

Reproductive Performance of Indigenous Bali Cows in the Different Farming Management and Thermal Environment of Lombok Island Indonesia

Gita Shaofi Akma, L. Wira Pribadi, M. Yassin

Post Graduate Program in Livestock Resource Management, University of Mataram Jalan Majapahit 62
Mataram, West Nusa Tenggara, Indonesia

Abstract: *The reproductive performance of Bali cows in the hot (THI = 78.07) and cold (THI = 64.90) environment, were evaluated by measuring postpartum estrous interval (PEI), estrous periode (EP), pregnancy rate (PR), calving interval (CI), and pre-weaning mortality (PM) of 397 cows farmed under different catagories of management such as intensive, semi-intensive, traditional, and extensive. Data were taken directly by intensive observation. The results of the study showed, reproductive performance of Bali cows in Lombok Island, Indonesia, were affected by both management system and thermal environments of farms. Bali cow's farmed under intensive management in the cold environment showed best reproductive performance in which 36.3 d PEI, 19.9 h EP, 97.9% PR, 363.0 d CI, and 2.0% PM, whereas those of farmed under extensive management in hot environment showed lowest performance in which 45.4 d PEI, 16.5 h EP, 52.1% PR, 553.0 d CI, and 8.1% PM.*

Keywords: *Bali cows, reproductive performance, thermal environment, farm management*

I. Introduction

The Bali breed is one of the four existing indigenous cattle breeds (Aceh, Pesisir, Madura and Bali) in Indonesia, and, are the most predominant genotype within the eastern island, e.g. in West Nusa Tenggara province. The majority of these cattle are maintained traditionally, therefore, the growth performance is considered to be low. However, comparing to other breeds, Bali cattle have better adaptation abilities especially in marginal environment [1], high meat quality and low fat percentage [2], high fertility and calf each year over a long time [3], and have high heterosis effect in crossbred [1].

Reproductive performance of indigenous Bali cattle have been widely studied in West Nusa Tenggara province of Indonesia [50], but these studies have been carried out mostly in lowland environment areas and no report is available on the performance of the indigenous cattle in cold environment of hilly areas particularly in Lombok Island.

It was reported that thermal environment condition influenced the reproductive performance of local breed of cattles in Indonesia [6, 7, 50]. Thermal elements of the environment such as air temperature and humidity were the most importance aspects of cattle production environment, because of their direct effects on productivities [8]. In the tropical countries, the thermal environment is varied by altitude [9]. Indeed, low altitude (lowland) existing as hot environment, while the high altitude (highland) as cold environment.

In the semiarid climate, *Bos indicus* cow's showed superior reproductive performance than *Bos taurus* cows [10]. It means that reproductive performances of cattle is affected by environment conditions, since the other study reported that normally *Bos indicus* or Zebu type cattle or some tropical cattle breeds have inferior reproductive performance compared to *Bos taurus* breeds that normally originated from temperate regions [11].

Reproduction performance evaluation in cattle production is an important step in the management system to determine whether an herd in the farming system shows an efficiency in the biological cycle or give an economic benefit or not. In cattle, the low reproductive performance (fertility) will act as a barrier to economic exploitation [12, 7, 13]. Indeed, it is necessary to measure various parameters of fertility in order to evaluate reproductive efficiency.

Reproductive traits are lowly heritable [14, 15, 16], indicating that a large proportion of the variation is environmental. Therefore, it is important to evaluate factors influencing economically important traits in a diversity of environments to understand the production environment. Performances of a breed of cattle are not expected to be the same under all environments. Therefore, the breed should be evaluated under a variety of environmental conditions.

II. Materials And Methods

This study was carried out in the small-holder farms of cattle production which spread at two different thermal environment areas i.e. hot and cold environment of Lombok Island, West Nusa Tenggara province, Indonesia. These two different areas showed average daily temperature, relative humidity, and temperature-humidity index (THI) of 33.3 °C, 63.4%, and 78.07 for hot environment, and 21.5 °C, 87.6%, and 64.9 for cold environment, respectively.

