Growth Rate and Body Size Mapping of Male Buffaloes during the Fattening Phase

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Abstract: *Background*: Buffalo is an animal that really likes water. Generally, buffalo like to soak in muddy waters and swamps around the cage. This behavior appears because buffalo have very few sweat glands. Therefore, if one wants to develop buffalo farming, he/she should look for special habitats or existing buffalo breeding centers. Differences in growth rates are caused by physiological factors and functional demands. Growth in animal body size usually follows an exponential function, with the growth rate varying from one body size to another. An animal's body size that functions earlier will grow faster with a greater growth rate than an animal that functions later. Differences in the growth rate of animal body size are also influenced by the constituent components of these body parts. Body parts composed primarily of bone will develop earlier than those composed of muscle or fat. During fattening, the body size of male buffaloes will have a different growth rate, where this difference indicates the potential for body size. The body size of a buffalo with a high growth rate has relatively large growth potential, while those with a small growth rate have small growth potential, or the body part has stopped growing because it has reached its maximum point. The purpose of this study is to determine the body size growth rate of male buffaloes, which have high potential during fattening. Mapping the body size of male buffaloes during fattening aims to help breeders determine at what age the buffaloes start to be fattened and slaughtered for meat production purposes so that they are economically quite profitable.

Methodology: Data was collected using a saturated sampling technique, in which the livestock taken were all buffaloes kept by the Sumber Sari Livestock Group in Kalianget village, Seririt District, Buleleng Regency, Bali, which met the requirements in terms of their health and physical condition. The data obtained were analyzed using the power model regression analysis to determine the growth rate of the body size of the buffaloes. To map the growth rate, Biplot analysis was carried out with a Promax rotation of 90, as the variable is the estimated body size of the buffaloes based on the equation of the power regression line, and the object is the age of the male buffaloes.

Conclusion: The results showed that the fastest growth rate or the greatest potential was chest width, followed by hip width, chest depth, body length, chest circumference, and shoulder height. At the same time, the slowest part of the lowest potential was the height of the hips. The results of mapping the body size growth rate of male buffalo aged 11-74 months with biplot charts showed that their growth potential was still quite high. However, there was a tendency for male buffalo over 30 months to have a slower growth rate in body size than those under 30 months.

Keywords: Male buffalo, body size, growth rate, Biplot, promax 90 rotation.

INTRODUCTION

The size of an animal's body over a certain period will change, but the growth rate in each part of the body is different. The overall body size (X) will be obtained if all body measurements are added up. The overall body size growth rate is the average growth rate of all animal body sizes. Animals have several body sizes with the same growth rate, but some are faster or slower than the overall body size.

Power regression analysis with the equation of $Y=aX^b$ can be applied to determine which part of the animal's body (Y) has a faster growth rate than the overall body size (b>1), that is, the part of the body with high potential. Meanwhile, if the growth rate is slower than the overall body size (b<1), then the potential is low, or the nucleus has already grown. Differences in growth rates are caused by differences in physiological and functional demands, as well as their constituent components. The parts of the animal's body that function earlier will grow first, while those that function later will also grow later. Differences in the rate of growth of animal body parts are also influenced by their constituent components, animal body parts which as constituents or main components are bones, will develop earlier than those consisting of muscle or fat. Swatland [1] and Sampurna and Suatha [2] reported that the growth rate of each part of an animal's body during a certain life phase differs from a certain time period.

Differences in growth rates in the Power function with different growth rates can be mapped using a Biplot chart with Promax Kappa 90 rotation. Each different growth rate will lie in 3 different quadrants so that it can be used to determine the growth rate of organs, tissues, or animal body parts [3].

Differences in the growth rate of male buffalo body size during fattening are very important to know which

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body size has the potential to grow and develop during fattening. Mapping the body size of male buffaloes during fattening aims to help breeders to determine at what age buffaloes start to be fattened and at what age slaughter is done for meat production purposes so that it is economically quite profitable.

Based on the description above, it can be hypothesized that every part of the male buffalo's body has a different growth rate during fattening.

MATERIAL AND METHODS

Data was taken using a saturated sampling technique in which the animals used as samples were all buffaloes kept by the Sumber Sari Livestock Group in Kalianget Village, Seririt District, Buleleng Regency, Bali which met the requirements of health and physical condition.

