*Pak. J. Agri. Sci., Vol. 60(2), 603-613; 2023*
*ISSN (Print) 0552-9034, ISSN (Online) 2076-0906*
*DOI: 10.21162/PAKJAS/23.90*
http://www.pakjas.com.pk

# Nutritional status and smallholder farmer characteristic of Bali cattle-oil palm integration system in the rural dryland area of Bangka Island, Indonesia

Zikril Hidayat, Suyatno, Rudy Priyanto, Henny Nuraini, Luki Abdullah and Suharyanto

[1]Bangka Belitung Center for Implementation of Agricultural Instrument Standards; Research Center for Animal Husbandry, National Research and Innovation Agency (BRIN); Departmen of Animal Production and Technology, Faculty of Animal Science, IPB University; Departmen of Animal Production and Technology, Faculty of Animal Science, IPB University, Department of Nutrition dan Feed Technology, Faculty of Animal Science, IPB University, South Sumatera Center for Implementation of Agricultural Instrument Standards
* Corresponding author's e-mail: hidayatjacky12@gmail.com; suya017@brin.go.id

Livestock-oil palm plantations integration system is intended to improve farming efficiency, where agriculture not only plays a role as the primary producer of food but also as a producer of feed, fertilizer, energy, and other bioproducts, leading to a sustainable agricultural system. Smallholder farmers in Indonesia integrated Bali cattle and oil palm with extensive, semi-intensive, and intensive management systems. This study evaluated the integrated system of oil palm and Bali cattle under different management systems regarding the characteristics of smallholder farmers, nutritional status, and weight gain of Bali cattle on smallholder farms. The study was conducted in the Regency of Central Bangka, Bangka Islands, Indonesia. The study included 108 Bali cattle grouped as calves, young, and adults. The observed variables included smallholder farmer characteristics, feed nutrients, feed nutrient consumption (Dry Matter (DM), protein, Ca, and P), feed digestibility, and body weight gain. A Randomized Block Design and analysis of variance for the obtained data were used in this experiment. Smallholder farmers implementing the integration of livestock-oil palm in Central Bangka Regency were dominated by inexperienced novice farmers. The majority of the farmer choose semi-intensive rearing management as this system produces compost as a by-product. The semi-intensive system also provides better feed quality for Bali cattle. Therefore, DM consumption in the semi-intensive system was higher than in other systems, especially in young bulls, heifers, and male and female calves ($P<0.05$). Thus, Bali cattle in the semi-intensive system had higher average daily gain than those in the intensive or extensive system. Therefore, it can be concluded that the semi-intensive management system is the best model in the Bali cattle-oil palm integration system in the rural dryland area, in accordance with nutritional status and the characteristics of smallholder farmers in Indonesia.
**Keywords:** integrated farming, dry matter, rearing management, digestibility

## INTRODUCTION

Feeding is the primary factor for the success of the beef cattle industry. Farmers need to balance the feed quality and feed cost to gain more profit. The nutrient content, such as proteins, vitamins, and essential minerals, combined with anti-nutrients such as lignin and tannins, determine feed quality. The provision of forage fodder is often constrained by its low productivity, not being continuously available, taking a lot of time and cost in forage maintenance, low economic value, and the unavailability of land for planting. Meanwhile, the supply of concentrate feed is constrained by high costs, so it is not affordable for smallholder farmers. The number of smallholder farms living in rural areas was around 90% of Indonesia's total beef cattle farms (Asikin *et al.*, 2020). This suggests that smallholder farmers are the main beef cattle farms in Indonesia. Cattle have been integral to rural area agricultural life in Indonesia for hundreds of years (Widi, 2015). However, Indonesia can only meet 60% of domestic meat needs (Agus and Widi, 2018).

Through the Minister of Agriculture, the Government of Indonesia has programmed a system for integrating livestock with plants, one of which is oil palm plantations. This integrated agriculture is intended to improve the efficiency of farming, where agriculture does not only play a role as the primary producer of food but also as a producer of feed, fertilizer, fiber, energy, biopharmaceuticals, and other bioproducts that lead to a zero waste agricultural system with

Hidayat, Z., Suyatno, R. Priyanto, H. Nuraini, L. Abdullah and Suharyanto. 2023. Nutritional status and smallholder farmer characteristic of Bali cattle-oil palm integration system in the rural dryland area of Bangka Island, Indonesia. Pakistan Journal of Agricultural Sciences. 60: 603-613.
[Received 11 May 2023; Accepted 23 Oct 2023; Published 11 Dec 2023]

the principle of reduce, reuse, and recycle. Oil palm plantations are one commodity with an abundant feed source for cattle. The potential by-product of oil palm plantation and industry are oil palm fronds (OPF), palm kernel expeller (PKE), palm press fiber, palm oil mill effluent (POME), and forage under a palm tree (Devendra, 2011). OPF and PKE have been widely used as animal feed in oil palm plantations and provide economic benefits for farmers (Suyatno *et al.*, 2021). OPF can also meet the nutritional needs of beef cattle if given properly (Ishida and Abu Hassan, 1997; Ooi *et al.*, 2017; Mookiah *et al.*, 2020).