A total of 397 Bali cows farmed under intensive, semi-intensive, traditional, and extensive farming management categories were used in this study, consisting of 210 cows in hot environment and 187 cows in cold environment. All of the cows were taken purposively based on some criteria such as 4 to 8 years of age, within the range of body condition score (BCS) 3 to 5, should be healthy, and last naturally mated within 2015. Both hot and cold environment animals were fed local forages with similar botanical and nutritional composition. Detail number of cows observed considering farming management categories and thermal environment are provided in Table 1.

Table 1. Number of observation by management and thermal environment categories of farms

Farming management system	Hot environment of farms	Cold environment of farms	Total
• Intensive	53	47	100
• Semi-intensive	66	50	116
• Traditional	55	51	106
• Extensive	36	40	76
Overall	210	187	397

Reproductive performance data as measured by post-partum estrous interval (PEI), estrous period (EP), pregnancy rate (PR), calving rate (CR), calving interval (CI), and pre-weaning mortality (PM) were observed directly. The term of response variables are as follows: postpartum estrous interval is the interval (days) from parturition to estrous; cows showing long PEI have low reproductive efficiency [7]. Calving Interval is the period of time between two successive calvings; it is the sum of the gestation period and days open period [12, 7]. Calving Rate is the percentage of cows served, which calve at term and have optimal chances of producing a living calf; this value might be lower than the conception rate determined during early pregnancy period because an average of 3 percent of abortions has to be occurred during pregnancy period [12]. Pre-weaning mortality is the percentage of animals dead between birth and weaning [17, 8].

Data were arranged in accordance to the location (thermal environment) and farm management categories. Analysis of variance and mean comparisons with least significance difference test were performed using SPSS program.

III. Results

The reproductive performance comprises Postpartum Estrous Interval (PEI), Estrous Period (EP), Calving Interval (CI), and Preweaning Mortality (PM) of indigenous Bali cows in the different farming management and thermal environment categories were shown in Table 2.

Table 2. Reproductive performance of Bali cows maintained under different farming management in the hot and cold environment of Lombok Island, Indonesia

Thermal Environment Categories	Farming Management System	Postpartum Estrous Interval (days)	Estrous Period (hours)	Pregnancy Rate (%)	Calving Interval (days)	Pre weaning Mortality (%)
Hot (THI=78)	• Intensive	41.4±5.7 ^a	20.6±1.8 ^a	92.2±3.8 ^a	370±21 ^a	2.9±0.2 ^a
	• Semi-intens	49.7±11.3 ^b	18.8±1.8 ^b	88.9±5.3 ^b	412±32 ^b	3.7±0.5 ^b
	• Traditional	46.3±14.8 ^c	20.3±1.6 ^a	90.7±9.7 ^a	390±36 ^c	3.5±0.3 ^b
	• Extensive	45.4±6.6 ^c	16.5±3.2 ^c	52.1±5.1 ^c	553±16 ^d	8.1±1.2 ^c
Cold (THI=64)	• Intensive	36.3±5.0 ^d	19.9±1.8 ^a	97.9±5.4 ^d	363±20 ^a	2.0±0.4 ^d
	• Semi-intens	37.0±10.3 ^d	18.4±2.0 ^b	91.5±5.0 ^a	382±26 ^b	2.7±0.4 ^a
	• Traditional	34.0±4.7 ^d	21.6±3.4 ^e	90.9±4.5 ^a	423±12 ^a	2.7±0.3 ^a
	• Extensive	38.4±11.3 ^d	14.6±1.7 ^f	65.7±5.7 ^e	508±28 ^c	11.3±2.5 ^b

Note: Means in the same column with different superscript is differ significantly (P<0.05)

3.1. Post-partum Estrous Interval (PEI)

Overall mean for PEI of Bali cows in the present study was 41.1±8.5 days. Thermal environment of farm area affected the interval significantly, but looked similar for Bali cows farmed under intensive, semi-intensive, traditional, and extensive management systems as shown in Fig.1. Bali cows farmed under cold environment showed shorter PPEI than those farmed under hot environment (36.5±8.3 vs 45.7±8.8 days).

