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Research Article

Forages Supplies and Effects on Growth Performance, Birth, Mortality, and Natural Increase of Bali Cattle at Breeding Center in Pulukan, Bali

Roy Malindo[1], Anuraga Jayanegara[2], Osfar Sjofjan[3], Siti Chuzaemi[3]*

[1]Directorate General of Livestock and Animal Health Services, Ministry of Agriculture, Jl. Harsono RM No.3, Ragunan, Pasar Minggu, Jakarta Selatan, 12550, Indonesia; [2]Department of Nutrition and Feed Technology, Faculty of Animal Science, Bogor Agricultural University Jl. Agatis, Kampus IPB Darmaga Bogor 16680, Indonesia; [3]Faculty of Animal Science, Universitas Brawijaya, Jl. Veteran, Malang, East Java, 65145, Indonesia.

Abstract | This study aimed to evaluate the dry matter supply from both forage and concentrate and the average daily gain of Bali cattle at the breeding center in Pulukan, Jembrana Regency, Bali Province. This study used an analytical survey approach. Data collection consisted of interviews and observations based on a questionnaire. The observed forage land area was 96.5 ha, including cropland of 26.5 ha and pasture of 70 ha. A total of 760 Bali cattle were observed to determine weight gain. The collected data were tabulated and analyzed using descriptive statistics and analysis of variance (ANOVA) using general linear model (GLM) was carried out using SAS OnDemand for Academics (ODA, Cary, NC, USA). The results indicated that the average dry matter supply was 49.6% of the cattle requirements, with 21.8% derived from forage and 27.8% from concentrate. The average daily gain was 0.4 kg/head/d, with males gaining 0.4 kg/head/d and females 0.3 kg/head/d. Based on age, the average daily gain of calves, young, and adults was 0.4, 0.3, and 0.4 kg/head/d, respectively. The dry matter supply in 2019, 2020, and 2021 was 1.5, 1.6, and 1.5% of body weight, while average daily gain was 0.3, 0.4, and 0.3 kg/head/d, respectively. The average birth percentage was 26.1% per year, while mortality was 4.7% per year. The average value of Natural Increase (NI) in the cattle population in Pulukan was 21.4% per year. In conclusion, the feeding system in Pulukan did not provide adequate levels of dry matter, affecting the average daily gain (ADG) did not meet its target of 0.5 kg/head/d and a low level of Natural Increase.

Keywords | Average daily gain, Bali cattle, Body weight, Dry matter, Nutritional status

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***Correspondence** | Siti Chuzaem, [1]Directorate General of Livestock and Animal Health Services, Ministry of Agriculture, Jl. Harsono RM No.3, Ragunan, Pasar Minggu, Jakarta Selatan, 12550, Indonesia; **Email:** schuzaemi@ub.ac.id
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INTRODUCTION

Beef cattle productivity is affected by feed quality and quantity (NRC, 2000), particularly forage (Costa et al., 2021). As primary producers, forage plants are essential to maintaining populations of ruminants and influencing beef production and quality (Tahuk et al., 2018). The fibre in forage primarily serves as an energy source and maintains normal rumen function and microbial activity (Guo et al., 2022; Adli et al., 2023). For economic and environmental reasons, forage also plays a significant role (Fuglie et al., 2021). It is well known that good feeding practices to improve forage consumption will raise profit (Khanh et al., 2020).

The provision of feed for animals is a major contributor to land and water use greenhouse gas emission (Adli, 2021). An inadequate feed supply is a significant obstacle

to developing cattle production in developing countries. Concerning forage supply in Indonesia, there are several issues: (1) uncertain production related to weather conditions (Kumalasari et al., 2021), (2) the poor quality of forage produced (Agus and Widi, 2018), and (3) limited land area for forage plantation (Bremer et al., 2022). Efforts to manage crops, pastures, and other forage sources need to be made better by considering the factors that affect the productivity and the quality of forage plants. Concentrates are often supplemented in order to overcome the insufficient nutritional supply from forages for cattle to meet performance targets (Romanzin et al., 2018). Accordingly, success in feed management can be seen from the increase in body weight gain, directly proportional to the feed's nutritional value (Tahuk et al., 2018; Sholikin et al., 2022).