Generally, the livestock breeds raised in Indonesia's livestock-oil palm integration system are local cattle, including Bali cattle. Bali cattle are superior and dominant breeds of Indonesian cattle developed by smallholder farmers because of their high fertility; disease resistance; and high adaptability to heat stress and low-quality feed (Martojo, 2012). Most of these cattle are raised by small farmers in rural areas (Mohamad *et al.*, 2012) and become the most suitable breed for small landholders (Martojo, 2012). Bali cattle also have a high dressing percentage (50.95%) that meets the criteria of beef cattle (Priyanto *et al.*, 2019).

Indonesia has the largest oil palm plantation in the world, with 14.6 million ha (BPS Statistic Indonesia, 2020). Oil palm plantations in Indonesia are mainly spread across the islands of Sumatra, Kalimantan, Sulawesi, and Bangka. The plantation area of oil palm at Bangka Islands in 2020 reached 72,206 hectares with a livestock capacity of up to 145,679 animal units (Suyatno *et al.*, 2021). Bangka Island also has a dry land agroecosystem with primarily sandy soil. Most of the land on Bangka Island is also ex-tin mining land, so it has limited nutrients for food crops. Therefore, oil palm is suitable for planting on Bangka Island, and livestock-oil palm integration has significantly contributed to the community's economy (Suyatno *et al.*, 2021) and the use of ex-mining land (Oktaviani, 2022). Integrating livestock-oil palm plantations can be a solution to make livestock and plantations more efficient and environmentally friendly.

Smallholder farmers in Bangka Island adopted Bali cattle and oil palm integration with extensive, intensive, and semi-intensive cattle rearing. However, the efficiency and sustainability of livestock and plantations in these three systems remain unclear. Research on the comparative application of the three integrated livestock management systems is minimal. Therefore, this study was designed to evaluate the integrated system of oil palm plantation and Bali cattle with different management systems regarding the characteristics of smallholder farmers, feed consumption and digestibility, and weight gain of Balinese cattle on smallholder farms marginal dry land Bangka Island. This study benefits the sustainability of livestock-oil palm integration through more efficient, profitable, and environmentally friendly management of marginal dry land.

## MATERIALS AND METHODS

***Experimental animal and site***: The experiment was carried out from August 2020 to January 2021 in the Regency of Central Bangka, Bangka Belitung Province. The research location was determined intentionally by fulfilling the elements of extensive, semi-intensive, and intensive management systems. Intensive system is carried out by keeping the cows in cowshed continuously, all the needs of the cows such as feed, water, mating are provided by the farmer. The feed in intensive system obtained from the by-products of the oil palm plantations. Semi-intensive was carried out by herding cattle in a limited way. Some of the feed needs were met by the cows that come from the forage in the space between palm oil tree in palm plantations (inter-oil palm plantation). Extensive systems, cattle were grazed continuously, cattle feed only depends on the availability of forage in inter-oil palm plantations (Matondang et al 2019). The materials used were 108 Bali cattle grouped by age (Calves aged 0.5-1.5 years, young aged 1.5-3 years, and adults aged >3 years)). Bali cattle are Indonesian native beef cattle that are domesticated from Banteng (*Bos javanicus*) thousands of years ago. Bali cattle are well adapted to tropical climate conditions in Indonesia and are the most widely kept cattle on smallholder farms (Mohamad *et al.*, 2012).

***Data collection and analysis:*** The variables observed were the characteristics of smallholder farmers, feed nutrients, nutrient consumption, digestibility of feed, and weight gain. The collection of data on the characteristics of farmers was done by interview. The nutritional data on the intensive maintenance pattern was collected by observing the cowshed's type and amount of feed. Nutritional data on extensive rearing patterns is carried out by calculating the grazing area for 24 hours, and cows are restricted in movement. Meanwhile, the forage consumed is quantified by the weight of the forage cut at the grazing boundary in a plot/quadrant measuring 1x1 $m^2$ placed on the land. Observation of feed consumption by sampling of feed and feces were carried out 2 times in the middle and the end of the study. The feeds and feces were analyzed for dry matter (DM), protein, ash, crude fiber, Ca, P, acid detergent fiber (NDF), neutral detergent fiber (NDF), lignin, and cellulose at the analytical chemistry laboratory, Indonesian Research Institute for Animal Production (IRIAP), Ciawi. Body weight was determined by weighing cows using digital scales. Average daily gain (ADG) is the difference between the final weight and the initial weight divided by the number of days of observation.

***Statistical Analysis:*** A randomized block design and analysis of variance for the obtained data were used in this experiment. Tukey's honestly significance difference (HSD) was used to see the difference between treatments (Steel and Torrie, 1993).

**Table 1. Differences between intensive, semi-intensive, and extensive beef cattle management systems on beef cattle and oil palm integration**

| Description | Intensive | Semi-intensive | Extensive |
|---|---|---|---|
| Reasons for choosing a management system | limited land area<br>social considerations<br>compost business | the land is medium to large<br>compost business | the location is adjacent to an oil palm plantation company<br>limited capital |
| Percentage in farmer population sampled | 39.60 % | 56.73% | 3.67% |
| Feed type | Chopped oil palm fronds, palm kernel expeller | Chopped oil palm fronds, palm kernel expeller, forage in the oil palm plantation area | forage in the oil palm plantation area |
| Grazing | No | ± 7 hours (10.00 AM-5.00 PM) | Continuously |
| Housing | Continuously | ± 14 hours (5.00 PM-10.00 AM) | No |
| drinking water supply | Once | Once | No |
| Average livestock ownership | 9.1 cows/ farmer | 6.0 cows/ farmer | 5.0 cows/ farmer |