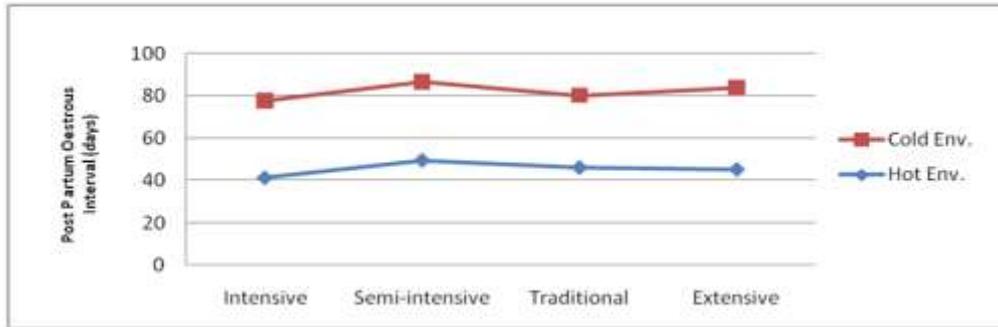


Fig. 1. Post partum estrous interval (days) of Bali cows maintained under different Farms management in the hot and cold environment

3.2. Estrous Periode (EP)

Indigenous cows in the present study showed EP in average of 18.8 ± 2.2 hours. This period is affected by management system of farm, but looked similar for the cows farmed in the hot (19.0 ± 2.1) and cold (18.6 ± 2.2 hours) environment as shown in Fig.2.

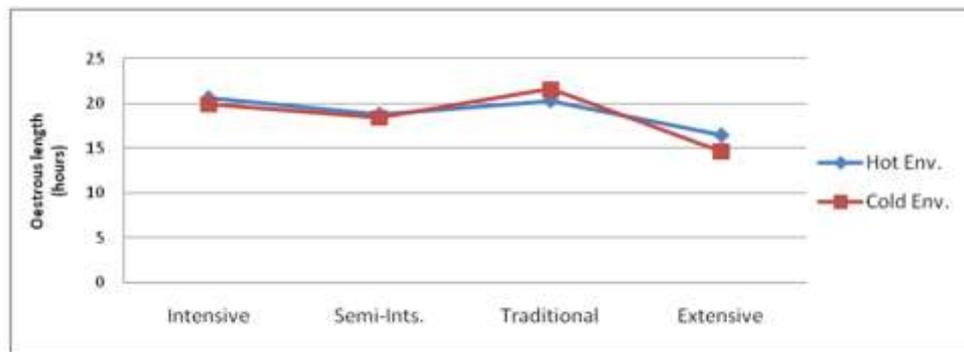


Fig. 2. Estrous periode (days) of Bali cows maintained under different management System in hot and cold environment of Lombok island, Indonesia

Bali cows farmed under extensive management have shortest EP both in the hot (16.5 ± 3.2) and cold (14.6 ± 1.7 hours) environment. However, those of farmed under intensive and extensive management was not different in EP each other.

3.3. Pregnancy Rate (PR)

Overall mean for PR of Bali cows in the present study was obtained 83.7 ± 5.6 %. Diagram in Fig.3 shown that the PR is affected by both management system and thermal environment of farm. Bali cows farmed in the cold environment (86.5 ± 5.2 % PR) tend to have higher PR than those of farmed in the hot environment (81.0 ± 6.0 % PR). Pregnancy rate was obtained significantly lowest for the cows farmed under extensive management both in the hot (52.1 ± 5.1 %) and cold (65.7 ± 5.7 %) environment.