Bali cattle are Indonesian native beef cattle and play as important markets due to their tolerance to macroclimatic conditions (temperature, rainfall, wind, humidity, light intensity), efficient feed utilization, and high carcass percentage (Santi et al., 2021). Previous studies of Bali cattle reported that the ADG of Bali cattle kept in semi-intensive and intensive systems was around 0.1–0.3 kg/head/day (Quigley et al., 2009; Mayberry et al., 2016). Panjaitan et al. (2014) reported that Bali cattle's average body weight gain was between 0.2–0.6 kg/head/day, while Tahuk et al. (2018) indicated that the ADG of male Bali cattle fattened in smallholder farms during the rainy season was 0.5 and 0.3 kg/head/d during the dry season.

The feeding system determines feed supply and affects Bali cattle production. Dry matter (DM) is an important variable in determining the number of nutrients in ration formulation and evaluating the effectiveness of feed supplied to cattle (Vickers, 2016). Optimizing DM supply is crucial for optimizing the growth period of cattle to attain optimal productivity. Providing adequate quality and quantity of DM is expected to increase the productivity of Bali cattle, which can be assessed using ADG. Therefore, this study aimed to evaluate the dry matter supply, both forage and concentrate, and ADG of Bali cattle based on the typical feeding system at the Bali cattle breeding center of Balai Pembibitan Ternak Unggul- Hijauan Pakan Ternak (BPTU-HPT) Denpasar in Pulukan, Bali Province.

MATERIALS AND METHODS

This study was conducted at the Bali cattle breeding center of BPTU-HPT Denpasar in Pulukan, Pekutatan District, Jembrana Regency, Bali Province. The study was conducted using a survey from April to June 2022. Quantitative data were collected through direct interviews using questionnaire sheets. The data included cattle population, body weight, forage production cropland and pasture production, concentrate feeding, and dry matter content. The variables measured included dry matter supply and average daily gain.

The cattle population is separated by sex and age. Sex consists of males and females, whereas age is defined according to BPS (2017) as (a) calf, <1 year; (b) young, 1–2 years; and (c) adults, >2 years. Body weight data of 760 Bali cattle were observed to determine weight gain. The observed forage land area is 96.5 ha, including cropland of 26.5 ha and pasture of 70 ha. The DM content of forage and concentrate was calculated using proximate analysis. DM supply was calculated using the equation:

DM supply= (DM/100) * forage/concentrate supply (ton).

DM requirements were calculated using the daily nutrient requirements of NRC (2000) for calf and Kearl (1982) for young and adult cattle in developing countries, presented in Table 1. The ADG was calculated using the equation:

ADG = (final body weight – initial body weight)/ days between initial and final body weight measurement.

Data analysis

Prior to statistical analysis, analysis of variance (ANOVA) using general linear model (GLM) was carried out using SAS OnDemand for Academics (ODA, Cary, NC, USA). The results were presented as standard error mean (SEM). Moreover, probability values were calculated using least significant different testing. The following model was used:

$$Y_{ij} = \mu + T_i + e_{ij}$$ (Adli et al., 2022)

Where Y_{ij} was parameters observed, μ was the overall mean, T_i was the dry matter supply, and e_{ij} was the amount of error number.

Table 1: Daily DM requirements of cattle with the target of daily gain is 0.5 kg.

Sex	Nutrient	Body Weight (kg)					
		<100[a]	100-150[b]	150-200[b]	200-250[b]	250-300[b]	300-350[b]
Male	- DM (%)	3.0	3.0	2.8	2.6	2.5	2.3
Female	- DM (%)	3.0	3.1	2.8	2.8	2.5	2.4

Note: a = nutrient requirements of NRC (2000); b = nutrient requirements of Kearl (1982).

Table 2: Population and the average body weight based on age and sex.

Cattle	2019			2020			2021		
	Pop	BW	SEM	Pop	BW	SEM	Pop	BW	SEM
	Heads	kg	kg	Heads	kg	Kg	Heads	kg	Kg
Calf	132	93.8	2.0	171	96.4	1.7	208	85.9	1.5
Male	61	94.5	3.2	91	100.0	2.5	101	86.0	2.1
Female	71	93.2	2.4	80	92.2	2.1	107	85.8	2.2
Young	150	177.8	3.2	247	161.5	3.3	258	178.9	3.2
Male	82	200.0	4.9	121	177.8	4.8	142	183.7	4.5
Female	68	154.5	2.5	126	143.9	3.8	116	172.4	4.2
Adult	802	261.8	5.6	730	237.6	7.3	731	264.8	6.1
Male	251	297.6	7.5	145	262.8	11.6	152	318.9	9.0
Female	551	217.6	5.1	585	203.7	4.6	579	217.4	4.0
Total	1,084	-	-	1,148	-	-	1,197	-	-

Note: Pop = population; BW = mean of cattle body weight; SEM = standard error of mean; Calf = <1 year; Young = 1-2 years; Adult = >2 years (BPS, 2017).

