)

The balance index (BI) determines the balance between morphometrics and body weight [11]. The results show that the average BI value of Bombana Island buffalo (0.71) is significantly different (P<0.05) which is higher than the other three populations. The BI value of Kolaka buffalo is significantly different (P<0.05) which is higher than that of Konawe and Bombana Mainland, while between Konawe and Bombana mainland buffalo are not significantly different (P>0.05). It indicates that the Bombana Island buffalo has a more balanced body conformation than the other populations. The balances and proportional body conformation are important so animals can be active grazing well, especially for buffaloes that live in habitat conditions with hilly or mountainous topography.

Cumulative Index (CI)

Cumulative Index (CI) is a morphological function indicator in cattle and sheep [10]. The results show that the average CI value of the Kolaka buffalo (2.79±0.31) is significantly different (P<0.05) from the Bombana mainland buffalo (2.67±0.26), but not different from the Bombana island (2.78±0.28) and Konawe (2.78±0.33), thus between Bombana Islands and Konawe buffaloes are not significantly different (P>0.05). The difference in the CI value of the Bombana mainland buffalo from other populations is responsive to cumulatively morphological functions to different environmental conditions. The CI value involving weight and body balance is important in determining body function. This morphological functionality is influenced by the environment so that the CI value can differ between livestock groups [10]. The quantitative variables such as wither height, rump height, rump length, rump width, chest depth, chest width, and body weight highly affect the morphometric index. Therefore, these variables are crucial aspects that need to be considered in buffalo farming [12].

4. CONCLUSION

In conclusion, four buffalo populations in Southeast Sulawesi are classified as excellent type of meat with the characteristics of a fat body, wide and long, short legs, and have a relatively flat backline. The results can be used in the selection program of meat-type buffalo in Southeast Sulawesi.

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