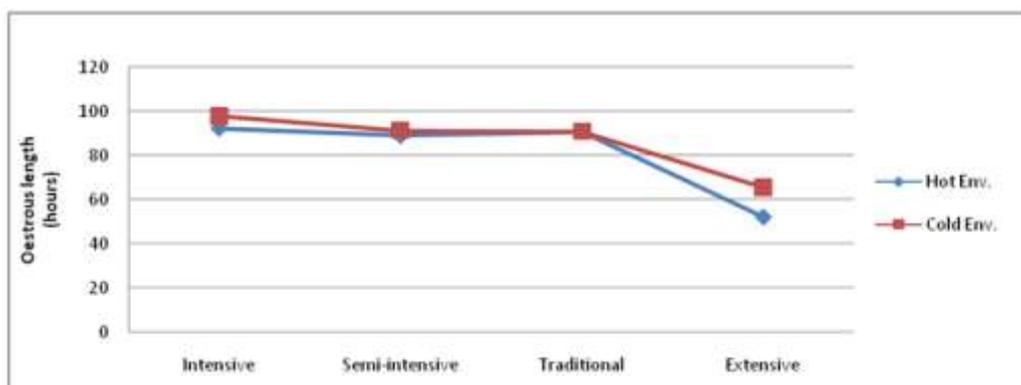


Fig. 3. Pregnancy rate (%) of Bali cows maintained under different management system in hot and cold environment of Lombok Island, Indonesia

3.4. Calving Interval (CI)

The mean CI of Bali cows farmed under intensive, semi-intensive, traditional, and extensive system in hot and cold environment, are provided in Table 2. The overall mean was obtained 418 ± 25 days. This interval is affected by both management system and thermal environment of farm, as can be seen in Fig. 4. Bali cows farmed under intensive management showed shortest CI, whereas those of farmed under extensive management showed longest CI, both in the hot and cold environment.

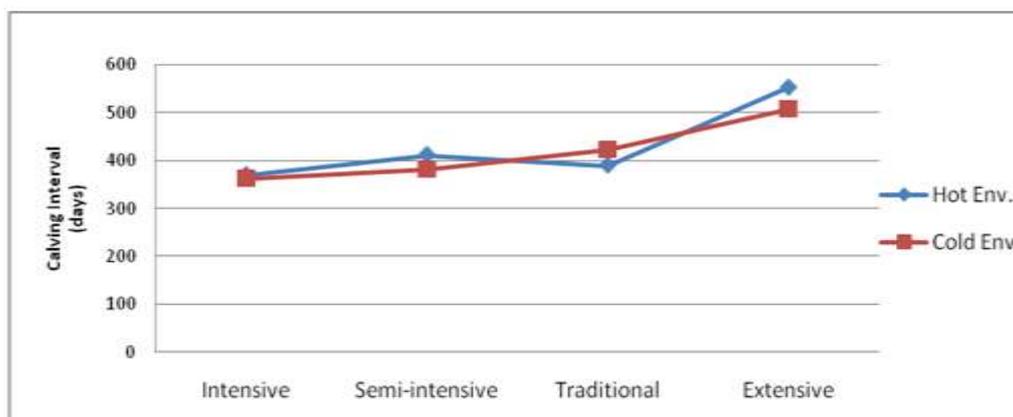


Fig. 4. Calving interval of Bali cows maintained under different farming management in hot and cold environment of Lombok island, Indonesia

3.5. Pre-weaning Mortality (PM)

Table 2 and Fig. 4 shows the effect of management and thermal environment of farm on the PM of Bali cows in Lombok Island, Indonesia. The results indicated that PM was significantly affected by both management and thermal environment of farms.

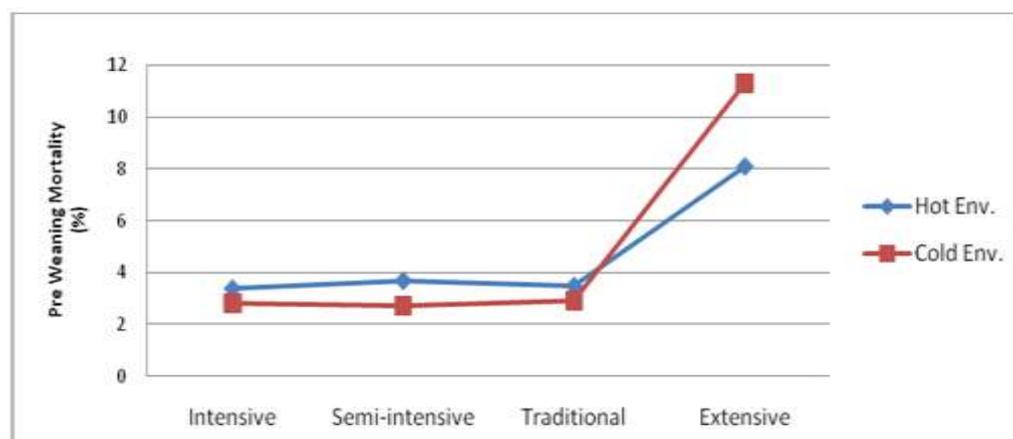


Fig. 4. Pre weaning mortality of Bali calves maintained under different farming management in hot and cold environment of Lombok island, Indonesia