## RESULTS

### *The characteristics of smallholder farmers*

**Table 2. Characteristics of smallholder farmers in the study**

| Variables | Beef Cattle Management System | | |
|---|---|---|---|
| | Intensive (n= 15) | Semi-intensive (n=21) | Extensive (n=23) |
| | -------------------- % --------------------- | | |
| Gender | | | |
| Male | 100 | 85.7 | 100 |
| Female | 0 | 143 | 0 |
| Age (years) | | | |
| 16 - 25 | 0 | 0 | 4.35 |
| 26 – 35 | 10.0 | 4.76 | 0 |
| 36 – 45 | 60.0 | 52.4 | 43.5 |
| 46 – 55 | 30.0 | 23.8 | 47.8 |
| >55 | 0.00 | 19.1 | 4.35 |
| Education level | | | |
| No formal education | 0 | 0 | 0 |
| Graduated from Elementary School | 10.0 | 33.3 | 52.2 |
| Graduated from Junior High School | 30.0 | 33.3 | 21.7 |
| Graduated from Senior High School | 60.0 | 19.1 | 26.1 |
| Bachelor | 0 | 14.3 | 0 |
| Beef cattle farming experience (years) | | | |
| ≤ 3 | 30.0 | 4.76 | 4.35 |
| 4 – 6 | 20.0 | 23.8 | 17.4 |
| 7 – 9 | 40.0 | 47.6 | 47.8 |
| ≥ 10 | 10.0 | 23.8 | 30.4 |
| Main job | | | |
| Farmers | 50.0 | 61.9 | 78.3 |
| Traders | 10.0 | 19.0 | 21.7 |
| Fisherman | 20.0 | 4.76 | 0 |
| Entrepreneur | 20.0 | 0 | 0 |
| Teacher | 0 | 4.76 | 0 |
| Employee | 0 | 9.52 | 0 |

The differences between intensive, semi-intensive, and extensive beef cattle management systems on beef cattle and oil palm integration are mentioned in Table 1. Most livestock-oil palm integrated systems at Central Bangka implement semi-intensive management systems (56.73%).

The characteristics of small farmers are identified to determine their level of farming ability and their reasons for choosing a management system in the integration of Cattle-Palm Oil. The characteristics of the farmers who were used as respondents in the study are shown in Table 2. Based on these data, most farmers are of productive age (15-55 years) and categorized as novice farmers. At productive age, farmers in rural areas still have strong physical conditions to raise livestock. Most of the farmers were male and had a range of education from elementary school to bachelor's degree.

***Nutrient content of feed*:** The type of feed given in this study varied for each rearing management (Table 3). The selection of feed compositions in each integration system was based on the feed availability at the farmer level. In the intensive system, the cattle were kept full-time in the cowshed. So the feed given was a mixture of oil palm plantation by-products. The economic benefits of this feed have been described in previous studies (Suyatno *et al.*, 2021). In the semi-intensive system, cattle were released and penned on a scheduled basis. When the cattle were released they consumed forage in the oil palm plantation area. When the cattle were in the cowshed they were fed by a mixture of oil palm plantation by-products by the farmers. Meanwhile, in the extensive system, beef cattle were released full-time in the oil palm plantation area. So they consumed all types of forage in the plantation area.

**Table 3. Composition of feed in each rearing management**

| Type of feed | Content of feed (%) | | |
|---|---|---|---|
| | Intensive | Semi-Intensive | Extensive |
| Chopped oil palm fronds | 84.5 | 61.0 | - |
| Palm kernel expeller | 15.0 | 4.5 | - |
| Forages under the oil palm trees | - | 34.0 | 100 |
| Salt | 0.5 | 0.5 | - |
| Total | 100 | 100 | 100 |

The composition of feed nutrients in consumed feed is presented in Table 4. The difference in the type of feed affects the DM. Higher DM was found in intensive management due to the type of feed given, which consisted of a mixture of palm kernel expeller and chopped oil palm fronds. Cattle reared under semi-intensive management, besides being fed a mixture of palm kernel expeller and palm fronds, also receive forage in the plantation area while the cows are grazing. Bali cattle in extensive management only consumed forage during grazing, which has a lower DM (23.65%).

**Table 4. Chemical composition of feed in each rearing management**

| Type of feed and chemical composition | Content of nutrient (%) | | |
|---|---|---|---|
| | Intensive | Semi-Intensive | Extensive |
| Chemical composition | | | |
| Dry matter | 44.90 | 26.65 | 23.65 |
| Protein | 8.86 | 8.62 | 8.73 |
| Calcium | 0.79 | 0.79 | 0.21 |
| Phosphorus | 0.30 | 0.40 | 0.47 |
| Organic matter | 37.66 | 16.22 | 14.08 |
| Fiber fraction | | | |
| Acid Detergent Fiber | 54.4 | 49.8 | 45.9 |
| Neutral Detergent Fiber | 68.4 | 65.3 | 62.9 |
| Lignin | 17.9 | 14.3 | 12.2 |
| Cellulose | 32.3 | 31.3 | 33.1 |

