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Research Article

Reproduction Performance as a Basis for Selecting Female Balinese Cattle in Traditional Breeding in East Halmahera Regency

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Abstract | This research aims to know the reproduction performance of Female Balinese Cattle that are bred traditionally to improve their genetic quality. The results of the research show a decrease in the reproductive performance of Bali cattle in this area. Population data indicates a decrease in cattle performance, both in terms of quality and quantity. Hence, appropriate reproduction management is needed. In this case, direct measurement is carried out in the field, in addition to observation and interview with the breeders. The number of cattle involved is 230 cattle and aged more than two years old. Furthermore, their weight was measured using the Djagra formulation. The variables studied include Post Partum Estrus, Post Partum Mating, Calving Interval, and Weight by calculating the mean, standard deviation, and variety coefficient. The results further obtained that on average, the cattle first gave birth at the age of 32.97 months old had a Standard Deviation (SD) value of 1.03, had postpartum estrus of 44.66 days, had an SD value of 1.08, had postpartum mating of 45.13 days had an SD 0,026, and had a Calving Interval of 13.02 days, had an SD 0,65. This indicates that the reproduction performance is not optimal yet. Therefore, this research is beneficial for the related parties to improve the reproduction quality and cattle selection.

Keywords | Catlle, Female, Performance, Reproduction, Selection, Traditional

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INTRODUCTION

Success in the ruminant farming business lies in the management of the five livestock businesses namely seed and mating management, feed, disease/health, housing systems and marketing management (Fatmona and Gunawan, 2022). In this case, the most important factor in the post-breeding business is the seed and marriage factors. Balinese cattle a cattle that are domesticated from Bos Sondaicus breed (*bos banteng*). Theoretically, Balinese cattle are originally from Bos Sondaicus due to their type, character, and appearance similarity (Hasnudi *et al.*, 2016). Balinese cattle are originally from Indonesia and have been numerously bred by Eastern Indonesian breeders due to their high adaptation ability (Baco *et al.*, 2020). Balinese cattle are spread and breed by small-scale breeders in almost all Indonesian regions (Prasetya *et al.*, 2022).

Bali cattle (*Bos javanicus*) are domesticated cattle from banteng (*Bos bibos*) which have high potential genetic resources (1). The advantages of Bali cattle are fast breeding, easy adaptation to the environment, ability to life in critical land, and high carcass percentage (2), staying productive in low-quality feed, and good fertility (3). To improve the

genetic quality of the Bali cattle selection program can be performed (4) which relies on the growth characteristic. (Setiaji *et al*., 2022).

Body condition scores (BCS) describe the relative fatness of a cow through the use of a nine-point scale and is an effective management tool to evaluate nutritional status of the herd (Rasby *et al*., 2014). The body condition scoring system allows producers to visually assess their cow herd using a number system that objectively describes the amount of condition or fat reserve of an animal. In this case, Body Condition Score (BCS) is one of the most important factors that affect cattle reproduction and further affects the post-partum interval (PPI), conception level (CR), and calving interval (CI) in beef cattle (Lan and Kenas, 2022). The success of a cattle breeding business is significantly related to the reproduction performance and mortality level of the female and calves (Rusdi *et al*., 2016; Ketut *et al*., 2016).

The development of Bali cattle farming can be designed if it is carried out based on the carrying capacity of the area. Balinese cattle breeding can be developed based on the carrying capacity of the area. The regional government of North Maluku has determined livestock production centers (livestock development areas) according to each condition for livestock development, including the East Halmahera district (Fatmona, 2007). In this case, the area to be developed significantly depends on the carrying capacity, potential area size, local human resources, and the existing livestock commodities potential (Fatmona and Gunawan, 2022). For the breeders, especially those in rural areas, beef cattle are an important asset, which cannot be separated from the agricultural system they own. Breeders also use beef cattle to pull plows to work in the fields and other workers. Cattle are also a source of additional income and savings for the farmers' families which can be used whenever farmers need money.