The mean PM of 8.1 ± 1.2 and $11.3 \pm 2.5\%$ for hot and cold environment cows respectively, which were farmed under extensive management, was highest compared to those of 2.9 ± 0.2 and $2.0 \pm 0.4\%$; 3.7 ± 0.5 and $2.7 \pm 0.4\%$; 3.5 ± 0.3 and $2.7 \pm 0.3\%$ for the cows farmed under intensive, semi-intensive, and traditional management respectively. In contrast to the PM found for the cows farmed under extensive management, the mean PM of cows farmed under intensive, semi-intensive, and traditional management both in the hot and cold environment were looked similar each others.

IV. Discussion

Production system of indigineus cattles in the world was mostly carried out in a cow-calf operation, in which reproductive performance has long been recognized as the most important aspects of the system. Success in this operation depends to a large extent on the establishment of a year-round calving interval in cows. In order to achieve this interval, an optimum voluntary waiting period of 65 days is recommended followed by conception within 85 to 90 [19, 20, 50].

The mean post-partum estrous interval of 41.1 ± 8.5 days found in this study was counted short interval for indigenous cows in the world. This interval is extremely shorter compared to the interval reported for various indigenous cows, such as indigenous cows of Azad Kashmir 145.42 days [21], Indigenous cows in Bangladesh 108.46 days [22], Cholistani cows of Iran 130.90 days [23], local cows of Thailand 72 days [24], and indigenous cows in Tanzania 86.4 days [25]), and the other Indonesian indigenous cows which was found within range of 46-104 days [49]. Some other finding in PEI for Bali cows was reported in average of 40.3 days [50, 27, 28]. The shortest PEI in the present study is 34 days. This interval was found for Bali cows farmed under intensive farming management in the cold environment, but it was not different with those of farm under semi-intensive, traditional, and extensive management. Bali cows farmed in the hot environment was found to have 9.2 days longer PEI than those of farmed under hot environment. This longer PEI of the cows in hot environment might be due to thermal stress experienced by the animal because of high daily temperature (31.3°C) and THI (78.1) of the environment. High environmental temperatures may suppress estrus resulting in period of anoestrus which interfere with ovulation [29]. Heat stress lengthens estrous cycle and shortens estrus period (30)(Fuquay 1981), also causes loss of ovarian activity and conception, then, interval from parturition to first post partum estrous (PEI) may increase [31].

Furthermore, the average EP of 18.8 ± 2.2 hours for Bali cows in the present study is within range of 18-19 hours, the normal EP for tropical breed of cows [32]. This period was, however, slightly shorter than 20.3 hours EP reported for the breed in the similar farms condition [50, 27], but it was in agreement with 18.5 hours EP reported for the breed in Breeding Centre of Bali Cattle, Bali, Indonesia [18]. Management system of farm affect EP of Bali cows significantly, but looked similar for the cows farmed in the hot (19.0 ± 2.1) and cold (18.6 ± 2.2 hours) environment as shown in Fig.2. Bali cows farmed under extensive management have shortest EP both in the hot (16.5 ± 3.2) and cold (14.6 ± 1.7 hours) environment. This short EP of the extensive cows might be due to low energy intake experienced by the animal because of low energy level of feed consumed. However, those of farmed under intensive and semi-intensive management was not different in EP each other.

The overall mean of $76.5 \pm 5.6\%$ PR for Indigenous Bali cows in this study was within range of 57.10-96.00% PR for the breed in Breeding Centre of Bali Cattle, Bali, Indonesia [18]. Pregnancy rate was obtained significantly lowest for the cows farmed under extensive management both in the hot and cold environment. This low PR of the extensive cows might be due to low energy intake experienced by the animal because of low energy level of feed consumed. Moreover, the average PR of 81.0% recorded for the cows farmed in the hot environment was significantly lower compared to the average of 86.5% for those of farmed in the cold environment. The obtained average PR of 95.5% for intensive cows was higher than 88.4% reported for the breed in Breeding Centre of Bali Cattle in Bali province, Indonesia [49]. While the obtained average PR of 90.8% for the traditional cows was within the range of 88.3 to 93.6% PR reported for the similar management Bali cows [34], but it was lower than 97.6% reported for the breed in the same province [44]. Pregnancy rate varied from 75 to 95% between herds and from 65 to 100% between sires, with an overall pregnancy rate of 93% [35].