***Source:*** Analytical Chemistry Laboratory IRIAP

***Consumption of Feed Nutrients*****:** Consumption of feed nutrients was showed in Table 5. The DM consumption of adult bulls and adult females was relatively the same in intensive, extensive, and semi-intensive rearing systems. However, DM consumption of young bulls, heifers, male calves, and female calves was statistically different (P<0.05). The consumption of DM in young bulls was ranged from 4.50-4.93 kg/head/day (intensive rearing), 6.03-6.62 kg/head/day (semi-intensive), and 4.86-6.65 kg/head/day (extensive). The consumption of DM in heifers was ranged from 4.20-4.70 kg/head/day (intensive), 5.92-6.29 kg/head/day (semi-intensive), and 4.15-4.71 kg/head /day (extensive). The consumption of DM in male calves was ranged from 3.38-3.73 kg/head/day (intensive), 4.23-4.53 kg/head/day (semi-intensive), and 3.31-4.22 kg/head /day (extensive). Meanwhile, consumption of DM in female calves was ranged from 2.95-3.50 kg/head/day (intensive), 4.06-4.48 kg/head/day (semi-intensive), and 2.35-3.14 kg/head/day (extensive).

Feed digestibility was evaluated by analyzing the digestibility of DM, organic matter (OM), lignin, and cellulose (Table 6).

**Table 5. The amount of consumption of nutrients in Bali cattle feed in the cattle-palm oil integration system with different rearing management.**

| Cattle Groups | Average weight (Kg) | Amount of nutrients consumed | | | P-value |
|---|---|---|---|---|---|
| | | Intensive | Semi-intensive | Extensive | |
| | | DM (kg/head/day) | | | |
| Bulls | 381.1 | 7.60±0.45 | 8.26±0.56 | 8.06±0.98 | 0.490 |
| Cows | 238.6 | 6.55±0.68 | 7.13±0.15 | 6.51±0.85 | 0.383 |
| Young bulls | 240.5 | 4.71±0.19$^{a}$ | 6.35±0.31$^{b}$ | 5.78±0.98$^{ab}$ | 0.017 |
| Heifers | 201.7 | 4.50±0.22$^{a}$ | 6.07±0.16$^{b}$ | 4.45±0.24$^{a}$ | 0.001 |
| Male calves | 143.6 | 3.54±0.17$^{a}$ | 4.36±0.13$^{b}$ | 3.74±0.50$^{ab}$ | 0.028 |
| Female calves | 131.5 | 3.27±0.25$^{a}$ | 4.27±0.17$^{b}$ | 2.74±0.34$^{a}$ | 0.001 |
| | | Protein (g/head/day) | | | |
| Bulls | 381.1 | 673.5±39.7 | 655.4±46.2 | 703.6±85.2 | 0.598 |
| Cows | 238.6 | 580.3±60.0 | 572.3±11.9 | 568.5±74.2 | 0.957 |
| Young bulls | 240.5 | 417.6±16.8 | 506.0±25.4 | 505.0±85.4 | 0.070 |
| Heifers | 201.7 | 398.9±19.2$^{a}$ | 484.8±13.5$^{b}$ | 388.8±20.9$^{a}$ | 0.001 |
| Male calves | 143.6 | 314.1±14.6 | 355.3±10.9 | 326.6±43.6 | 0.189 |
| Female calves | 131.5 | 290.2±22.3$^{a}$ | 349.3±13.4$^{b}$ | 239.2±29.4$^{a}$ | 0.003 |
| | | Calcium (g/head/day) | | | |
| Bulls | 381.1 | 59.9±3.50$^{c}$ | 48.6±3.66$^{b}$ | 16.9±2.24$^{a}$ | 0.001 |
| Cows | 238.6 | 51.7±5.35$^{c}$ | 42.0±0.94$^{b}$ | 13.7±1.79$^{a}$ | 0.001 |
| Young bulls | 240.5 | 37.2±1.50$^{b}$ | 38.4±1.72$^{b}$ | 12.1±2.03$^{a}$ | 0.001 |
| Heifers | 201.7 | 35.5±1.71$^{b}$ | 37.1±0.96$^{b}$ | 9.3±0.56$^{a}$ | 0.001 |
| Male calves | 143.6 | 27.9±1.31$^{b}$ | 28.2±0.89$^{b}$ | 7.8±1.07$^{a}$ | 0.001 |
| Female calves | 131.5 | 25.8±1.98$^{b}$ | 27.6±1.10$^{b}$ | 5.7±0.71$^{a}$ | 0.001 |
| | | Phosphorus (g/head/day) | | | |
| Bulls | 381.1 | 22.8±1.34$^{a}$ | 25.0±1.95$^{a}$ | 37.9±5.22$^{b}$ | 0.002 |
| Cows | 238.6 | 19.6±2.03$^{a}$ | 20.8±0.52$^{a}$ | 30.6±4.00$^{b}$ | 0.002 |
| Young bulls | 240.5 | 14.1±0.57$^{a}$ | 20.3±0.72$^{b}$ | 27.1±4.52$^{c}$ | 0.001 |
| Heifers | 201.7 | 13.5±0.65$^{a}$ | 19.7±0.50$^{b}$ | 20.9±1.31$^{b}$ | 0.001 |
| Male calves | 143.6 | 10.6±0.50$^{a}$ | 15.0±0.47$^{b}$ | 17.5±2.42$^{b}$ | 0.002 |
| Female calves | 131.5 | 9.8±0.75$^{a}$ | 14.5±0.65$^{b}$ | 12.8±1.59$^{b}$ | 0.005 |