One of the solutions in solving the problem in beef cattle population is by increasing and improving the performance of female cattle, considering their important role in population development. The performance of the cattle can be seen through several parameters including first calving, Post-Partum Estrus, Post-Partum Mating, Calving Interval, and Body Weight. Their performance can be improved by improving the feed, management and improving the genetic quality of cattle through artificial insemination technology. One of the problems in the society is the lack of identification of the reproductive performance of prospective Balinese female cattle to be inseminated (AI) (Irwansyah *et al*., 2021).

In this case, the novelty raised is that this study produces comprehensive data in East Halmahera Regency concerning the reproductive performance of Balinese cows breed traditionally. There has been no research regarding the reproductive performance of Balinese cows which were assumed to have experienced a decline in reproductive performance, so the results of this research are expected to be the basis selection and treatment to overcome these problems.

The objective of this research was to determine the performance of Balinese cattle breed traditionally with several parameters, including first calving age, post-partum estrus, post-partum mating, calving interval, and body weight.

MATERIALS AND METHODS

This research site is East Halmahera Regency, North Maluku, Indonesia in three districts, namely Maba, South Wasile and North Maba Cities, which were determined through purposive sampling. This study was carried out or ninety days (three months) from May to July 2019. In this case, Balinese cattle was employed with the criteria that the cattle aged above two years old by looking at the teeth shape, then body measurements such as body weight using the jagra method, as well as body length, gumba height, and chest circumference using references (Heryani *et al*., 2018). Meanwhile, the measurement of first calving age, post-partum estrus, post-partum mating, and calving interval was conducted through interview and questionnaires distribution to 70 small-scale breeder families who own the livestock mentioned above. The age determination of the female cattle is carried out by looking at the composition of the number of incisors' changes (source: Yuliantika *et al*., 2016) in Figure 1.

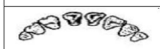
	The age of 1 month old has 2 or more incisors, and the central incisors appear in the first month.
	The age of 1-2 years old, the companion central incisors (I1) are replaced by permanent teeth (I1). Within 2 years, the central permanent tooth (I1) reaches full development.
	The age of 2- 2.5 years old, intermedial incisor teeth (I2) are replaced by permanent intermedial teeth (I2). Full development is generally at 3 years old.
	The age of 3-3.5 years old, the second or lateral companion intermedial teeth (I3) is replaced by the second permanent intermedial tooth (I3). The intermediate starts to experience wear and tear at the age of 4 years old.
	The age of 4-4.5 years old, the corner teeth (I4) are replaced by permanent teeth (I4). By the age of 5 years, the corner teeth are generally fully developed.
	The age of 5-6 years old, the permanent teeth (I1) are even, the intermediate pair are partly even, and the corner teeth start to look smooth.
	The age of 7-10 years old, nI1 shows significant wear, and at the age of 10 years I4 starts to show significant wear.
	The age of 12 years old, the curved corners are not visible and have a clear triangular shape indicating increasing age.

Figure 1: Age determination based on cattle teeth composition.

Next, the variables were measured: First calving age of cows, post partum estrus, post partum mating calving interval using the interview method with 70 traditional breeders

using a questionnaire. The respondents' criteria include: Natural livestock mating system, The natural mating system determines the research respondents using the criteria of breeders who have female Balinese cattle and have more than three years of breeding experience. The body length and gumba height was measured using a measuring stick (caliper), while chest circumference was measured using a butterfly brand measuring tape, and other equipment such as recording tools such as pens, camera paper and others.

The measurements of cows include the following: Body weight measurements follow the Djagra formula, namely measuring body weight based on calculations of body measurements quoted in the article (Heryani *et al.*, 2018) dengan as follows:

Meanwhile, the cattle measurements also include the body weight measurements based on Djagra formula (Yuliantika *et al.*, 2016) as follow:

Data analysis

$$\text{Body weight (kg)} = \frac{\text{Body Length (cm)} \times (\text{Chest Circumference})^2}{1104}$$

The cattle measurement shall be carried out when the cattle is in a normal standing position and the legs support the body in a balanced manner. In this case, the measurement was done using the method proposed in article (Heryani *et al.*, 2018) and (Galib *et al.*, 2017). The measurements of the body sizes are seen in Figure 2.