RESULTS AND DISCUSSION

Results

Table 2 shows that the Bali cattle population steadily increased from 1,084 to 1,197 heads during 2019–2021. The number of calves and young cattle increased from 132 to 208 heads and from 150 to 258 heads, respectively. The average body weight of calves was 92.8±24.2 kg, while young and adults were 173.6±47.5 kg and 255.7±82.7 kg, respectively. Table 3 shows that nutritional requirements varied throughout the year. Based on the number of cattle, sex, and body weight, the dry matter requirement fluctuated with an average of 2,227.5 tonnes/yr.

Table 3: Bali cattle dry matter requirements.

Nutrient	2019	2020	2021
Dry matter (tons/yr)	2,249.7	2,094.5	2,290.6

Table 4 shows that the fresh production of king grass (*Pennisetum purpuphoides*) increased from 2,145.4 tonnes in 2019 to 2,896.8 tonnes in 2021. King grass productivity increased from 89.4 to 120.7 tonnes/ha/yr, and DM production increased from 290.3 to 480.3 tonnes. Competidor grass (*Paspalum notatum cv. competidor)* has been planted in an area of 70 ha, which produced 274.5 tonnes in 2021 in fresh condition, higher than in 2020 and 2019. Competidor grass productivity increased from 3.3 to 3.9 tonnes/ha/yr, and DM production increased from 54.0 to 56.6 tonnes. The type of legume cultivated is Indigofera (*Indigofera zollingeriana*) which produced 141.3 tonnes in 2021 in fresh condition and has fluctuated since 2019. Indigofera productivity range was 48–56 tonnes/ha/yr, and DM production range was 39.5–46.2 tonnes. The DM contents range in king grass was 13.5–16.6%, competidor grass was 20.6–29.4%, and Indigofera was 31.1–32.9%.

Table 5 shows that the average DM contents in concentrate for calves and adults were 89.1% and 88.3%, respectively. Concentrate as-fed feeding decreased from 775.6 tonnes in 2019 to 616.2 tonnes in 2021, and DM production decreased from 685.5 tonnes to 544.8 tonnes in 2021. Concentrate DM supply was decreased from 30.5% to 23.8%, with an average of 27.9% of cattle requirement. Figure 1 shows that the forage DM supply increased from 17.3% to 25.5%, the concentrate decreased from 30.5% to 23.8%, and the feed supply fluctuated.

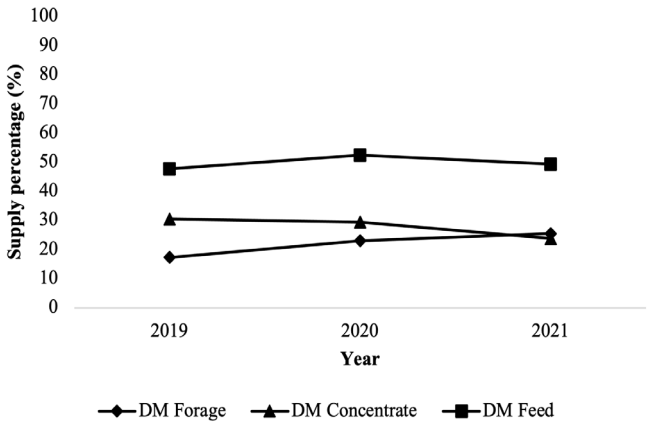

Figure 1: Percentage of DM supply during 2019–2021 in Pulukan.

Table 6 shows that the total DM supply increased from 1,074 to 1,127.9 tonnes. This study indicated that the proportion of grasses and legumes was between 96:4 and 94:6. The forage DM supply increased from 0.5% to 0.8% of body weight, while concentrate DM supply decreased from 1% to 0.7% of body weight. The range of feed DM supply was 1.5–1.6% of body weight. The ratio of forage and concentrate was increased from 36:64 to 51:48. Figure 2A shows that the ADG of calves, young, and adults were

Table 4: Quality and quantity of forage production.

