Buletin Peternakan 43 (3): 184-187, August 2019

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

Bulletin of Animal Science

ISSN-0126-4400/E-ISSN-2407-876X Accredited: 36a/E/KPT/2016
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v43i3.40322

Growth patterns of Holstein Friesian Dairy Cow (FH) from Birth to First Child based on Mathematical Analysis of the Gompertz Model

Desi Ratnasari[1*], Afton Atabany[1], Bagus Priyo Purwanto[2], and Lia Budimulyati Salman[3]

[1]Department of Animal Husbandry Production and Technology, Bogor Agricultural University, Bogor, 16680, Indonesia
[2]Animal Husbandry Technology and Management Study Program, Vocational School, Bogor Agricultural University, 16151, Indonesia
[3]Department of Animal Husbandry Production and Technology, Padjadjaran University, Bandung, 45367, Indonesia

Article history
Submitted: 31 October 2018
Accepted: 30 July 2019

* Corresponding author:
Telp: +62 853 7563 8493
E-mail:
ratnasaridesi2627@gmail.com

ABSTRACT

This aims of this study was to estimate the bodyweight of FH dairy cows from birth to first child by knowing growth patterns and creating a standard curve for dairy cattle growth at BBPTU-HPT Baturraden dairy cow in Baturraden district, Banyumas Regency, Purwokerto, Central Java. Data obtained in the form of secondary data from births in 2005-2016 were 1437 tails and primary data were 353 tails. Data were analyzed using SAS 9.4 program with NLIN procedures (Non-Linear) using Gompertz models. The results show that the Gompertz models is easy in the calculation process with the data deviations that are close to the field of data and the models have a high degree of accuracy with the coefficient of determination (R^2) 99.83%. The conclusion of this study is that the resulting curve of the Gompertz model can be used as a standard growth curve of Friesian Holstein dairy cattle in Indonesia from birth to first calf.

Keywords: Friesian Holstein (FH), Gompertz model, Growth pattern

Introduction

The development of dairy farming in an area can be seen from the increase in livestock population, increased milk production and the quality of milk produced in the area. The current increase in the population of dairy cows with milk production is not yet comparable to domestic milk needs, so the amount of milk imports is still high. Consumed milk consumption per capita from domestic production (8708 kg/year) with a total population of dairy cows in Indonesia is 544791 (Animal Husbandry and Animal Health Statistics, 2017) .

Friesian Holstein (FH) cows come from the temperate provinces of West Friesland and North Holland *(temperate)* with four seasons namely spring, summer, autumn and winter (Blakely and Bade, 1991; Pane, 1986). The ability of FH cows to produce high milk with lower fat content compared to other dairy cows. The production of FH dairy cows in their home country reaches 6,000-8,000 kg/head/lactation, whereas in the UK around 35% of the total dairy cow population can produce up to 8069 kg/head/lactation (Arbel *et al.,* 2001). The nature of dairy cows is generally calm, docile and adaptable (Pane, 1986). FH cows is widely maintained in Indonesia both in the scale of companies and small farms.

The growth of a livestock is a collection of the growth of parts of each component that can be seen from the physical appearance and weight of his life. Hafez (1963) states that growth is a change in size, shape, composition and structure that normally will increase the size and bodyweight of animals. Lawrence and Fowler (2002) explain that growth is one of the main characteristics of every living thing. Low growth results in small-bodied FH cattle, inhibition of adult sex, delays in first breeding and low milk production (Toharmat and Suryahadi, 1997).

Growth curve is a reflection of the ability of an individual or population to actualize themselves as a measure of the development of body parts to the maximum size (adult) in the existing environmental conditions (Lawrence and Fowler, 2002). In general, growth in the form of sigmoid or "S". The "S" curve represents a form of acceleration and deceleration that is limited by turning points or inflection points. The inflection point is the maximum point of growth in bodyweight (Brody, 1974). This study aimed to determine the accuracy of a prediction model of Gompertz growth and bodyweight of dairy cows FH from birth to the first litter.