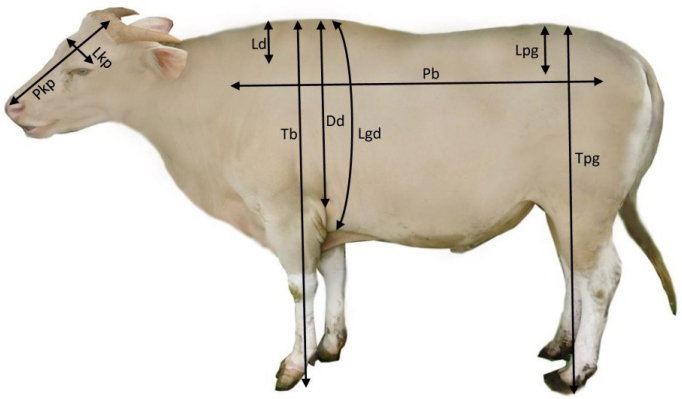


Figure 2: Body measurement method for cattle Ld = chest width, Tb = body height, Dd = chest depth, Lgd = chest circumference, PB = body length, Lpg = hip width, Tpg = hip height).

The calculation of the average, standard deviation, and coefficient of diversity based on Steel and Torrie (1993) uses the following equation.

Average

$$\bar{X} = \frac{\sum_{i=1}^{N} x_i}{N} = \frac{X_i + X_i + X_i + \cdots + XN}{N}$$

Description: $\bar{X}$= Average, X_i = ith data, N= Amount of data.

Standard deviation

$$SD = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N-1}}$$

Description: SD= Standard deviation, X_i= ith data, $\bar{X}$= Average, N= Amount of data.

Coefficient of diversity

$$KK = \frac{SD}{\bar{x}} x\ 100$$

Description: KK = coefficient of diversity, SD= standard deviation, $\bar{X}$= average value.

Research area

East Halmahera Regency is located in North Maluku, Indonesia and formed by Law no. 1 of 2003. Astronomically, East Halmahera Regency is located between 00^{0}40'-01^{0}04' North Latitude and 126^{0}45'-129^{0}30' East Longitude with total area of 6,538.10 km^2 consisting of 10 districts and 104 sub-districts or villages. The largest district is South Wasile by 1,175.48 km^2, while the smallest district is Wasile by 337.32 km^2. Data on each district area in the Regency are as follow.

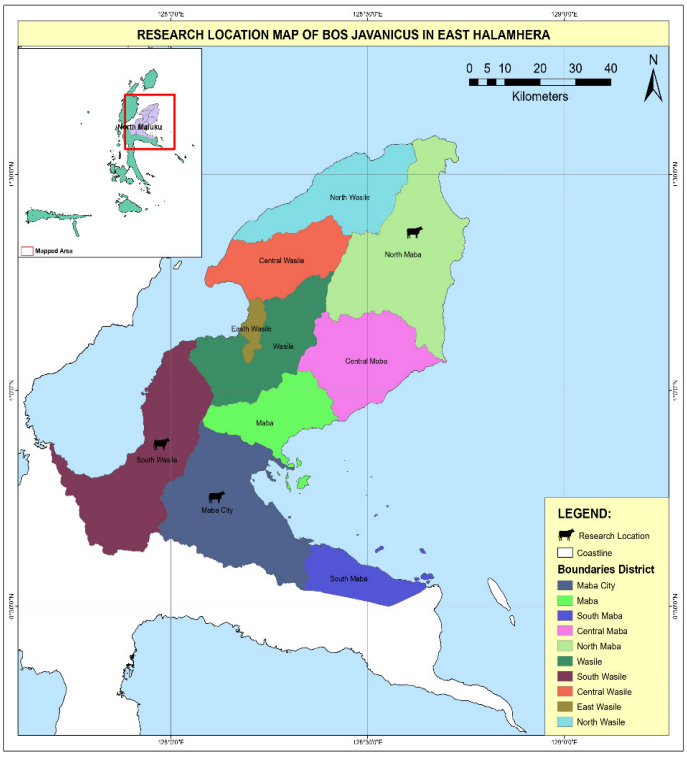


Figure 3: Map of research location in east Halmahera Regency, North Maluku, Indonesia.

