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Pattern of Growth Lengths, Circumference Chest and Body Weight of Bali Pig

KEYWORDS: Bali pig, body weight, size at birth, maximum size, inflection point.

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ABSTRACT *The research in patterns of body length growth, chest circumference, and body weight of Bali pigs was carried out in the village of Musi, Gerogak district, Buleleng, Bali. This study aims to determine the measurement of body length, chest circumference and body weight during birth and the maximum growth size that can be achieved, as well as determining when the growth had reached inflection points and its adult size. The sample used in this study are Bali pigs at the age of 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, and 26 weeks, consisting of 2 males and 2 females. Data were analyzed with sigmoid regression analysis model, by determining the body length, chest circumference, body weight at birth, its maximum size, and as when it reaches the inflection point and maximum size based on the equation obtained. The results showed the body length, chest circumference, and body weight followed the sigmoid pattern. Male and female bali pigs during birth has the same body length, chest circumference, and body weight. While the maximum size of body length, chest circumference, and body weight were different between male and females. Most rapid inflection point of chest circumference was achieved at the age of 6 – 8 weeks, while the fastest adult size reached at the age of 32 - 34 weeks.*

Introduction

The simplest growth curve is linear model, but generally growth does not follow a linear model. General growth curve on body size began when hatching or birth (Wo) and body size at a certain age (Wt), with k as the exponential growth rate :

Wt = be^{kt}, monomolekuler / logestik : Wt = A - be^{kt} , sigmoid : $Wt = \frac{A}{1+be^{-kt}}$, Gompertz : $Wt = e - be^{-kt}$ and parabolic :

Wt = bt^{k}) (Swatland, 1984). Budimulyati at al. (2015) compared three growth curves in Friesian Holstein cows namely: Logistic Y = A (1 + e^{-kt}), Gompertz Y = A exp (-Be^{-kt}) and Von Bertalanffy Y = A (1-Be^{-kt})^3 , with each inflection point (ln M)/k, (ln B)/ k and (ln 3B)/k.

Sampurna (1992) reported that the growth patterns of body parts and organs of broilers are shaped as sigmoid. Broiler males reach the inflection point at a more mature age than broiler females, males boiler also reaches the maximum size that is larger than the female broiler. Tazkia and Angraeni (2009), reported a growth curve of body measurements and body weight of cow FH is generally patterned sigmoid, which reflects the growth of livestock from the beginning of birth, then the acceleration phase until it reaches a point of inflection. Then the cattles reaches adulthood and in this phase already begins to occur a deceleration phase of growth which is relatively constant.

Sampurna et al (2014) reported the growth curve of the body dimensions of Bali cattle is in the sigmoid shape, with a point of inflection in the age :$\frac{1}{k}$ (Ln b)and reached the adult body at the age of :

$\frac{1}{-k} Ln[\frac{0,0526}{b}]$, where: k: is the speed of growth and b: is a constant. Sampurna et al (2011) reported that the growth curve of body length males Landrace pigs are achieved with the equation: Y = 205 - e (5.174 - 0,035X), with a correlation coefficient R: 0.994, while for the female equation: Y = 172 - e (4.955 - 0,040X), with a correlation coefficient R: 0.993. Growth curve of chest circumferences of males Landrace pigs are achieved with the equation: Y = 205 - e (5.174 - 0,035X), with a correlation coefficient R: 0.994, while for the female equation: Y = 172 - e (4.955 - 0,040X), with a correlation coefficient R: 0.993.

Genetically Bali pigs have a slower growth compared with common pig races, but the benefits shows more efficiency towards water; which they are still able to survive despite being fed a potluck, therefore many people still farm Bali pigs in several villages in Bali. The Meat flavor of Bali pigs more preferable instead of the common races pigs, because the meat of Bali pigs more savory compared of the races pig; this is due to genetic and dietary factors. Genetically, Bali pigs are the fatty type, rather than the mostly meat type like the common races pigs. Bali pigs are much faster to store fat in its body, therefore the fat on its shoulder and back is thicker than common pig races. Thickness of fat on the brisket is a good thing in the making of suckling pig culinary, because suckling pig skin will be thicker and more tender. Bali pig farming still have enough potential to developed, they are still required for customs purposes and consumer needs, especially for culinary. Therefore the need and effort to preserve Bali pigs, which is a Balinese native germplasm, should be kept not to become extinct. The efforts to preserve Bali pigs is very important to know the pattern of growth, which shows the development of Bali pigs so we can determine its growth potential.