Data are presented as mean ± standard deviation (SD), numbers in the same row with different letters indicate a significant difference (P<0.05)

***Feed digestibility:***

**Table 6. The level of digestibility of feed on the integrated cattle-palm oil system with different management systems.**

| **Cattle group** | **Digestibility Level (%)** | | | **P-value** |
|---|---|---|---|---|
| | **Intensive** | **Semi-intensive** | **Extensive** | |
| | | DM digestibility | | |
| Bulls | 68.2±4.85$^{a}$ | 75.2±3.77$^{ab}$ | 77.2±2.37$^{b}$ | 0.038 |
| Cows | 68.1±3.37 | 64.3±6.67 | 71.1±4.82 | 0.349 |
| Young bulls | 43.2±7.93$^{a}$ | 68.3±2.85$^{b}$ | 73.5±3.72$^{b}$ | 0.001 |
| Heifers | 59.7±2.38$^{a}$ | 75.2±2.60$^{b}$ | 72.6±1.28$^{b}$ | 0.001 |
| Male calves | 71.1±2.59$^{a}$ | 79.2±1.58$^{b}$ | 79.2±3.31$^{b}$ | 0.002 |
| Female calves | 64.7±3.15$^{a}$ | 79.5±3.02$^{c}$ | 72.6±4.93$^{b}$ | 0.001 |
| Average | 62.5±10.22 | 73.6±6.08 | 74.4±3.16 | |
| | | OM Digestibility | | |
| Bulls | 68.9±4.73$^{a}$ | 77.1±3.48$^{b}$ | 79.2±2.19$^{b}$ | 0.017 |
| Cows | 70.3±2.94 | 69.6±5.67 | 72.6±4.62 | 0.725 |
| Young bulls | 44.4±7.80$^{a}$ | 69.6±2.70$^{b}$ | 76.3±3.32$^{b}$ | 0.001 |
| Heifers | 64.2±1.97$^{a}$ | 76.4±2.46$^{b}$ | 75.5±1.15$^{b}$ | 0.001 |
| Male calves | 79.1±1.88 | 80.6±1.47 | 80.3±3.13 | 0.515 |
| Female calves | 67.7±2.44$^{a}$ | 80.9±2.85$^{c}$ | 74.0±4.67$^{b}$ | 0.001 |
| Average | 65.8±11.60 | 75.7±5.07 | 76.3±2.98 | |
| | | Lignin Digestibility | | |
| Bulls | 58.4±6.46 | 67.9±4.77 | 67.0±3.31 | 0.077 |
| Cows | 63.6±4.31 | 65.1±6.62 | 57.8±6.61 | 0.359 |
| Young bulls | 46.5±7.42$^{a}$ | 65.6±3.14$^{b}$ | 61.3±4.79$^{b}$ | 0.006 |
| Heifers | 56.8±2.86$^{a}$ | 73.6±2.79$^{b}$ | 59.0±0.99$^{a}$ | 0.001 |
| Male calves | 67.8±2.84$^{a}$ | 75.9±1.82$^{b}$ | 70.9±4.62$^{ab}$ | 0.014 |
| Female calves | 59.6±3.94$^{a}$ | 75.5±3.66$^{b}$ | 62.3±6.66$^{a}$ | 0.002 |
| Average | 58.8±7.22 | 70.6±4.96 | 63.1±5.02 | |
| | | Cellulose Digestibility | | |
| Bulls | 66.2±5.11$^{a}$ | 79.9±2.94$^{b}$ | 83.2±1.77$^{b}$ | 0.001 |
| Cows | 77.7±3.61 | 71.8±5.59 | 79.1±3.61 | 0.147 |
| Young bulls | 58.2±5.65$^{a}$ | 76.2±2.27$^{b}$ | 80.4±2.88$^{b}$ | 0.001 |
| Heifers | 61.3±2.78$^{a}$ | 80.5±2.18$^{b}$ | 80.9±0.99$^{b}$ | 0.001 |
| Male calves | 74.1±2.26$^{a}$ | 84.3±1.23$^{b}$ | 85.4±2.44$^{b}$ | 0.001 |
| Female calves | 62.8±3.48$^{a}$ | 84.9±2.31$^{b}$ | 80.8±3.60$^{b}$ | 0.001 |
| Average | 66.7±7.64 | 79.6±4.98 | 81.6±2.28 | |

Data are presented as mean ± standard deviation (SD), numbers in the same row with different letters indicate a significant difference ($P<0.05$)

The difference in rearing management had a significant effect ($P<0.05$) on the DM digestibility, OM digestibility, lignin digestibility, and cellulose digestibility in almost all groups of cattle observed. The results showed that the DM digestibility in intensive management ranged from 43.2%-68.2%, in semi-intensive 64.3%-79.5%, and in extensive 71.1%-79.2%; OM digestibility in intensive management ranged from 44.4%-79.1 %, in semi-intensive 69.6%-80.9%, and extensive 72.6%-80.3%. Meanwhile, the average digestibility of lignin in intensive, semi-intensive, and extensive rearing management was 58.8%, 70.6%, and 63.1%, respectively. The average cellulose digestibility in intensive rearing management was 66.7%, semi-intensive was 79.6%, and extensive was 81.6%.