The data collection method was by direct observation of male buffaloes kept by buffalo farms in the Sumber Sari Livestock Group in Kalianget village, Seririt sub-district, Buleleng regency, Bali. To find out the actual size of the body, the researcher took measurements directly in the field.

According to Kampas [4], measuring the body size of an animal can be done by the following methods:

1. Shoulder height, measured from the highest point of the shoulder past the back of the *scapula perpendicular* to the ground.
2. Inner chest, measured from the base of the *gumba* to the sternum just behind the elbow.
3. Chest circumference, measured around the chest cavity behind the shoulders.
4. Body length is measured as the straight distance from the protrusion of the shoulder bone or the humeral tubercle background to the sitting bone or tuber.
5. Hip height measured the perpendicular distance from the first sacrum bone to ground level.
6. Hip width measures the distance/width between the two hip joints.
7. Chest width is measured from the largest distance to the right and left chest at the chest circumference measurement position.

The measurement scheme is shown in Figure **1**.

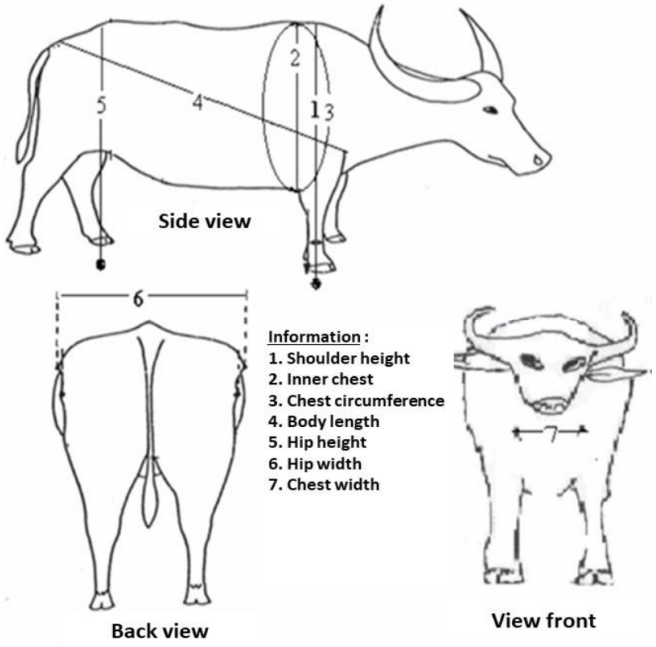

Figure 1: Image of Buffalo Cattle Body Size Measurement Scheme.

The data obtained is processed using the power model regression analysis method to determine the male buffalo's body size growth rate. To map the growth rate, the researcher conducts a Biplot analysis with a Promax rotation of 90 where the variable is the estimated body size of the male buffalo based on the power regression line equation, and the object is the age of male buffaloes in the Sumber Sari Livestock Group in Kalianget village, Seririt sub-district, Buleleng regency, Bali.

The analytical procedure used is the SPSS (Statistical Product and Service Solutions) program [5].

RESULTS AND DISCUSSION

The study of the body size growth rate of male buffaloes aged 1-6 years (11-74 months) gives the results shown in Table **1**.

The results of this study indicate that the body of male buffalo aged 11 – 74 months which has the fastest growth rate or the greatest potential, is the width of the chest, followed by the width of the hips, the depth of the chest, the length of the body, the circumference of the chest, and the height of the shoulders. At the same time, the slowest part of the lowest potential is the height of the hips. The difference in the growth rate of the body size of male buffalo

Table 1: Growth Rate of Body Size of Male Buffalo Aged 11 – 74 Months

No.	Male Buffalo Body Size (cm)	Correlation Coefficient (R)	Constant (a)	Growth Rate (b)	Equality Regression
1	Shoulder Height	0.963	0.716	0.784	$Y_1 = 0.716X^{0.784}$
2	Inner Chest	0.969	0.022	1.224	$Y_2 = 0.022X^{1.224}$
3	Chest Circumference	0.982	0.419	0.924	$Y_3 = 0.419X^{0.924}$
4	Body Length	0.961	0.106	1.073	$Y_4 = 0.106X^{1.073}$
5	Hip Height	0.964	1.378	0.686	$Y_5 = 1.378X^{0.686}$
6	Hip Width	0.975	0.0001	1.909	$Y_6 = 0.0001X^{1.909}$
7	Chest Width	0.959	0.006	1.383	$Y_7 = 0.006X^{1.383}$

during fattening at the age of 11-74 months is caused by differences in physiological demands and constituent components.