In general, the area of East Halmahera Regency varies, from lowlands along the coast to highlands in the mountains. The altitude of areas in East Halmahera Regency also varies. The lowest altitude is in South Wasile District with

an area height of 8 meters above sea level, while the highest altitude is in Central Maba District with an area height of 82 meters above sea level.

RESULTS AND DISCUSSION

First calving age

Bali cattle in East Halmahera Regency have an average maternal age of 5.44 years has a fairly good Standard Deviation (SD) value of 0.28 and an average first calving age of 32.97 months, has a Standard Deviation (SD) value 1,03, which ranges from 30 to 36 months with a percentage of 88.3%, so the average first calving age is 33 months. Meanwhile, those aged more than 36 months is at the percentage of 11.7% of 230 respondents. Compared to the other research, this region is slower than West Java, which is 31.48 months (Wimbavitrati *et al*., 2020). Hence, it is necessary to carry out artificial insemination to improve production performance. Contribution to the development and application of artificial insemination (AI) in beef cattle is very important to improve genetics and livestock productivity (Pernas *et al*., 2023). Other factors in livestock selection are also important, such as genomic and phenotypic selection criteria are very important (Guti *et al*., 2023).

The advantages of Bali cattle, especially their productivity, are quite high. This can be seen from several indicators of productivity, including birth weight, weaning weight, adult weight, rate of increase in body weight, as well as reproductive characteristics such as sexual maturity, puberty age, calving interval, and percentage of births. Bali cattle also have the advantage of a high level of adaptation (Zafitra and Gushairiyanto, 2020). In addition, other indicators, such as production and reproductive characteristics, are very important and economical that can be used as selection parameters (Fatmona and Putranti, 2021).

Based on the research data in this first sub-discussion, namely the age of the mother, the age at first calving and the weaning age of Bali cattle in this region, it is important to serve as a reference or have implications in other places, that the importance of this data is so that we can know and select livestock whose performance It is good to use as a further nursery and try to overcome the problems experienced by Balinese livestock parents, for example management and environmental problems.

Female Balinese Cattle Performance in East Halmahera Regency is shown in Table 1.

Aspect of female cattle reproduction

Reproduction is a process to produce new individuals. This can occur sexually and asexually in animal. The asexual reproduction process will occur through division, fragmentation or budding, while sexually it begins with the formation of gametes, fertilization and embryo development until a new individual appears (Mastrodonato *et al*., 2022). Reproduction in female livestock is a complex process that will involve the entire animal's body. The reproductive system can function if female livestock have entered sexual maturity. The reproductive aspect variables of Bali cattle breeds consist of post partum estrus, post partum mating, calving interval which are discussed in the following sub-chapter.

Post-partum estrus of female balinese cattle in east halmahera regency

Post-partum estrus (PPE) was obtained by determining the time span between the calving and the first estrus after giving birth (Riyanto *et al*., 2017). The time span between calving and first estrus ranges from 50 to 60 days or 1.5 months – 2 months. The expected time for uterine involution in cattle ranges from 30 to 50 days or 1 – 1.5 months. Estrus involution generally occurs before the first estrus period after parturition (Riyanto *et al*., 2017). The cause of the high PPE is believed to be because the estrus period occurs after giving birth and breeders are not careful in detecting the estrus. Breeders cannot distinguish estrus specifically; they only pay attention to estrus through behavior and sounds. Genuine estrus is clearly described by the vulva and vagina being enlarged and reddish in color as well as discharge from the vagina (Riyanto *et al*., 2017).

Table 1: Age, first calving age, and weaning age.

