GENETIC ANALYSIS OF REPRODUCTIVE TRAITS IN BALI CATTLE MAINTAINED ON RANGE UNDER ARTIFICIALLY AND NATURALLY BRED

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ABSTRACT

The aim of this study was to evaluate genetic analysis including heritability and further phenotypic and genetic trends of reproductive traits in Bali cattle. Reproductive traits studied were age at first calving (AFC), calving interval (CI) and pregnancy rate (PR). Data of reproductive traits were collected from Breeding Centre of Bali Cattle, Denpasar-Bali at the year period of 2000-2007. To evaluate the genetic analysis, heritability were estimated using the Mixed Model Least Squares and Maximum Likelihood procedure. The phenotypic and genetic trends were calculated using regression equation. Estimation of heritability for AFC, CI and PR were 0.22, 0.41 and 0.40, respectively. The phenotypic trend of AFC, CI and PR decreased at an average rate of 1.70 month, 10.4 days and 0.75% per year, respectively. The same pattern was showed for genetic trends for AFC, CI and PR decreased at 0.38 month, 4.25 days and 0.30% per year respectively in the same period. The heritability of reproduction traits in Bali cattle were considered as moderate to high (0.22-0.41) which means that the selection program will be more effective and efficient in improving the genetic merits in Bali cattle.

Keywords: heritability, age at first calving, calving interval, pregnancy rate, Bali cattle

INTRODUCTION

Beef cattle production is an important component of smallholder farming systems in Indonesia. Bali cattle (*Bos sondaicus*) are one of important local beef cattle breeds contributing to the development of livestock and devote meat production in Indonesia. The population of Bali cattle in Indonesia are recorded 3.271.000 in 2010 or more than 27 % of the total cattle population in Indonesia (Direktorat Jenderal Peternakan, 2010). The advantages characteristics of the Bali cattle breed are its high fertility, high meat quality, low fat percentage (Bugiwati, 2007), its survival and capacity to perform under poor environmental and climatic conditions in harsh dry land areas such as in eastern Indonesia (Tolihere, 2002). In beef cattle production such as Bali cattle, selective breeding mainly has been purposed to improve production trait such as average daily gain (ADG), growth rate and very rare in reproduction trait. However, reproduction trait appear most economically important in meat production whatever the production system. Economic losses from impaired reproductive traits such as fertility are main cause of the production loss as a result of prolonged calving interval, increased insemination costs, reduced return from calves born and higher replacement costs (Bagnato and Oltenacu, 1994). In fact, reproductive traits dramatically affect productivity. On the other hand, genetic improvements of reproductive traits are considered to be limited because of lower heritability. Heritability estimations for reproductive traits of different beef cattle breeds have been reported by several studies (Oyama *et al.*, 2004 Borman *et al.*, 2006; Goyace and Guiterez, 2001). Oyama *et al.* (2004) estimated heritability of reproductive performance in Japanese black cattle including age AFC, CI and days opens (DO) were 0.20; 0.05 and 0.05 respectively. Borman *et al.* (2006) obtained heritability of pregnancy rate for Angus cattle was 0.13. In another study, estimated heritability of

AFC, CI and gestation length in Spanish beef cattle Asturiana de los Valles cattle were 0.27, 0.12 and 0.15, respectively. However, information of genetic parameter such as heritability related to reproductive traits for Indonesia indigenous cattle such as Bali cattle are very rare because the expression of reproductive traits is often constrained by the management system employed and depends on the existing recording scheme used for the breed (Johnson and Notter, 1988; Meyer *et al.*, 1990). Therefore, the estimation of genetic analysis such as heritability and genetic trend for reproductive traits are important in designing appropriate breeding program aim at maximizing genetic improvement.

The aims of this study were to estimate genetic analysis of major reproductive traits including age at first calving, calving interval and pregnancy rate on Bali cattle in Breeding Centre of Bali province

MATERIALS AND METHODS

Data description

Data used in this study were collected from Breeding Centre of Bali cattle in Bali province during the period 2000-2007. The traits analyzed included: age at first calving (AFC), calving interval (CI) and pregnancy rate (PR). The records number of AFC, CI and PR were 138 heads, 96 heads and 450 heads, respectively. Detail of data structure according to traits studied with various classes and subclasses were described previously in Gunawan *et al.* (2011). Data available for AFC and CI were from year of 2001-2006, records for PR was available from 2000 to 2007 from artificial insemination and natural mating. The data structure is presented in Table 1.