The body size, whose constituent components consist of bones, such as shoulder height and hip height, is that long bones are required to grow earlier and stop faster so that the growth rate is low. At the age of 11-74 months, the body length, as well as its constituent components, consists of flat bones. Thus, the nucleus grows slower or has a greater potential than height. Meanwhile, the components of the chest width, hip width, chest depth, and chest circumference consist of muscle and fat, so the growth rate is still quite large (1> 1) since physiologically, growth starts from bone, then muscle, and finally fat. The growth rate of the body size of livestock whose constituent components consist of muscle and fat has a greater potential if there is muscle growth or fat accumulation in that area.

Sampurna and Nindhia [3] reported that if the sizes of organs, tissues, or body parts are added up, the overall body size (X) will be obtained. The growth rate of overall body size is the average growth rate of organs, tissues, or animal body parts so that in every organ, tissue, or animal body part, there are several that have the same growth rate, faster or slower. Differences in the growth rate of organs or body tissues at a certain time are determined by their function, while the growth rate of body parts compared to overall body size depends on the dominant constituent components such as bone, muscle, or fat [1, 2].

Differences in the body size growth rate of male buffaloes aged 11-74 months are shown in Figure **2**.

The graph shows that if the body size has a low potential (b<1), then the line for shoulder height and hip height will be convex upwards, while those with a high potential (b>1), such as chest width, hip width, and deep chest lines will convex downwards. If the potential is approaching one (b=1), such as body length and chest circumference, then the line tends to be straight. The graph is shown in Figure **3**.

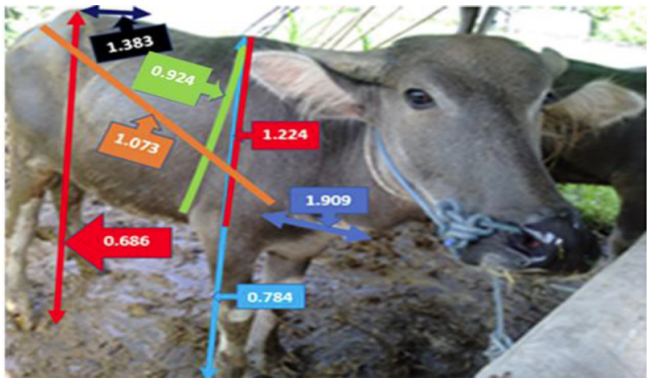

Figure 2: Growth Rate of Body Size of Buffalo Buffalo Age 11-74 Months.

Sampurna and Nindhia (2017) [3] reported the power function with the equation $Y = aX^{b,}$ which has domain x> 0 and co-domain Y> 0, where a is a positive constant, then if b = 1, a straight line will be formed showing the change in co-domain which is proportional to the change in domain. If b < 1, then a convex line will form, which indicates the co-domain change is slower than the domain change. On the other hand, if b> 1, a concave line will form, indicating that the co-domain changes faster than the domain. Power regression analysis is a form of nonlinear regression that is usually used to find the relationship between two variables that have different increases in a certain time. Thus, which variable has a faster or significantly increased rate can be determined.

Mapping the growth rate of male buffalo's body size based on the age of 11-74 months during fattening with biplot graphic images can be illustrated in Figure **4**.