Materials and Methods

This research was conducted in August 2018 at the Center for Superior Livestock Breeding and Animal Feed Forage (BBPTU-HPT) Baturraden dairy cattle, Kemutug Lor Baturraden District, Banyumas Regency, Purwokerto, Central Java. Baturraden has a height of ±675 m above sea level (asl) (Soribasya, 1980). Average temperatures ran ge from 18-28ºC, humidity of 70-80% with rainfall of 6,000-9,000mm/year. The primary data used in this study were 353 female FH cows, newborns to 25 months of age and secondary data including: date of birth, birth weight, weaning age of a female child, weaning weight, age of first marriage, first birth weight, age of first child and bodyweight of first child. The tools used in the form of measuring sticks and tape measure Rondo.

Measurement parameters are: 1) Bodyweight, i.e. obtained from the weighing results or from the results of measurement of the circumference of the chest using a measuring tape then converted, in kg units. 2) Chest circumference (b), i.e. circle the chest cavity behind the shoulder joint *(os scapula)* , in units of cm (Kujoro *et al.,* 2009) (Figure 1). 3) Body length (a), starting from the edge of the humeral bone to the sitting bone *(tuber ischii)* , in units of cm (Kujoro *et al.,* 2009) (Figure 1). 4) Shoulder height (c), i.e., starting from the highest point of the shoulder *(os vertebrae thoracalis)* upright to the ground surface, in units of cm (Kujoro *et al.,* 2009) (Figure 1).

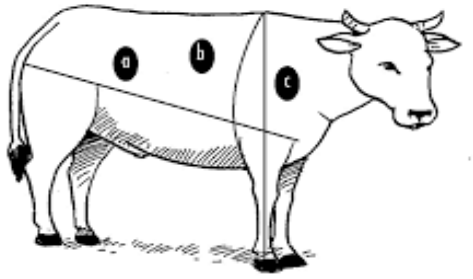

Figure 1. The parts of the body are measured in cattle . Symbols a (bodylength), b (chest circumference), c (shoulder height).

Data were analyzed using the SAS 9.4 program to obtain a growth curve model using the Gompertz model (Blasco *et al.,* 2002), with the form of a mathematical equation as follows:

$$Y = A \exp(- Be^{-kt})$$

Note: A = Adult bodyweight (asymptote); B = scale parameter (integral constant value); e = Basic logarithm (2.718282); k = average growth rate until the animal reaches the first breed; t = Time in units of months.

To estimate bodyweight and age at the time of inflection using the Gompertz model can be calculated with the formula:

Inflection weight = Ae^{-1}

Age of inflection = (ln B) / k

Note: B = Value of the parameter scale (integration constant); e = natural number (e = 2.718282); k = Average growth rate.

Result and Discussion

Results of growth curve analysis from birth to first calf, age and weight of the inflection point in FH dairy cows using the Gompertz growth curve model (Table 1). The results showed that the largest value of parameter A (adult weight) achieved using the Gompertz model (523.7 kg) was heavier than that of Anggraeni *et al.* (2008) in KPSBU Lembang with the average weight of cows when giving birth to the first 416.20 kg. This difference is due to different measurement times. Differences in the expression of dairy cow growth can also be caused by several factors including differences in climate, feeding, management and genetic ability of each animal. The Gompertz model in estimating adult weights has a low bias (Arango and Van Vleck, 2002). The k value is the rate of growth towards the first birth weight associated with the growth rate of FH dairy cows in the Gompertz model (0.0947). The graph of the Gompertz model is shown in Figure 2.