No	Variable	Average	N	Standard deviation	Coefficient of diversity (%)
1.	Age (years old)	5.44		0.28	5.14
2.	First calving age (Months)	32.97		1.03	3.12
	a. 30-36 month		203		
	b. > 36 months		27		
Total			230		
3	Weaning age (Months)	6.01		0.83	13.80
	a. 6-8 months		3		
	b. > 8 months		227		
Total			230		

Table 2: Post-partum estrus, post-partum mating, calving interval of Balinese female cattle in east Halmahera regency.

No	Variable	Average (days)	Amount of sample (Cattle)	Standard deviation	Coefficient of diversity (%)
1	Post-partum estrus (days)	44.66	N	1.08	2.43
2	Post-Partum Mating (days)	45.13	N	0.026	0.06
3	Calving Interval (days)	13.02	N	0.65	4.97

Description: Amount of sample N=320.

Results of previous research show that the average Post-Partum Estrus (PPE) of Balinese cattle in East Halmahera is 44.66 days, according to the standards, the Standard Deviation value is quite good, 1.08. It takes longer compared to the results of previous studies ranging from 28-43 days. It was stated (Laksmi *et al*., 2019) that the average time of first and second ovulation of primiparous cattle is 27.67 and 47.67 days postpartum, while the average time of first and second ovulation of pluriparous cattle is 28.33 and 43.33 days postpartum. This showed a correlation between body condition scores and hormone levels, namely Leptin levels of 0.861; LH level of 0.960; FSH level of 0.799; and Estrogen level of 0.761 (Laksmi *et al*., 2019).

There is a need to address reproductive performance problems caused by genetic or seed factors as well as environmental factors, for example feed factors, temperature and humidity factors, as well as artificial insemination management factors.

Poor reproductive performance is one of the most common reasons for the slaughter of female cattle (Temesgen *et al*., 2022).

One effort to improve the reproductive performance of cows is artificial insemination (AI), which has been widely used to increase productivity and improve genetic quality. (Ramadhan *et al*., 2022). Efforts to detect methods from the start of pregnancy are an important management factor in cattle reproduction and production programs (Yakobus *et al*., 2023). In the previous research, during the first ovulation, all cattle do not show any signs of estrus. However, in the second ovulation 2 primiparous cows and 1 pluriparous cattle show less obvious signs of estrus, 1 primiparous cattle and 1 pluriparous cattle show moderate signs of estrus, and 1 pluriparous cattle show clear signs of estrus (Yuliantika *et al*., 2016).

The average duration of pregnancy is 324.2 days, the first calving age is 3.7 years, calving period is 1.1 times, calving interval is 467.1 days, and post-partum mating is 128.5 days The condition of low postpartum estrus is also influenced by the amount of nutrients in the ration, where the higher the protein, the better the reproductive performance. In this case, the protein levels increases natural estrus by 66.05% and produce natural mating by 91.65% (Sonjaya *et al*., 2020). Estrus needs to be synchronized to improve the reproductive performance of cattle, in Madurese cattle, it affects the form of estrus symptoms and pregnancy (Luthfi and Efendy, 2019).

Post-partum mating of Balinese cattle in East Halmahera Regency

Parity is a period in the animal reproductive cycle process that shows the number of births of the parent animal. Parity can provide an idea of the cow's actual physical maturity. Primiparas or mother cows that have experienced one parturition have a physical maturity level of around 82-90%, meaning that the mother cow has not yet reached optimal growth levels (Muslimin *et al*., 2022).

Post-Partum Mating (PPM) is the time interval between the first mating and calving (Riyanto *et al*., 2017). Female cattle should be bred 60–80 days or 2–2.5 months after calving because it takes a minimum of 50–60 days or 1.5–2 months to achieve complete uterine involution in the female cattle (Setiawan *et al*., 2021). This aims to ensure that breeders do not wait for the next estrus which will increase the maintenance costs if they are not mated and produce offspring immediately. Previous research showed that post-partum mating took too long due to delays in mating after giving birth. In general, post-partum estrus (PPE) was delayed due to inaccurate detection of estrus by breeders (Muslimin *et al*., 2022).