Nutrient	King grass			Competidor grass			Indigofera		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Quality									
DM, %	13.5	13.6	16.6	23.2	29.4	20.6	31.1	32.9	32.7
Quantity									
As fed, ton	2,145.4	2,681.3	2,896.8	232.3	258.5	274.5	142.4	120.1	141.3
DM, ton	290.3	366.0	480.3	54.0	76.1	56.6	44.2	39.5	46.2

Table 5: Concentrate feeding for calf and adult cattle.

Nutrients	Calf concentrate			Adult concentrate		
	2019	2020	2021	2019	2020	2021
Quality						
DM, %	89.7	88.7	88.3	89.6	86.9	87.3
Quantity						
As fed, ton	68.2	82.8	60.2	707.4	613.8	549.6
DM, ton	60.8	73.8	53.6	624.7	542.0	485.3

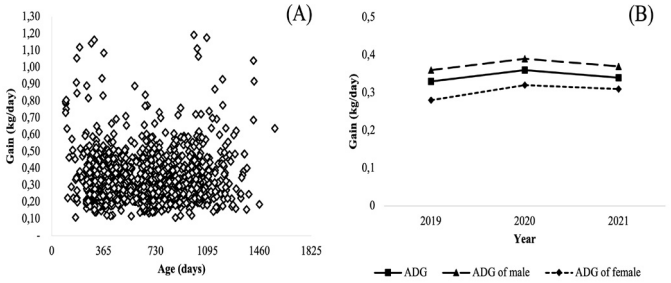

Figure 2: Average daily gain: (A) based on age; (B) based on year and sex.

Table 6: Nutritional status of feed.

Feed supply	2019	2020	2021
Nutrients production			
DM, ton	1,074.0	1,097.4	1,127.9
Forage			
Grass and legume ratio	94:6	96:4	95:5
As feed, % of BW	3.3	4.3	4.3
DM, % of BW	0.5	0.7	0.8
Concentrate			
As feed, % of BW	1.1	1.0	0.8
DM, % of BW	1.0	0.9	0.7
Feed			
Forage and concentrate ratio	36:64	43:56	51:48
DM, % of BW	1.5	1.6	1.5

0.4, 0.3, and 0.4 kg/head/d, respectively, while the ADG of males tended to be higher in value than females (Figure 2B). Based on DM supply, the average ADG in 2019, 2020, and 2021 was 0.3, 0.4, and 0.3 kg/head/d. The range of males ADG was 0.3–0.4, while females were 0.2–0.4 (Table 7).

Table 7: ADG based on body weight, sex, year, and DM supply.

Sex	Year	DM (% BW)	Body Weight (kg)					
			<100	100–150	150–200	200–250	250–300	>300
			n=391	n=231	n=267	n=144	n=46	n=70
Male	2019	1.5	0.3	0.4	0.4	0.4	0.4	0.3
	2020	1.6	0.4	0.4	0.4	0.4	0.4	0.4
	2021	1.5	0.4	0.4	0.4	0.3	0.4	0.4
Female	2019	1.5	0.3	0.3	0.3	0.2	-	0.2
	2020	1.6	0.4	0.3	0.3	0.3	0.2	-
	2021	1.5	0.3	0.4	0.3	0.3	0.2	-

Table 8: Birth, mortality, and natural increase.

Bali cattle	2019	2020	2021	Mean
Birth (heads)	220	338	343	300.3±56.8
Male (%)	50.4	52.7	49.0	50.7±1.5
Female (%)	49.6	47.3	51.0	49.3±1.5
Birth on mother (%)	39.9	57.8	59.2	52.3±8.8
Birth on population (%)	20.3	29.4	28.6	26.1±4.1
Mortality (%)	3.3	7.0	3.8	4.7±1.6
Natural Increase (%)	17.9	22.5	24.9	21.4±3.3

Table 8 showed cattle births increasing as the population increases from 2019 to 2021. The average birth percentage to the population (on population) reaches 26.1% per year, with the highest percentage occurring in 2020, 29.4% per year. The average percentage of births by mothers was 52.3% per year, with a high of 59.2% in 2021. The average percentage of mortality reaches 4.7% per year, with the highest percentage occurring in 2020, 7% per year. The highest cause of mortality were accidents which reached 41.6%, then enteritis and bloat present 13.7% and 8.7%, respectively.