Livestock growth pattern is influenced by genetic factors, gender and governance maintenance. Body size at birth and maximum body size, such as body length, chest circumference and body weight, affects the behavior of the growth curve throughout life (from birth to death) of the animal. The behavior of the curve can describe the speed of growth, the time it is growing rapidly, deceleration of growth, time of inflection point, time of sexual maturity, time reaching adult measurement, and the time that the cattle should be harvested so it is profitable. Livestock

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growth patterns can also be used as a guideline to determine the nutritional needs of cattle. If bone growth manifested from the body length has reached the maximum size, the growth of meat or fat that is manifested of chest circumference is growing faster, it is then we can determine the nutritional needs of the animals.

The curve of growth in livestock is affected by body size at birth and the maximum body size in adulthood, during the growth of birth/hatching to adulthood/death rate of growth at the time of a certain age are always changing. The body size of a particular animal are; the growth speed is very fast at birth and then decreases and eventually zero speed, there is also a first deceleration, then acceleration to achieve the inflection point at a certain age, then speed decreases and eventually zero growth speed. It is therefore necessary to find an equation that could explain the changes in speed at a certain age determined by its birth and maximum size.

Materials and Methods
Samples and Research Tools.
The samples used were Bali pigs aged 0-26 weeks in the village of Musi, Gerogak, Buleleng district, Bali, Indonesia. Bali pigs were observed at the age of 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, and 26 weeks, each consisting of 2 males and 2 females, bringing the total number of samples observed 14 x 2 x 2 = 56 heads.

The tools used in this study is in the form of meters, length 150 cm, with a scale measuring scales mm and a tool with a scale capacity of 25 kg and 200 kg.

Research Variables
The independent variables are gender and age, while dependent variabel is a measure of body length, chest circumference and body weight at the age of 0-26 weeks. Cofounding variable is the sow and variable control is management and health.

Measurement Method.
Body length measurement is done by measuring from the anterior portion of the vertebrae cervicales primum until tuber sacrale, chest circumference is measured by circling the region vertebrae lumbales primum (Getty, 1985) and body weight was measured by a weighing scale.

Data Analysis.
Data were analyzed with Sigmoid regression analysis model with two specified

parameters, namely: the size at birth and the

maximum size, the equation :

$$Y = \frac{(A-D)}{1+\left(\frac{X}{C}\right)^b} + D$$

Where: Y: is a measure of body length, body circumference and body weight, A; is the body length, chest circumference and body weight at birth, D: is the length of the body, the body circumference and maximum body weight after adult, b and c are constants used to determine the point of inflection. In the form of linear equations:

$$Ln[\frac{(A-Y)}{(Y-D)}] = -LnC^b + bLnX \ ,$$

the regression line:

$$\hat{Y}i = \beta o + \beta 1 Xi \ .$$

This model can be solved by determining in advance the Tilapia A and D, then the transformation of the dependent variable Y, with

$$Ln[\frac{(A-Y)}{(Y-D)})]$$

and to the independent variable X with Ln (X), then the value of

$$C = e^{(\frac{|\beta o|}{|\beta 1|})}$$

b = β1, while the value .

$$Y = \frac{(A-D)}{1+\left(\frac{X}{C}\right)^b} + D = (A-D)\left(1+\left(\frac{X}{C}\right)^b\right)^{-1}$$

First derivative :

$$Y' = -(A-D)\left(\frac{b}{C^b}\right)(X^{b-1})\left(1+\left(\frac{X}{C}\right)^b\right)^{-2}$$

Second derivative :

$$Y'' = [2\left(\frac{b}{C^b}\right)X^{b-1}\left(\frac{b}{C^b}\right)X^{b-1} - (b-1)\left(\frac{b}{C^b}\right)(X^{b-2})\left(1+\left(\frac{X^b}{C^b}\right)\right)]$$
$$[(A-D)\left(1+\left(\frac{X^b}{C^b}\right)\right)^{-3}]$$

The inflection point is achieved if the second derivative of the sigmoid models equals to zero (Y''= 0), is achieved if:

$$X = C\left[\frac{(b-1)}{b+1)}\right]^{\frac{1}{b}} .$$

At adult size; if the size reaches 80% of the maximum size, it is achieved at the age of :

$$X = C\left[\frac{0{,}80D - A}{0{,}20D}\right]^{\frac{1}{b}} .$$

The growth rate at the time of birth is zero, while the rate of growth after birth per day is:

$$Li = \left(\frac{Y_{i+1} - Yi}{X_{i+1} - Xi}\right)$$

Results and Discussion
Results
The Sigmoid regression analysis model indicated that there was highly significant correlation (P <0.01) between age and size body of dimensions Bali male and female pigs with the equation in Table 1.