The growth curve shape describes the growth of livestock from birth to death, generally in the form of sigmoid or "S" which is limited by the turning point or inflection point (Brody, 1974). Lawrence and Fowler (2002) explain that growth patterns as a simple form with the highest growth rate occur in early life then increase slowly until they reach a constant when the cattle are old. In the growth curve there is an important point, namely the inflection point when it reaches puberty. The results of this study indicate that the inflection point was reached at the age of 7.6 months with a bodyweight of 192.66 kg. Lawrence and Fowler (2002) state that puberty in dairy cows occurs at 8-9 months with a gap between puberty and first mating 6-7 months. Folley *et al.* (1973) stated that FH cattle experienced puberty at the age of 8-12 months.

Comparison of the accuracy of the Gompertz model in explaining field data can be done by evaluating the overall difference between the field data and the data generated by the

Table 1. Equation models for the growth of FH dairy cows from birth to first birth

Model	Equation	$t_{(i)}$ (month)	$Y_{(i)}$ (kg)
Gompertz	$Y = A \exp(- Be^{-kt})$		
	$Y = 523.7 \exp(- 2.0628e^{-0.0947t})$	7.6459	192.6585

Note: t_i = time of inflection (month); Y_i = the weight at the inflection point (kg); e = natural number (e = 2.718282); t = recording time (month).

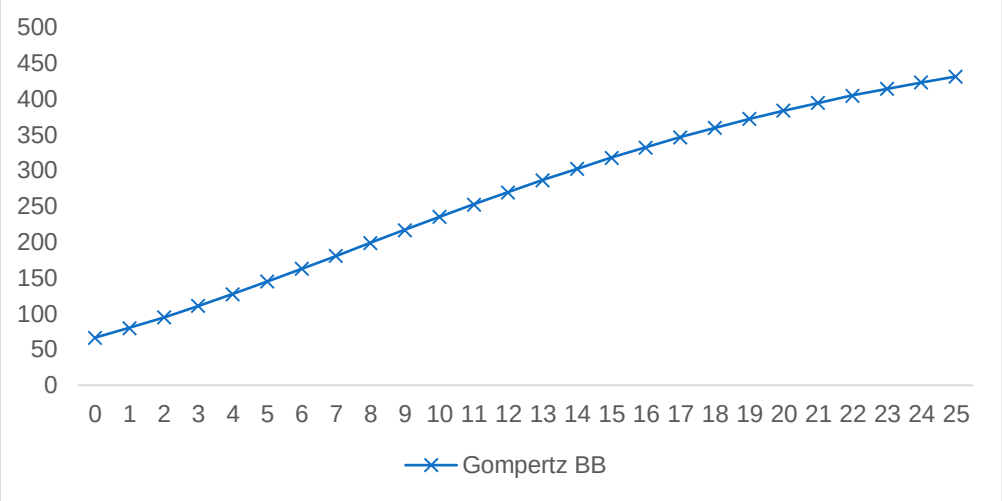

Figure 2. Growth curve of FH dairy cows from birth to first calf with the Gompertz model.

growth curve model parameters. The comparison could be done by using the parameter deviations of data in the form of determination coefficient (R^2). The coefficient of determination (R^2) using Gompertz growth model reaches 0.9983. Susilawati (2010) research results on Sumatran Composite sheep showed the coefficient of determination of the Gompertz model (97.35%) higher than other growth models. In accordance with the research of Nasri *et al.* (2008) on lactation dairy cows in Canada, that the coefficient of determination of the Gompertz model (85%) was higher. Lopes *et al.* (2015) states that the coefficient of determination in lactation dairy cows with the Gompertz model (68%) is higher than other growth models. The coefficient of determination is strongly influenced by the latest data on animal weighing. Comparison of data accuracy can also be seen from the number of iterations in the model. In this study, the number of iterations is small, ie 5. The more iterations are done, it means that the model is more difficult to achieve convergence. This is in accordance with research Budimulyati *et al.* (2012) with 6 iterations less than other growth models.

Conclusions

A mathematical model of a Gompertz is a simple model in the calculation of the number of iterations a bit and have a high degree of accuracy with the coefficient of determination (R^2) 99.83%. This curve can be used as a standard for the growth curve of Friesian Holstein dairy cattle, both on the scale of community farms and companies in Indonesia.