Dry matter requirement

This study indicated that the average cattle population increased by 5% per year during 2019–2021. The population of calves and young increased while the adults fluctuated. Adinata et al. (2014) stated that population size fluctuates throughout time due to variations in population growth. Compared to young and calves, adults dominated

the population structure. The population of the female is higher than the population of males. The ranges ratio of males to females is 1:3, which is higher than the ratio recommended by Kementan (2006), which is 1:10. The average body weight of calves in this study was higher than that reported by Astiti and Rukmini (2020), young was higher than that reported by Garantjang et al. (2020), and adults was higher than that reported by Tahuk et al. (2018). This study showed that males tended to be higher in value than females. Suranjaya et al. (2010) stated that sex affected the growth of livestock. The presence of testosterone produced by the testis in males caused males to grow faster than in female livestock (Susilawati et al., 2017, 2020). The presence between X and Y bearing spermatozoa were influenced change of the offspring (Kusumawati et al., 2019).

Nutrient requirements vary among cattle and are influenced by age, body weight, production stage, growth rate, environmental conditions, breed, gender, and other factors (NRC, 2000). This study revealed that the variation in cattle population growth that occurred during 2019–2021 caused fluctuations in DM requirements. In 2020, the number of adults was lowest while the calves and young increased. Thus, the DM requirement was lower than in 2019 and 2021.

Dry matter supply

Forage production

The feeding system in Pulukan is dependent on forage and purchased concentrates. Pulukan produced forage through cropland and pasture. The forage feeding system in Pulukan relied on king grass (*Pennisetum purpuphoides*), representing 86.7% of forage crop production. Another forage crop is the legume Indigofera (*Indigofera zollingeriana*) and in the form of pasture is competidor grass (*Paspalum notatum cv. competidor*). The fresh production of king grass in this study was lower than Suyitman (2014) reported, potentially reaching 1,076 tonnes/ha/yr and 89 tonnes/ha/defoliation. This study's average annual DM production of competidor grass was 0.9 tonnes/ha. Heuzé et al. (2021) reported that under moderately fertilized and rain-grown conditions, the annual DM production of competidor grass is typically between 3 and 8 tonnes/ha. According to Hawolambani et al. (2015), the composition of grasses and legumes needs to be considered because increasing the percentage of legumes will increase the production and quality of forage. The average DM production of Indigofera in this study was 17.3 tonnes/ha/yr, lower than that reported by Tarigan et al. (2010), which could produce 33.3 tonnes/ha/yr. The DM contents in king grass and competidor grass are in the range of that reported by Hendarto and Setyaningrum (2022) and Heuzé et al. (2021), respectively, while DM contents in Indigofera are higher than that reported by Ali et al. (2014). This study showed that king grass is the highest producer of DM contents (78.2%) compared to competidor grass (12.9%) and Indigofera (8.9%).

Concentrate feeding

Concentrate supplementation aims to improve feed quality to reduce the gap between nutrient requirements and the availability of nutrients from forage. Due to suboptimal feed production, the Pulukan feeding system, relying on forage as the primary feed source, also provides concentrate to meet cattle needs. This study revealed that DM contents in concentrate for adults are in the range recommended in The Indonesia National Standard by the National Certification Body (Kementan, 2017), above 86%. The ratio of forage and concentrate in feed increased from 36:64 to 51:48. Madruga et al. (2019) indicated that an increase in forage proportion in cattle feed ration could increase DM intake and body weight.

Nutritional status

FORAGE as-fed and forage DM supply ranges were 3.3–4.3% and 0.5–0.8% of body weight, respectively. Forage provided DM on average at 21.8% in feed compared to cattle nutrient requirements. Thus, the feed was supplemented by concentrate to minimize the nutrient requirements gap. Concentrate as fed and concentrate DM supply ranges were 0.8–1% and 0.7–1% of body weight, respectively. The average DM supply from concentrate was 27.9%. Supplementing concentrate increased the average feed DM supply to 49.8%. The feed DM supply, both forage and concentrate, ranges between 1.5% and 1.6% of body weight, which is lower than Kearl's nutrient requirements (1982). Vickers (2016) reported that the DM demand for beef cattle is between 2% and 2.5% during the growing period. The dry matter supply of both forage and concentrate was insufficient to meet the nutrient requirements of Bali cattle in Pulukan. Then, it is necessary to improve forage availability as the primary feed source for ruminants.