Mapping the body size growth rate of male buffalo using a biplot chart shows that the growth potential for

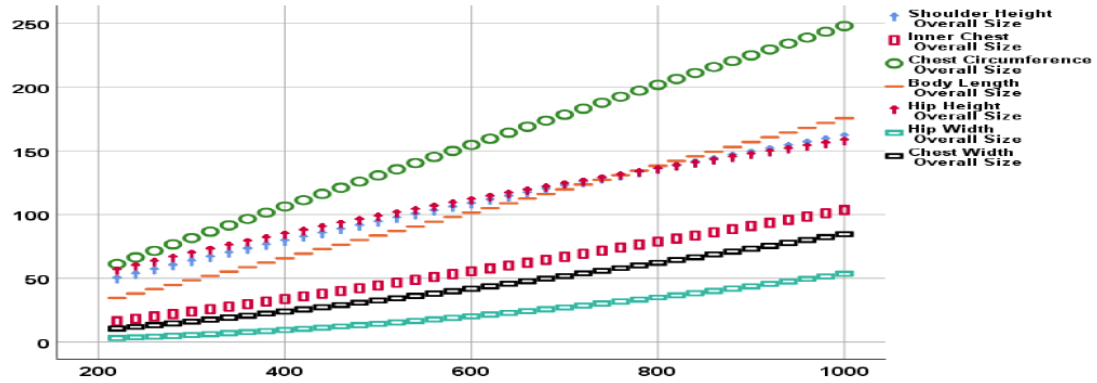

Figure 3: Body Size Chart for Male Buffalo aged 11-74 Months.

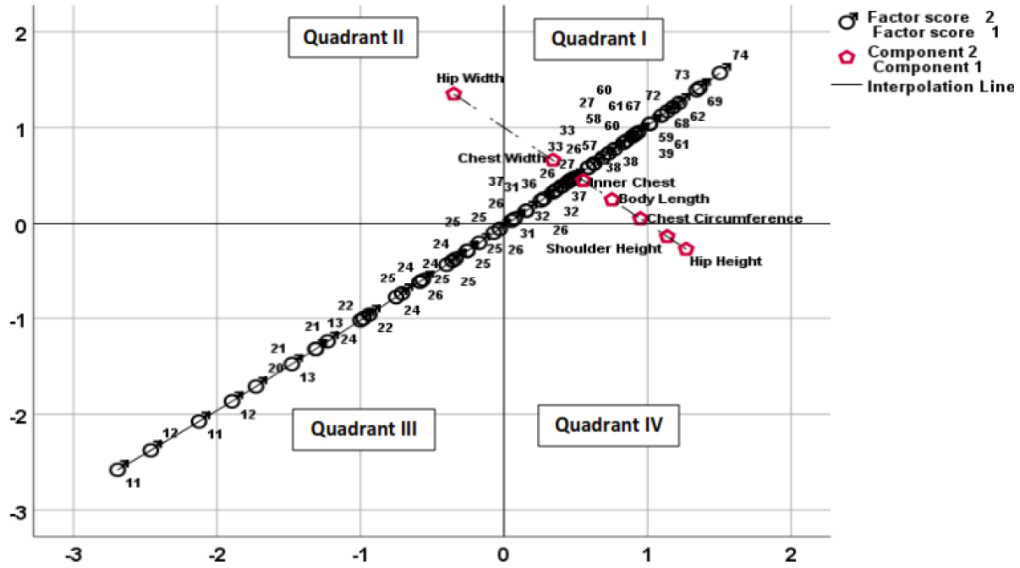

Figure 4: Biplot Graph of Body Size of Male Buffalo aged 11 – 74 Months.

male buffalo aged 11-74 months is still quite high. This can be seen from the coordinate distance between the age of the buffalo, which is still relatively the same. However, there is a tendency for the distance between buffaloes aged 11 months to 30 months where the distance is farther than after 30 months. These results indicate in male buffalo at 30 months of age, the rate of growth of body size is slower than in those under 30 months. This is in line with Sampurna *et al*. [6], which mention the distance between the ages in terms of length and circumference of male and female buffalo showing differences in growth rates. The older the buffalo, the slower the growth rate, with the smaller the distance between the coordinates.