***Average daily gain*:** Average daily gain of cattle was significantly different ($P<0.05$) in each rearing management in the group of heifers, male calves, and female calves (Table 7). Average daily gain of cattle in the group of a young female, male, and female calves in extensive rearing management was lower than intensive and semi-intensive rearing management. Average daily gain of heifers was ranged from 190.0-260.9 g/head/day (intensive), 205.8-268.5 g/head/day (semi-intensive), and 146.4-204.9 g/head/day (extensive). While ADG in male calves ranged from 173.9-263.7 g/head/day (intensive), 205.3-261.1 g/head/day (semi-intensive), and 99.4-204.7 (extensive). While the ADG in female calves ranged from 154.0-288.3 g/head/day (intensive), 195.0-250.0 g/head/day (semi-intensive), and 129.3-153.4 g/head /day (extensive).

**Table 7**. **Average Daily Gain (ADG) of Bali cattle on the cattle-palm oil integration system**

| Cattle groups | Intensive | Semi-intensive | Extensive | P-value |
|---|---|---|---|---|
| Bulls (g) | 150.4 ± 69.3 | 161.7 ± 68.0 | 164.1 ± 44.4 | 0.216 |
| Cows (g) | 165.6 ± 66.2 | 168.7 ± 68.0 | 162.4 ± 119.2 | 0.998 |
| Young bulls (g) | 240.4 ± 48.9 | 246.9 ± 32.1 | 206.8 ± 31.8 | 0.172 |
| Heifers (g) | $218.4^{ab} \pm 26.2$ | $228.4^{a} \pm 27.3$ | $182.3^{b} \pm 25.9$ | 0.015 |
| Male calves (g) | $216.3^{a} \pm 30.3$ | $236.4^{a} \pm 24.9$ | $157.4^{b} \pm 44.0$ | 0.012 |
| Female calves (g) | $214.9^{a} \pm 51.6$ | $222.3^{a} \pm 19.6$ | $142.2^{b} \pm 9.7$ | 0.001 |
| Average | 201.0 ± 57.5 | 210.7 ± 59.3 | 169.2 ± 57.2 | |

Data are presented as mean ± standard deviation (SD), numbers in the same row with different letters indicate a significant difference (P<0.05)

## DISCUSSIONS

***Identification of cattle rearing system in smallholder farmer*:** Small-scale beef cattle businesses in Central Bangka Regency are carried out in groups and independently. There are 26 livestock farmer groups in Central Bangka Regency. Among them, 14 groups carry out beef cattle business integrated with oil palm with intensive, semi-intensive, or extensive maintenance management. In an intensive management system, livestock is kept in cowsheds continuously (Figure 1A). In a semi-intensive system, livestock is kept in cowsheds and released periodically (Figure 1B). As for the extensive management system, livestock is fully grazed in the oil palm plantation area (Figure 1C). Until 2019, the number of cattle integrated with oil palm reached 1.144 heads and involved 205 farmers spread across Central Bangka Regency. Most farmer groups and individual farmers raised Bali cattle (Matondang *et al.*, 2019).

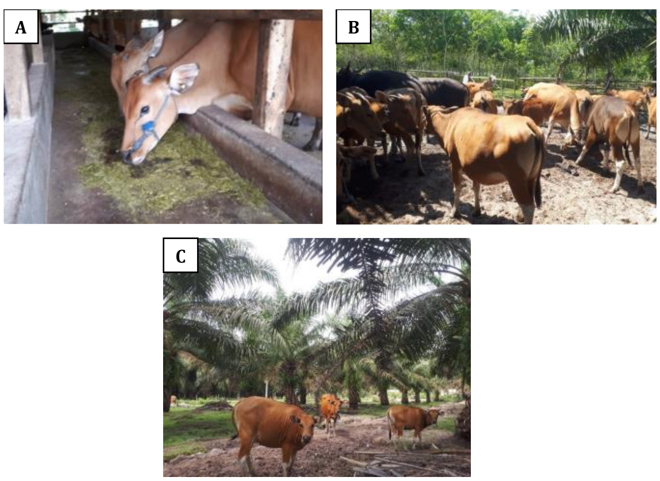


**Figure 1. Integration of Bali cattle with oil palm plantations with rearing management systems: Intensive, where the cattle are kept in cowsheds continuously (A); semi-intensive, whereby cattle are kept in cowsheds (5.00 PM-10.00 AM) and released (10.00 AM-5.00 PM) periodically (B); extensive, where cows are fully grazed in the oil palm plantation area (C).**

The study's results revealed that the farmer's reasons for choosing a management system were determined mainly by the area and location of the land as well as the presence or absence of a compost processing business. Compost processing can only be done if the manure is collected in the cowshed. Most livestock-oil palm integrated systems in Central Bangka implement a semi-intensive management system (Table 1). This system makes it easier for farmers to provide feed than an intensive system, and farmers also obtain additional benefits from processing manure into organic fertilizer (Wulandari and Deciyanto, 2020).

This research analyzed farmer competence by gender, age, education level, farming experience, and primary occupation (Table 2). In the intensive and extensive rearing system, all work was done by male farmers, as the local community assumed that men were the breadwinners in the family. In semi-intensive management systems, there were 14,29% female farmers. The involvement of rural women farmers has long been known to have an essential role as one of the pillars of food production (Raidimi, 2014; Diiro *et al.*, 2018). Women in rural areas have been reported to be effective community mobilization and social development agents. Rural women are essential in agricultural production systems (Adenugba and Raji-Mustapha, 2013). The presence of women in livestock-farming activities from various studies can provide financial contributions in the form of increasing family income (Amrawaty *et al.*, 2017).