The recorded average CI of 418.0 days for Bali cows in the present study were slightly longer than 360.9 days reported for the breed in Breeding Centre of Bali Cattle in Bali province [18]. This was, however, related to the different proportion of intensive cows observed; this study observed 25% intensive cows, while the Breeding Centre of Bali Cattle in Bali Province observed 100% intensive cows. Besides, recorded average CI of 386.5 days for the traditional cows was shorter than 450.6 days reported considering the breeds in the similar farms management system [50]. The average CI among the indigenous and crossbred cattle in the tropical country was reported within range of 365-536 days [49]. There was an increase in CI from intensive (366 days) to extensive (530 days) farm management of cows observed, indeed the cows farmed under poorer management showed greater increasing index. This may be due to the more comfortable environment of the farms for the cows, where the animals have higher feed intake [37, 38] and of course higher energy intake [25], and using less energy for maintenance [39]. However, another study in indigenous PO cows that took place in East Java [7]. significant effects of management of farms on calving interval. Some other factors including the animal itself, farm management, nutrition, and other climatological aspects might be involved and could explain that different result.

The mean PM in the present study were in the range of 2.0 to 11.3%, with overall mean of $4.6 \pm 0.6\%$. It was, however, slightly lower than $7.8 \pm 1.5\%$ PM reported for Bali cows in Breeding Centre of Bali Cattle in Bali province [18], but it was extremely lower than 27.5% PM reported for crossbred cattle's in smallholder farms of Thailand [45]. It has been suggested that pre-weaning mortality rates of at least 30% is normal for cattle in the tropics [45].

Furthermore, pre-weaning mortality (PM) was higher in the hot environment than those in cold environment for intensive, semi-intensive, and traditional cows. Incontrast for those of farmed under extensive management. This suggested that the wide variation in thermal environment between those two different altitudes have significant effects on the calves and their dams during pre-weaning period. Thermal environment

can have a strong influence on pre-weaning performance of animals [49]. The recorded average daily temperature of 31.6 °C for lowland environment exceeded the comfort zone temperature range of 10 to 27°C for tropical cattle breeds [8], while the 24.5 °C for highland were within normal range; the recorded average daily THI of 79.2 for lowland was indication of thermal stress environment for beef cattle breeds, while the 69.4 for highland was considered to be a safety zone [44]. In relevance to this result, a previous study [45], it was in contrast with other study [18], who reported that the year did not show significant effect on that trait.

The highest levels of calf mortality recorded in this study occurred in newborn calves under extensive management in hot temperature of lowland environment. Noteworthy, the majority of calf mortality in smallholder farms is presumed to be caused in the dry season when feed resources are low in quality and quantity [69], leading to milk production of dams as low as 1.5 liter per day [49]. Moreover, poor suckling ability do to thermal stress may result in inadequate colostrum intake, thus, the most frequent causes for calf losses were poor immune-competence that may cause pre-weaning mortality [48]. Although pre-weaning mortality has been pointed out as a problem inherent to *Bos sondaicus* such as Bali cattle [18, 27], the pre-weaning mortality has also been reported as a problem in *Bos taurus* such as Angus, Hereford, Jersey, Holstein, Limousine, and Brown Swiss [49], and *Bosindicus* such as Brahman [48] and Ongole [7].

V. Conclusion

Reproductive performance as measured by postpartum estrous interval, estrous periode, pregnancy rate, calving interval, and pre-weaning mortality, were highest in Bali cows farmed under intensive management in the cold environment of highland. Whereas the lowest reproductive performance was in the hot environment of lowland and farmed under extensive management. Bali cows have a high chance to produce a calf a year, more than the others indigenous cows of Indonesia.

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