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Table 1. Results Regression Analysis of Sigmoid Model. Chest Circumference and Body Weight of Bali Male and

Body Size	Correlation Coefficient (R)	Model Sigmoid Equation	Inflection Point (Weekly)	Age Adults (Weekly)	Size time Inflection Point	Adult Size
Body Length (Cm) Males	0.985	$Y=\frac{(21.75-140)}{(1+\left(\frac{X}{16.63}\right)^{1.77}}+140$	8.1	32.2	47.5	112.0
Body Length (Cm) Females	0.990	$Y=\frac{(21.75-138)}{(1+\left(\frac{X}{17.64}\right)^{1.78}}+138$	8.6	34.0	47.2	110.4
Chest Circumference (Cm) Males	0.988	$Y=\frac{(20.50-145)}{(1+\left(\frac{X}{22.04}\right)^{1.44}}+145$	6.7	50.4	39.6	116.0
Chest Circumference (Cm) Females	0.990	$Y=\frac{(20.50-140)}{(1+\left(\frac{X}{21.72}\right)^{1.54}}+140$	8.0	46.7	41.6	112.0
Body Weight (Kg) Males	0.986	$Y=\frac{(0.65-138)}{(1+\left(\frac{X}{29.32}\right)^{2.09}}+138$	17.8	56.7	36.5	110.4
Body Weight (Kg) Females	0.995	$Y=\frac{(0.65-136)}{(1+\left(\frac{X}{32.37}\right)^{2.13}}+136$	20.0	61.9	36.5	108.8

Bali pig body length of the males and females at birth has the same length of 21.75 cm. Bali pig male body length Reaches a maximum size of 140 cm, the inflection point at the age of 8.1 weeks with a size of 47.5 cm and reached adult size by the age of 32.2 weeks with a size of 112 cm, while females reached maximum size of 138 cm, the inflection point at the age of 8.6 weeks with size of 47.2 cm in size and reached adult size by the age of 34.0 weeks with a size of 110.4 cm. Chest circumference of Bali male and female pigs at birth have the same circumference that is 20:50 cm. Chest circumference Bali male pigs reached a size of 145 cm maximum, the inflection point at the age of 6.7 weeks with 39.6 cm in size and reached adult size by the age of 50.4 weeks with the size of 116 cm, while females reached maximum size of 140 cm, the inflection point at the age of 8.0 weeks with 41.6 cm in size and reached adult size by the age of 46.7 weeks with a size of 112.0 cm. Bali pigs body weight in male and female at birth have the same length is 0.65 kg. Bali male pig body weight reached 138 kg maximum size, the inflection point at the age of 17.8 weeks, with a size of 36.5 kg and reached adult size by the age of 56.7 weeks with a size of 110.4 kg, while the females reached maximum size of 136 kg, the inflection point at the age of 20.0 weeks with the size of 36.5 kg and reached adult size by the age of 61.9 weeks with the size of 108.8 kg.

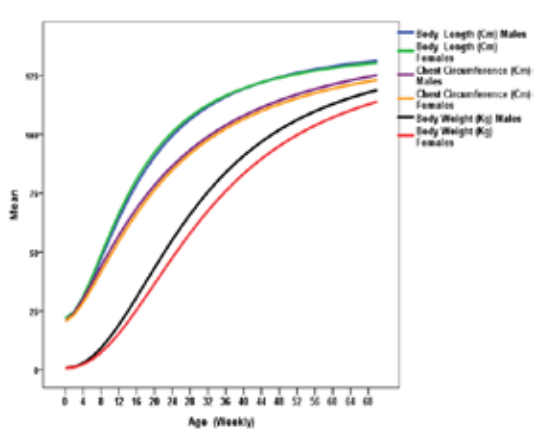

Figure 1. Sigmoid Regression Model of Body Length, Female Pigs.

Figure 2 shows the birth body length, chest circumference and body weight of pigs Bali female pigs have on average the same size, increasing adult age chest circumference and body weight where males appeared larger in size than the females, while the body length did not seem different up to the age of 70 weeks.