Average daily gain

This study revealed that the ADG of Bali cattle in Pulukan was lower than the target of 0.5 kg/head/d. The various environmental factors, management, and feeding practices affected ADG (Fallo et al., 2019; Sulfiar et al., 2022). The current feeding system in Pulukan provides dry matter lower than the cattle requirements probably affects body weight gain. Wangi et al. (2017) indicated that insufficient feed consumption and low nutrition quality result in a lack of energy, resulting in stunted growth or even weight loss. Pribadi (2015) reported that cattle fed natural grass gained 0.2 kg/head/d, while fed Napiergrass and corn stover gained 0.4 kg/head/d (Mayulu et al., 2021). Marsetyo et al. (2012) also reported that Bali cattle's ADG fed with elephant grass only was 0.1 kg/head/d and increased to 0.4

kg/head/d when elephant grass was supplemented with Gliricidia (Rusdy et al., 2019).

DM supply is an essential indicator that can be used as a cattle performance index due to its close relationship with weight gain and carcass weight (Mayulu et al., 2021). Regarding DM supply, the ADG in 2019, 2020, and 2021 was 0.3, 0.4, and 0.3 kg/head/d, respectively. With a DM supply of 1.5%, the ADG reached 0.3 kg/head/d, which is lower than those supplied DM 1.6% of body weight ADG of 0.4 kg/head/d. The low ADG is probably due to the low nutritional content. Riswandi et al. (2020) stated that the feed's quality affected body weight gain despite the DM supply. Its nutritional value influences microbial growth similarly to how a high fibre content influences consumption and digestion. If body weight gain is insufficient or poor, there may be a need for improved feed efficiency in feed ingredients.

Natural increase

The average percentage of births to Bali cattle in the population in this study was higher than the percentage of births reported by Samberi et al. (2010), 19.5% per year, and lower than Tonbesi (2008), 27.1% per year. The average number of births by mothers in this study was lower than that reported by Samberi et al. (2010), 72.3% per year, and Tonbesi (2008), 67.7% per year. This study's low percentage of on-mother births could be due to maternal factors. The increase in the Bali cattle population also increases the mortality rate. The mean percentage of mortality in this study was higher than the percentage reported by Samberi et al. (2010), 1.3% per year. Animal-related accidents result in several serious injuries and deaths yearly (Langley and Morrow, 2010). Non-infectious reasons besides infectious diseases may also cause enteritis. For instance, enteritis can be caused by feeding cattle an inappropriate feed or a drastic change in feed. The higher amount of concentrate than forage in Pulukan may cause bloat. Concentrate feeds have a high starch content. The high consumption of easily digestible carbohydrates causes higher fermentation activity, so the amount of gas produced is also higher, which can cause an increase in rumen volume.

Birth and mortality will determine the Natural Increase (NI) population rate. NI values between 0% and 50% are in the low category, values above 50% to 80% are in the medium category, and above 80% are in the high category (Sumadi et al., 2001). The average value of NI in the cattle population in Pulukan is 21.4% per year. The NI value is included in the low category. The results of this study are higher than the NI values reported by Samberi et al. (2010), which is 18.2% per year, and is close to the NI value reported by Tonbesi (2008) is 21.7%. The low NI value in this study was due to the low number of births by mothers. To improve the value of NI, it is necessary to increase the birth rate and decrease the mortality rate annually.

CONCLUSIONS AND RECOMMENDATIONS

The current feeding system provides dry matter from forage and concentrates that do not meet the cattle's nutritional requirements and thus limit the body weight gain, number of births by mothers, and Natural Increase of Bali cattle in Pulukan. The current feeding system tends to have higher mortality may be caused by inappropriate feed, which stimulates enteritis and bloat. Further improvement in the quality and quantity of feed supply is required to gain body weight and Natural Increase optimally.

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NOVELTY STATEMENT

By using the modelling, the novelty of this research would help evaluate the dry matter supply from both forage and concentrate and the average daily gain of Bali cattle at the breeding center in Pulukan, Jembrana Regency, Bali Province. As consequences related to the information about this research the related government can be used as the SNI of Bali cattles.

AUTHOR'S CONTRIBUTION

Roy Malindo contributed to collecting data, analysis of nutrient,data analysis and preparing the original manuscript. Osfar Sjofjan and Siti Chuzaemi contributed to the research design, revised the manuscript and supervision. Anuraga Jayanegara supervised and revised the manuscript grammatically. All authors read and approved the final version of the manuscript in the present journal

Conflict of interest

The authors have declared no conflict of interest.

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