Respondents who applied intensive management systems had a better level of education, and 60% of them graduated from high school. In the semi-intensive maintenance system, most only finished elementary and junior high schools, respectively 33.33%. While in extensive management, most (52.17%) graduated from elementary school. Farmers' education level affects behavior and decision-making in accessing information, technology, capital, and markets (Ntshangase *et al.*, 2018).

Most respondents in this study are the productive age (15-55), indicating that most were in good physical condition to manage beef cattle farms. In this study, the 36-45 years group was the most dominant age group. This age group is the peak productive age for agricultural workers in the USA (Tauer, 2017). The farmer's age influences how farmers obtain information on technology (Mittal and Mehar, 2015). Farmers are more actively seeking information from various sources at a productive age. Hence, productive age also influences the inputs of technological innovation that will be applied.

Most farmers in all beef cattle management systems are novice farmers (Table 2). Farming experience of less than 10 years is categorized as a novice farmer (Ahearn and Newton, 2009). The length of experience in raising livestock affects the success rate of farmers in developing their businesses (Sirajuddin *et al.*, 2016). Most of the respondents in this study have a main job as cash crop farmers, while beef cattle is only a side business. The characteristics of novice farmers tend to be unstable, limited livestock and land ownership, and low livestock productivity. Therefore, they need a lot of attention from the government, especially regarding capital and technology support (Ahearn and Newton, 2009).

***Adequacy of livestock nutrition***

***Feed nutrient*:** The type of feed given to Bali cattle with this integrated system differed for each rearing management. The difference in the type of feed affects the DM content. Higher DM was found in intensive management due to the type of feed given, which consisted of a mixture of PKE and chopped OPF. Cattle reared under semi-intensive management were fed a mixture of PKE, OPF, and consumed forage in the plantation area while the cows were grazing. Bali cattle in extensive management only consumed forage during grazing, which has a lower DM (23.65%).

Dry matter and crude protein content of fresh OPF is generally only 31.1% and 4.2%, respectively (Ishida and Abu Hassan, 1997; Wan Zahari *et al.*, 2003). Protein availability in all rearing management ranged from 8.62% to 8.86%. The protein level in the feed affects the growth performance and characteristics of the carcass (Li *et al.*, 2014). Bali cattle still produce good carcass quality if fed 12% crude protein (Tahuk *et al.*, 2018).

As an essential element, the content of minerals in the feed is also analyzed. The main minerals are Ca and P, which reinforce the structure of bones and teeth (Cherian, 2019). Ca and P are important minerals that can affect growth and reproduction in cattle. Cattle that are grazed on land with low P levels often experience a deficiency of P which results in slow growth (Dixon *et al.*, 2020). The results showed that Bali cattles reared extensively received less Ca and P than Bali cattles reared intensively and semi-intensively. Ca content in forage on oil palm land ranges from 0.14-0.39%. The content of minerals in the forage is determined by the mineral content in the soil where the forage grows. If the soil where the forage grows is poor in minerals, the forage that grows will also be deficient in minerals(Gartenberg *et al.*, 1990). The content of P and Ca in forage in the tropical area of South Sumatra, which neighbors the island of Bangka, is also influenced by the season (Ali *et al.*, 2019).

The content of Ca in oil palm fields decreases as oil palm plantations age (Viegas *et al.*, 2021). The lowest calcium availability was found in extensive rearing management, which was 0.21%. If calculated with a DM of 23.65% (Table 4), the amount of Ca is only 0.49 g/kg Dry Matter Intake (DMI). Meanwhile, the dietary requirement of Ca for beef cattle is 5.12 g/kg DMI (Costa E Silva *et al.*, 2015). The level of Ca in the blood of Bali cattle reared in rice fields were also low due to consuming feed with low Ca (Pujiastari *et al.*, 2015). Phosphorus is essential in bone mineralization and reproduction (Zhou *et al.*, 2021). In this study, the availability of P in extensive rearing management was higher than intensive and semi-intensive. In the extensive rearing management, animals can choose specific forage in plantation areas dominated by grasses and legumes. Legumes in the tropics have an average P content of 3.82 g/kg DM (Castro-Montoya and Dickhoefer, 2020).

The highest content of ADF, NDF, and lignin was found in the feed given to intensive management, which was 54.4%; 68.4%; and 17.9%, respectively. Meanwhile, the cellulose content was almost the same in all management systems, ranging from 31.3%-33.1%. The high lignin in this intensive system is because most of the feed comes from OPF. The lignin content in OPF is reported to be as high as 20% to 20.5% (Ishida and Abu Hassan, 1997). Lignin is a combination of closely related compounds containing carbon, hydrogen, and oxygen. Lignin is highly resistant to chemical degradation, including enzymatic degradation (Janusz *et al.*, 2017). High lignin in forages can inhibit cell wall degradation during digestion (Casler and Jung, 2006; He *et al.*, 2018). Degradation of lignin and cellulose in the rumen can be increased by adding cosubstrate during rumen fermentation, such as a feed from food waste (Xing *et al.*, 2020).