The average Post-Partum Mating (PPM) in East Halmahaera Regency is 45.13 days, ranging from 30 to 90 days of 230 female cattle. Post-Partum Mating is greatly affected by Post-Partum estrus and the estrus detection accuracy by breeders. The data involved in this research are lower than previous research data, where there was an emergence of post-partum estrus in less than or equal to 3 months in the highlands. This is statistically higher (80%; $p < 0.05$) compared to cattle in the lowlands (20%). Estrogen levels in post-partum estrus were 502.84 ± 232.20 pg/ml and 272.95 ± 184.43 pg/ml in the highlands and lowlands, respectively, showing statistically significant differences ($p<0.05$). The increased post-partum estrogen levels that occurred every month in the two groups showed a significant difference ($p<0.05$). It can eventually be concluded that Balinese cattle raised in the highlands show better reproductive performance than those in the lowlands

(Pemayun *et al*., 2020). The reasons might be in the forms of low reproductive rate and others (Hamid, 1975). One of the important goals of cattle breeding is to increase the lifespan of cattle, which is also most important economic traits (Strapáková *et al*., 2023). Hence, these cattle need intensive reproductive management (Praxitelous *et al*., 2023). Meanwhile, cattle parasites live inside or on the body of beef cattle (Strydom *et al*., 2023).

Calving interval of Balinese female cattle in east Halmahera regency

The research results on the calving interval show above 13 months. In terms of time efficiency, it is detrimental to farmers. Calving interval is the distance between one calving to the next calving. The optimal calving interval is around 12 months or 365 days (Ananda *et al*., 2020), with a pregnancy period of nine months and a breastfeeding period of three months (Atha *et al*., 2020).

Previous research results showed that in female cattle, the first mating age is 26.87 months, the S/C value is 1.64, re-breeding after calving is 4.52 months, weaning age is 3.97 months, calving interval is 14.32 months, and the calving rate in the population is 45.5%. The reproductive efficiency value obtained was 91.8%, the natural increase was 44.68%, the net replacement rate for males and females was 1,207% and 253% respectively and the potential output is 44.11% (Rohyan *et al*., 2016). It was further stated that the highest and lowest average duration of pregnancy was 235 days and 224 days, respectively. The highest and lowest average S/C is 5.5 times and one time. The average calving interval in Senggreng, Trenyang, Sambigede and Jatiguwi villages is 440 days, 399 days, 420 days and 403 days. In addition, the number of pregnant cattle in the first AI, second AI, and more than the second AI was 27 cattle, 32 cattle, and 24 cattle (Yuliantika *et al*., 2016).

Calving Interval (CI) is the period of time between one calving and the next. Calving records are directly related to the calving period. The shorter the calving period, the more ideal the number of children conceived within the calving period. The calving interval will be shorter when estrus appears quickly after calving (Budiyanto *et al*., 2023).

The best calving interval (CI) is one year that is nine months of pregnancy and ninety days of breastfeeding. Theoretically, it would be good if a female cattle can produce one calf every year. The long Calving interval value is caused by the length of the Open Days, which is caused by calf who are not weaned (Prasetiyo *et al*., 2015). The average calving interval of the Balinese cattle in East Halmahera Regency, North Maluku is shown in Table 3.

Table 3: Average of calving interval in 320 female Balinese cattle.

Calving	Body condition score	Mating system	Average calving interval (months) Average ± KK
1	3	Natural	13.02± 1.54
2	3	Natural	13.00± 1.49
3	3	Natural	13.03±1.42

To achieve a calving interval of 12 months, a female cow must be pregnant again at maximum of 85 days after the previous calving so that the calving interval can be optimal (Juliantari *et al*., 2021). The calving interval is often used as a measure of reproductive efficiency, because a long calving interval can be detrimental to the farmer and indicates poor reproductive function so that fewer calf are produced during the productive period. The results of the research sub-discussion of Post Partum Estrus, Post Partum Mating, Calving Interval of Bali Cattle in this region are important to be used as a reference or have implications in other places, that the importance of this data is so that we can know and select livestock that perform well which will be used as seeds for subsequent breeding and trying to overcome the problems experienced by Balinese parent livestock, for example management and environmental problems.