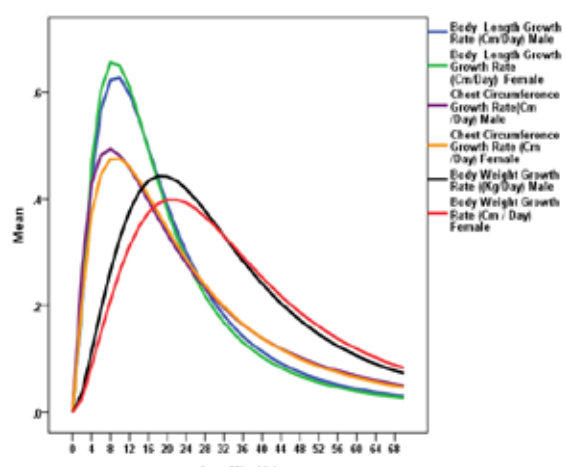

Figure 2. Growth Rate of Body Length, Chest Circumference and Body Weight Bali Male and Female Pigs.

Figure 2 shows that at the age of 0-12 weeks growth rate of the most highest body length, followed by chest circumference and the lowest is body weight, while the after the life of more than 26 weeks, the fastest growth rate is body weight, followed by chest circumference and the slowest is the body length. The fastest growth rate of body length is achieved at the age of 8-9 weeks, chest circumference 6-8 weeks, and body weight of 17-20 weeks

Discussion

Measurement of body length, chest circumference and body weight of Bali pigs at birth was influenced by the

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size of the parents body and the males as well as the maintenance management of its parents, in this study Bali male and female pigs were taken from the same origin with the same maintenance management, so the body length, chest circumference and body weight at birth have size the same. Furthermore, the more mature age, body length, chest circumference and body weight, in addition were affected by the parent and stud (genetic), were also influenced by sex factor. Kay and Housseman (1987) states that the male hormone androgen in animals can stimulate growth so that males are larger compared to females. Male animals usually grow faster, mature more slowly and have a more muscular carcass with less fat than female cattle, bulls that are castrated deposit more fat and less muscle during growth (Nasrul, 2012).

Body length, chest circumference and body weight of male Bali pigs has a point of inflection at a younger age than female Bali pigs , this is because estrogen produced by the ovaries is generally has little effect or no effect on protein synthesis and skeletal, but effective in increasing the formation of body fat. Estrogen is more effective in causing the pipe piphyscal to close. Therefore, females stop growing at a faster rate than males (Nasrul, 2012). If compared with pigs that have been reared intensively and have undergone selection like Landrace pigs, pig Bali has a point of inflection at a much older age. Livestock that are already experiencing intensively reared selection, will have an increasingly rapid inflection point. Landarce pigs have a very young inflection point, that is during newborn piglets (Sampurna *et al*. 2011). Bali pigs including a very slow growth when compared with Landrace pigs, it was due to the Bali pig has not experienced selection and reared extensively. Genetically, bali pigs have a slower growth compared with the pig common import race. It takes 8-10 months to achieve a body weight of 90-100 kg, while imported pigs race only 5-6 months, but the benefits, more efficient against water, still survive although given feed roughing.

The fastest inflection point was the circumference of the chest, followed by a body length and the last was the weight at a younger age. While at the older age, the fastest inflection was the body length, followed by chest circumference. The sooner it reaches the inflection point, it was not necessary faster at reaching adult size. Each difference was caused by differences in function and its constituent, body length serves to form the body and composed of bones, chest circumference forming the chest cavity and composed of muscle and fat, while body weight illustrate the change in volume resulting from changes in the length and circumference. Every part of the body or organs have inflection points and reach adult size at different ages, depending on the demands of the physiological and functional as well as its constituent components (Swatland, 1984, Sampurna at al. 2014).

Conclusion.

Body length in male and female Bali pigs at birth reached a point of inflection at the age of 8 - 9 weeks and reached adult size at the age of 32 - 34 weeks, whereas the maximum size that can be achieved are males 140 cm and females 138 cm. Chest circumference in male and female Bali pigs at birth reaching a point of inflection at the age of 6 - 8 weeks and reached adult size at the age of 46 - 51 weeks, whereas the maximum size achieved by males was 145 cm and 140 cm in females. Body weight in male and female Bali pigs at birth was 0.65 kg reaching a point of inflection at the age of 17 - 21 weeks and reached adult size at the age of 56 - 62 weeks, whereas the maximum size that were achieved at 138 kg in males and 136 kg in females.

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