Genetic analysis.

To evaluate genetic effect, mixed models were performed to calculate the heritability AFC, CI and PR which enable the implementation of additional random effect. In the heritability model, sire and dam were included as a random effect in the model which account for the genetic effect. The total variance and covariance components were sorted into additive and non-additive (environmental and residual genetic) components (Meyer, 1992).

$$Y_{ijk} = \mu + S_1 + D_{ij} + E_{ijk}$$

Where:

μ = common mean

S_i = effect of the i^{th} sire

D_{ij} = effect of the ij^{th} dam within the ith sire

E_{ijk} = uncontrolled environmental deviations associated with each record which is assumed to be random, independent and normally distributed with a mean 0 and a common variance

Heritabilities were estimated from dam and sire variance components, according to Becker (1992) as follows:

$$h^2 d = \frac{\delta^2 d}{(\delta^2 s + \delta^2 d + \delta^2 w)}$$

where:

h^2_d = heritability from dam component

δ^2_s = sire variance component

δ^2_d = dam variance component

δ^2_w = within progeny variance component

Standard errors for heritability estimation were approximated by the method of Becker (1992):

$$SE\ (h^2 s + d) = \sqrt[4]{\frac{\frac{2}{K_3^2}\left[\frac{MS^2 s}{s-1+2} + \frac{MSd^2}{d-s+2}\right]}{S^2 T}}$$

$$K_3 = \frac{1}{S-1}\left[\frac{N-\sum n^2 1}{n1}\right]$$

where:

MS_D = Mean square of dam

MS_s = Mean square of sire

Table 1. Structure Data for the Estimation of Genetic Analysis for Age at First Calving, Calving Interval and Pregnancy Rate in Bali Cattle

Structure of data	Age at First Calving (months)	Calving Interval (days)	Pregnancy Rate (%)
Mean	43.86	360.93	88.44
Standard deviation	0.70	4.47	1.51
Coefficient of variation (%)	18.81	12.13	36.19
Number of animals	138	96	450

d^2_T = Total variance
d = Number of dams
s = Number of sires
K_3 = Number of progeny per sire

The phenotypic and genetic trends for reproductive trait AFC; CI and PR were calculated by regression of average AFC, CI and PR and average predicted breeding values for the traits versus the dam's birth year (in the case of the reproductive traits) according to Filho *et al.* (2005).

$$Y = a + bX$$

where:
Y = AFC, CI and PR or breeding value
a = Intercept,
X = dam's birth year
b = the regression coefficient for Y on X

RESULTS AND DISCUSSION

Heritability and standard error for reproductive traits, age at first calving (AFC), calving interval (CI) and pregnancy rate (PR) are presented in Table 2.

Age at first calving

Heritability estimation for age at first calving (AFC) in Bali cattle was 0.26±0.07. The heritability estimation for AFC in this study correspond well with Oyama *et al.* (2004) who reported that heritability estimation of AFC for Japanese black cattle was 0.20. However, this value was higher than those usually found in literature for tropical cattle. Goyahce and Guiterez (2001) reported heritability of AFC for the Spanish beef cattle was 0.12. The mean heritability for AFC of cows calculated from 4 published papers was 0.10 (Koots *et al.*, 1994). The same authors reported that mean of calculated unweighed and weighed heritability for heifer compilled from 7 publication was 0.09 and 0.06, respectively. Nevertheless, available papers are scarce and usually based on small samples. Differences found among result are probably due to breed differences, statistical analysis (animal or sire models), selection pressure within population, sample size and environmental effect (Abdullah and Olutogun, 2006). The moderate estimated heritability for AFC observed in this study indicates that there is potential for improvement of this trait through selection. AFC is economically important because it determines when an animal commences its productive life and hence could influence lifetime productivity (Makgahlela *et al.*, 2008). A reduced age at first calving will increase the number of calves born for a given number of animals (Javed *et al.*, 2000). Morever, the reduction in age at first calving indicated an improvement in the genetic merit of this trait including managemental practices and nutritional management (Gunawan *et al.*, 2011).