Body weight of female Balinese cattle in east Halmahera regency

Based on the research results conducted in East Halmahera, the average weight of Balinese cattle is 264.77 kg, with an average chest circumference of 154.38 cm, an average body length of 122.35 cm, and a gumba height of 113.53 cm. Compared to the body morphology of cattle in other areas, especially on Java island of Java, the cattle in this area is smaller. In addition to reproductive problems, many other factors also cause low performance, including feeding problems, inbreeding and disease management. The desired birth weight standard in the selection program is important to prevent the occurrence of dystocia (Said *et al*., 2020).

The results of previous research showed that the highest estimated weight of adult males and females in Jatiguwi village is 340.40 kg and 352.31 kg, respectively (Prafitri *et al*., 2022) Among the cattle slaughtered, the highest weight is in the 300-400 kg weight category. Based on the research, external traces were found on 2 cattle (1%) of 200 cattle observed at the Denpasar city slaughterhouse (Yuliantika *et al*., 2016). The birth weight and calving interval are productivity traits that can be improved by selection programs. However, the desired birth weight standard in the selection program is important to prevent the occurrence of dystocia There is no significant difference in reproductive performance between working and non-

working cattle (Suteky, 2009). Furthermore, the average body size of female cattle in East Halmahera Regency, North Maluku is presented in Table 4.

Table 4: Average, standard deviation and coefficient of variation in body length, gumba height and chest circumference of Female Balinese Cattle in East Halmahera Regency, North Maluku.

Variable	Amount of cattle	Average	Standard deviation	Coefficient of diversity
Body weight (Kg)	N	264.77	3.27	1.24
Chect circumference (cm)	N	154.38	2.06	1.33
Body length (cm)	N	122.35	1.60	1.31
Gumba height (cm)	N	113.53	2.01	1.77

Description: Amount of sample N=320.

Selection is an effort to improve the genetic quality of a livestock population. The selection response that occurs depends on the intensity of selection, heritability and standard deviation of the selected traits. The standard deviation of the characteristics or performance of the selected cattle will show the diversity in the population, which is known as the coefficient of diversity. The most effective selection to improve the genetic quality of Balinese cattle is based on the chest circumference compared to others (DA *et al*., 2017). Morpho Metrics are studies related to variations and changes in livestock body size and are useful for identifying and describing livestock potential quantitatively (Sumaryadi *et al*., 2021).

Data on the weight of Bali cattle in this area is important to use as a reference or have implications in other places. The importance of this data is so that we can find out and select cows that perform well in terms of body weight for further breeding and try to overcome the weight problems experienced by mother cows.

Low body weight can also be affected by diseases other than feed and management. Previous research generally found enzootic pneumonia in calves and young cattle (Poonsuk *et al*., 2023). Diseases can also reduce production, one of which is bovine interdigital phlegmon (IP), an infective bacterial disease due to lesions in the interdigital skin (Celani *et al*., 2023).

CONCLUSIONS AND RECOMMENDATIONS

Based on the research results, it can be concluded that all variables studied in mother cows such as age at first calving, post partum estrus, post partum mating, calving interval and body weight of Bali cow mothers at this research location are relatively poor when compared to mother cows in other areas in Indonesia, especially on the island of Java. This research is very useful and can be applied in other places regarding reproductive performance as a basis for selecting and improving the reproductive performance of Bali cattle among breeders with traditional rearing systems in the area.

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NOVELTY STATEMENT

In this case, the novelty raised is that this study produces comprehensive data in East Halmahera Regency concerning the reproductive performance of Balinese cows breed traditionally.

AUTHOR'S CONTRIBUTION

SF: Conceptualization, data curation, formal analysis, investigation, methodology, writing original draft. SU: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, writing original draft, writing review and editing. Gunawan: Conceptualization, funding acquisition, investigation, methodology, project administration.

Conflict of interest

The authors declare that they are not aware of any competing financial interests or personal relationships that may exist influence the work described in this paper.

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