The growth pattern of livestock body parts generally follows a sigmoid pattern; that is, at first, it is slow, then it gets faster, and after it reaches the maximum speed (inflection point), then it slows down again and stops growing after the body size reaches the maximum point. Each body part will reach maximum speed and size at different ages. Sampurna *et al*. [7] reported that the body size growth pattern for Bali cattle follows a sigmoid pattern. Sampurna *et al*. [8] also reported growth patterns in body length, chest circumference, and body weight in male and female Bali pigs following a sigmoid pattern. Body length and chest circumference reach the fastest growth rate at 6 - 8 weeks, while body weight gains the fastest growth rate at 17 - 20 weeks. Male pigs reach their maximum speed at a younger age than sows. The results of this study are in accordance with Owens *et al*. [9], who showed that body weight in relation to age is a sigmoid curve, where the increase is accelerated until puberty, and the inflection point can be observed, then the increase becomes slower until adulthood. Grant and Helferich [10] stated that in the first phase, growth is accelerated until puberty, especially the growth of bone

Table 2: Coordinates of the Patten Matrix Body Size of Male Buffalo Age 11 – 74 Months

Quadrant	Male Buffalo Size (cm)	Component	
		I (Abscissa)	II (Ordinate)
I	Chest Width	-0.35000	1.35000
II	Inner Chest	0.55100	0.44900
	Chest Circumference	0.95000	0.05000
	Body Length	0.75200	0.24800
	Hip Width	0.34100	0.66000
III	Shoulder Height	1.13700	-0.13700
	Hip Height	1.26900	-0.26900

and muscle tissue which is stimulated by the release of growth hormone. In the second phase, after puberty, growth slows due to the increased action of steroid hormones that increase adipose tissue deposition.

Most male buffaloes under 30 months are in quadrant III, or below the X axis, while those over 30 months are in quadrant I, which is above the X axis. These results show that the male buffaloes in quadrant III are still smaller than the average body size. While those in quadrant I have their body size already larger than the overall male buffaloes. Mattjik and Sumertajaya [11] state that objects that are above the X-axis have a higher value (above average). Conversely, if an object is located below the X-axis, then it has a lower value (below average). If the object is located almost in the middle, then it has a value close to the average.

The body size of the male buffaloes is in 3 quadrants. In quadrant I, there are hip width, chest depth, circumference, and body length. In quadrant II are chest width. In quadrant IV are shoulder height and hip height.

The location of the body size coordinates for male buffalo during fattening is shown in Table **2**.

Sampurna and Nindhia [3] reported that organs, tissues, or animal body parts are located in quadrant I, so the growth rate is the same as the overall body size. If an organ, tissue, or body part is in quadrant II, then the organ, tissue, or body part of the animal is in a growth rate that is faster than the overall body size.

Conversely, if an organ, tissue, or body part is in quadrant IV, the organ, tissue, or body part of the animal is at a slower growth rate than the overall body size. The highest growth potential for buffalo body size is chest width, followed by hip width, chest depth, body length, chest circumference, shoulder height, and hip height. The results of mapping the body size of a male buffalo with a Biplot chart based on the estimation of the power function can describe the location of the coordinates of the object (age of the buffalo) and variables (body size of the male buffalo). Therefore, it can be used to determine at what age the male buffaloes that are in the fattening phase (aged 11 – 74 months) grow fast, slowly even stop growing.

The body size of the male buffaloes with the highest potential for growth is the width of the chest, and the lowest is the height of the shoulders and the height of the hips. Meanwhile, other body measurements such as hip width, chest depth, body length, and chest circumference have moderate growth potential. These results indicate that during the fattening phase of male buffalo aged 11-74 months, the shoulder height and hip height have stopped growing or have reached adult size. Meanwhile, the width of the hips, inner chest, body length, and chest circumference are still growing.

Muscle growth and fat accumulation in the chest area have a tendency to the side, which are the left and right sides of the buffalo's chest. The highest growth potential is the width of the chest, which is higher than the width of the hips, inner chest, and girth. The results also demonstrate that muscle growth and fat accumulation in male buffaloes are towards the front body rather than the rear.

CONCLUSION

1. The results show that the fastest growth rate or the greatest potential is chest width, followed by hip width, chest depth, body length, chest circumference, and shoulder height. Meanwhile, the slowest or lowest potential is hip height.

2. The results of mapping the body size growth rate of male buffaloes aged 11-74 months with biplot charts show that their growth potential is still quite high. However, there is a tendency for male buffaloes over 30 months of age to grow slower than those under 30 months.

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