Calving Interval

Estimated heritability in Bali cattle breed for calving interval (CI) was 0.41±0.09 (Table 2). Heritability value in this study was classified in high category because it was more than 0.4 (Noor, 2010). Heritability for CI in the present study was higher than those usually found in the literature. Koots *et al.* (1994) calculated an average heritability from four published paper was 0.01 and 0.06 for multiparous cows and heifers, respectively. Goyahce and Guiterez (2001) obtained heritability of calving interval was 0.27 in Spanish cattle. Pryce *et al.* (2000) calculated a CI heritability in British Holstein of 0.02. Haille-Mariam and Kassa-Mersha (1994) obtained heritability for CI in Boran cattle exploited in Tropical conditions was 0.07. Braga-Lobo (1998) estimated the heritability in Zebu cows was 0.14+0.01. High heritability values of CI indicated the existence of a relatively high additive genetic variable and therefore, a rapid genetic improvement of the management practice should be achieved (Estrada-Leon *et al.*, 2008).

Table 2. Estimated Heritability and Standard Errors for Age at First Calving, Calving Interval, and Pregnancy Rate in Bali Cattle

Traits	Number of Animal	V_A	V_E	V_P	$h^2 \pm SE$
Age at first calving (AFC)	138	0.627	10.459	11.086	0.26±0.07
Calving interval (CI)	96	154.04	1342.960	1497.00	0.41±0.09
Pregnancy rate (PR)	450	95.282	843.828	939.110	0.40±0.10

V_A=Variation of Aditif, V_E=Variation of Environment, V_p=Variation of Phenotype

High heritability values of CI suggests that selection on the basis of individual performance will be effective to decrease CI in Bali cattle. Calving interval is a trait of high economic importance and a reduction in CI could be described as one of the outcomes of improved fertility. Calving interval (CI) can be considered a good indicator of cow fertility because of the high correlation between CI and several direct measures of fertility (Olori *et al.*, 2002). Calving interval (CI) is the time between two successive calving. Thus, it is only available for cows from the second parity onwards. Since the CI is based only on the period between two calving, it can be computed from minimal data, but does not take information from the first parity or the end of a cow's life span into account. Calving interval is useful to measure the reproductive ability when there is no fixed breeding season and cows calve throughout the year (Rush and Groeneveld, 2001).

Pregnancy Rate

The calculated heritability for pregnancy rate of Bali cattle was 0.40±0.10. These estimates heritability of Bali cattle in this study was lower than the value obtained by Eler *et al.* (2001) which found that the heritability estimate of pregnancy in Turkeys cattle was 0.57 ± 0.01. Nevertheless, this result is higher than most previous estimation founded in some literature. Heritability for pregnancy rate has been reported to range from virtually zero to over 0.20 (Doyle *et al.,* 2000). Evans *et al.* (1999), in a single-trait analysis, obtained a value of 0.14±0.09 and, in a two-trait analysis with scrotal circumference, obtained a value of 0.24±0.12 for the Hereford breed. Moreover, Doyle *et al*. (2000) reported that heritability of pregnancy rate was 0.21 ± 0.01 for Angus breed. The estimated heritability of pregnancy rate was 0.10±0.09 in Canchim cattle. Borman *et al.* (2006) obtained that heritability of pregnancy rate was 0.13±0.07 in Angus cows. Higher heritability values recently of pregnancy rate may be attributed to the adopted analytical procedures, which may be more appropriate for the analysis of categorical data (Snelling *et al.,* 1995). The explanation for this difference is probably that all the results reported in the literature were obtained from populations of *Bos taurus* origin. Bali cattle breed (*Bos sondaicus*) has not yet been selected for precocity, and, therefore, its genetic variability appears to be much higher. High heritability values of pregnancy rate in Bali cattle suggest that selection on the basis of individual performance will be effective to achieve the increasing of pregnancy rate.

The Phenotypic and Genetic Trends of Reproductive Traits

The phenotypic and genetic trends for reproductive traits included AFC, CI and PR between 2000 and 2007 are shown in Figure 1 and 2, respectively. In general, there were decreasing phenotypic and genetic trend for AFC, CI and PR. There were consistent phenotypic trend for AFC, CI and PR over the years from 2003 onwards (Figure 1). The phenotypic trends of AFC and PR decreased obviously from 2003 to 2006 and there was decreasing trends for phenotypic trends for CI from 2003 to 2005. There were also decreasing genetic trends for AFC, CI and PR over the years. In general, there was decreasing genetic trends for AFC from 2002 to 2006 except for 2004. On the other hand, the genetic means of CI was sharply decrease in 2002 and 2005, but increase in 2004. Also, there was a decreasing trend for the genetic means of PR in 2001, 2003 and 2006, but