References

Anggraeni, A., N. Kurniawan, and C. Sumantri. 2008. Pertumbuhan pedet betina dan dara sapi friesian-holstein di wilayah kerja bagian barat KPSBU Lembang. Seminar Nasional Teknologi Peternakan dan Veteriner 2008. pp. 122-131.

Animal Husbandry and Animal Health Statistics. 2017. Animal Husbandry and Animal Health Statistics. Publisher of the Directorate General of Animal Husbandry and Animal Health Ministry of Agriculture, Jakarta.

Arango, J. A. and L. D. Van Vleck. 2002. Size of beef cows: early ideas new development. Genet. Mol. Res. 1: 51-63.

Arbel, G., D. Chalid, and M. E. Ensminger. 2001. Karakteristik Sapi Perah Fries Holland. Institut Pertanian Bobor Press, Bogor.

Blakely, J. and D. H. Bade. 1991. Ilmu Peternakan. Edisi IV. Universitas Gajah Mada Press, Yogyakarta.

Blasco, A., M. Piles, and L. Varona. 2002. A bayesian analysis of the effect of selection for growth rate on growth curves in rabbits. Genet. Sel. Evol. 35: 21-41.

Brody, S. 1974. Bioenergetics and Growth: with special reference to the Efficiency Complex in Domestic Animals. New York. Hafner Press. A Division or Macmillan Publishing Co, Inc. Pp. 489-493.

Budimulyati, L. S., C. Sumantri, R. R. Noor, A. Saefuddin, and C. Talib. 2012. Comparison on accuracy of logistic, gompertz and von bertalanffy models in predicting growth of new born calf until first mating of Friesian Holstein heifers. Journal of Indonesian Tropical Animal Agriculture. 37: 151–160.

Folley, R., D. L. Bath, F. N. Dickinson, and H. A. Tucker. 1973. Dairy Cattle Principles Practices Problems Profits. Lea and Febriger. Philadelphia.

Hafez, E. S. E. 1963. Symposium on growth: physio-genetics of prenatal and postnatal growth. J. Anim. Sci. 22: 779-791.

Kujoro, A., Sutarno, and O. P. Astirin. 2009. Bodyweight and statistic vital of Texel sheep in Wonosobo District by giving the ramie hay as an additional woof. Nusantara Bioscience. 1: 23-30.

Lawrence, T. L. J. and V. R. Fowler. 2002. Growth of Farm Animals. 2nd edn. CABI Publishing, Oxon, UK.

Lopes, S., J. France, N. E. Odongo, R. A. McBride, E. Kebreab, O. Alzahal, B. W. McBride, and Dijkstra. 2015. On the analysis of Canadian Holstein dairy cow lactation curves using standard growth functions. J. Dairy Sci. 98: 2701-2712.

Nasri, M. H. F., J. France, N. E. Odongo, S. Lopez, A. Bannink, and E. Kebreab 2008. Modelling the lactation curve of dairy cows using the differentials of growth functions. J. Agri. Sci. 146: 633-641.

Pane, I. 1986. Pemuliabiakan Ternak Sapi. PT. Gramedia, Jakarta.

Soribasya, S. 1980. Sapi perah. Jenis Teknik Pemeliharaan dan Analisa Usaha. Penebar Swadaya, Jakarta.

Susilawati, D. 2010. Pertumbuhan non linear, pendugaan heritabilitas dan nilai pemuliaan domba Komposit Sumatera (50% Local Sumatera, 25% st. Croix, 25% Barbados blackbelly). Tesis. Institut Pertanian Bogor, Bogor.

Toharmat, T. and H. Suryahadi. 1997. Pemberian ransum anak sapi dan sapi dara. Pelatihan Manajemen Pakan Sapi Perah untuk Tenaga Teknis Koperasi/KUD Susu. Kerjasama Fakultas Peternakan IPB-GKSI-CCA, Bogor.