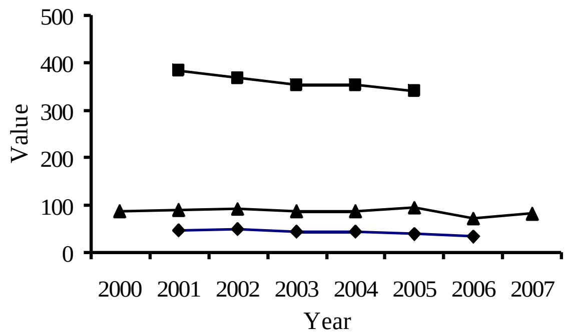

Figure 1. Phenotypic Trends of AFC, CI and PR of Bali Cattle. ♦: AFC, ■: CI, ▲: PR

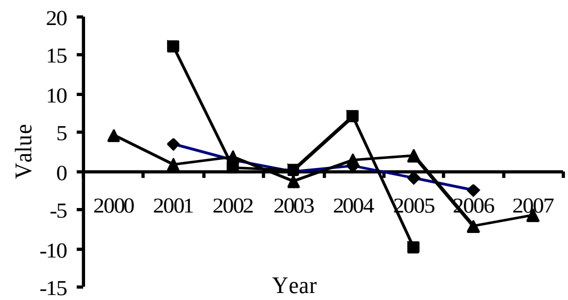

Figure 2. Genetic Trends of AFC, CI and PR of Bali Cattle . ♦: EBV AFC, ■: EBV CI, ▲: EBV PR

Table 3. Phenotypic and Genetic Trends of Reproductive Traits

	Regression Equation	R^2
Phenotypic trend	AFC = 48.9 -1.70x	50.7
	CI = 390-10x	84.8
	PR = 90.3-0.75x	18.9
Genetic trend	EBV AFC = 1.13-0.38x	50.7
	EBV CI = 11.9-4.25x	84.8
	EBV PR = 0.73-0.30x	18.9

increased in 2000 and 2005 (Figure 2). Phenotypically, AFC, CI and PR decreased at an average rate of 1.70 month, 10.4 days and 0.75% per year respectively. The same patterns were showed for average estimated breeding values (EBVs) of AFC, CI except in 2004 and PR except in 2004 and 2005 which indicated genetic trends. Mean breeding value for AFC, CI and PR decreased 0.38 month, 4.25 days and 0.30 percent per year respectively (Table 3)

The decreasing trend observed for AFC, CI indicated an improvement in the genetic merit of these traits (Gunawan *et al.,* 2011; Makgahlela *et al.,* 2008). This may be a part of correlated response to selection for increase daily gain. However, the decreasing trend for PR more fluctuation compared to AFC and CI. The fluctuation of values observed for pregnancy rate indicated that environment may play a great role in the ability of cow to become pregnant in the breeding centre (Gunawan *et al.,* 2011). A possible cause of this undesirable trend is intense selection to increase daily gain, without giving much attention on fertility. Reproductive traits showed no definite trend that indicated low degree of R^2 except CI for phenotypic and genetic trend. This result was in agreement with Chen *et al.* (2003) who observed very little genetic progress in reproductive traits. The low degree of genetic progress for the reproductive traits can be explained mainly by two factors. First, in this selection program, the greater emphasis was on the performance traits rather than on the reproductive traits. Second, these traits generally have a low heritability and this may slow down genetic progress. Chen *et al.* (2003) argued that the low rates of genetic trends were because breeders were not selecting them or that the selection applied was ineffective due to heritabilities. Based on a study of the reproductive traits of lines selected for performance traits, Kerr and Cameron (1995) pointed out that the estimates of genetic parameters could be biased for reproductive traits when measured in females selected based on other performance traits

CONCLUSION

Estimated heritability of reproductive traits in Bali cattle included age at first calving (AFC), calving interval (CI) and pregnancy rate (PR) were 0.22, 0.41 and 0.40, respectively. The heritability of reproduction traits in Bali cattle were considered as moderate to high (0.21 to 0.41) which means that the selection program will be more effective and efficient to improve the genetic merits in Bali cattle. The selection for AFC, CI and PR could improve female reproductive efficiency. Inclusion of both traits especially CI and PR in the selection criteria for Bali cattle program is recommended in order to achieve genetic merits of economical importance in reproductive traits. Better phenotypic performances in these traits may also be achieved through changes in Bali cattle management.

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