***The consumption of feed nutrients*:** The consumption of DM in intensive and extensive rearing management tends to be lower than DM consumption in semi-intensive. The low consumption of DM in intensive rearing management was due to the low consumption of fresh feed ingredients. In addition, it can also be caused by the low palatability of oil palm fronds. Young Bali cattle fed fresh chopped palm fronds mixed with palm kernel expeller were reported to have low palatability (Ibrahim *et al.*, 2013).

The high levels of NDF in intensive management systems also affect the low consumption of DM. The component of NDF fills the rumen space and is slow to digest. So the lower the NDF content, the more feed can be consumed (Poorkasegaran and Yansari, 2014). Meanwhile, the low consumption of DM in extensive rearing management was due to the lower DM content of forage in oil palm plantations compared to the other two treatments, low forage productivity in oil palm areas, and the number of cattle grazing exceeds the available forage.

Significant differences in protein consumption occurred in young females and female calves, where protein consumption in intensive and extensive rearing management was lower than in the cows reared in semi-intensive systems (Table 5).

In general, protein consumption in beef cattle with the cattle-palm oil integration system in this study was low.

The consumption of Ca in extensive rearing management was lower than intensive and semi-intensive rearing management in all groups of cattle. The low Ca consumption was due to the low Ca content in forage in oil palm plantation areas which was consumed in extensive rearing management (Table 4). Additional mineral intake is needed to meet the Ca requirement (Zhou *et al.*, 2021). The highest P consumption in cattle was shown by extensive rearing management. Meanwhile, P consumption in semi-intensive rearing management tended not to differ significantly from extensive rearing management. P content in the feed consumed in intensive rearing was lower than in semi-intensive and extensive rearing management.

***Dry matter digestibility*:** The difference in rearing management significantly effect DM digestibility in most groups of cattle observed. The digestibility of DM in intensive rearing management was lower than in semi-intensive and extensive. The low digestibility of DM in intensive rearing management was caused by the high content of NDF (68.4%) and lignin (17.9%) in the feed given, which is a mixture of palm fronds and palm kernel expeller (Harper and McNeill, 2015; Janusz et al., 2017). Similar results were that young Bali cattle treated with palm fronds as much as 40%-60% experienced DM digestibility of 53.51%-54.56% (Nanda *et al.*, 2014). The same results were also obtained for the DM digestibility of 25-40% rice straw-based feed, ranging from 60.93 - 64.53% (Widodo *et al.*, 2012). However, the digestibility of DM in intensive rearing management was better than that of DM in feed containing citronella pulp and fresh citronella in buffalo, namely 49.9% and 44.1% (Sari *et al.*, 2017).

***Organic matter digestibility*:** Different rearing management in this study significantly affected the digestibility of OM. The digestibility of OM in intensive rearing management was lower than in semi-intensive and extensive rearing management in groups of adult bulls, young males, heifers, and female calves. Meanwhile, OM digestibility in semi-intensive rearing management was relatively the same as in extensive rearing management. The digestibility of OM in intensive rearing management ranged from 44.4% to 79.1%. The lowest OM digestibility was obtained in the group of young bulls (44.36%). Moreover, the OM digestibility value was relatively average in the other observed cattle groups. In vitro study using *Phanerochaete chrysosporium* mold resulted in palm midrib OM digestibility of ranged from 42.24% to 51.63% (Rahayu *et al.*, 2015).

The digestibility of OM in extensive rearing management was significantly high (72.6%-80.3%). The feed of Bali Cattle in this rearing management was obtained from palm oil trees and the forage in the plantation areas. The digestibility of OM in Bali cattle with feed based on natural grass and Kumpai grass was passably in the range of 73.14%-79.96% (Riswandi *et al.*, 2015).

***Lignin digestibility*:** Lignin digestibility showed significant differences in young bulls, young females, male calves, and female calves with different rearing management. The digestibility of lignin in young bulls, heifers, male calves, and female calves in intensive rearing management was lower than in semi-intensive and extensive rearing management. The level of lignin digestibility was higher than that of rice straw feed lignin with the addition of 2% Saccharomyces cerevisiae which only resulted in 37% lignin digestibility (Suryapratama and Suhartati, 2012).

Table 5 shows that the mean digestibility of lignin was lower than DM, OM, and cellulose in all maintenance management systems. Lignin is the most difficult-to-digest feed component (Janusz *et al.*, 2017). The lignin and hemicellulose fractions are linked by ferulate cross-links, which decrease cell wall digestibility (Grabber, 2005). Rumen microbes are blocked by high concentrations of lignin in the primary wall, thereby preventing the total digestion of plant cells (Harper and McNeill 2015). Lignin that livestock can tolerate is 7% (Goering and Van Soest, 1970).

***Cellulose digestibility*:** Different rearing management in this study significantly affects the cellulose digestibility in adult bulls, young males, heifers, male calves, and female calves (Table 6). Cellulose digestibility in intensive rearing management was lower than in semi-intensive and extensive rearing. Meanwhile, the semi-intensive and extensive rearing management tended to be the same in all groups of cattle observed. The high lignin content of consumed feed influenced the low digestibility of cellulose in intensive rearing management. The binding of lignin to cellulose fiber makes plant cell walls solid (Abdel-Hamid *et al.*, 2013). Cellulose is the main constituent of plant cell walls (Harris and DeBolt, 2010). However, the cellulose digestibility in this study was better than that of rice straw feed with the addition of 2% Saccharomyces cerevisiae, which only had 25.66% cellulose digestibility (Suryapratama and Suhartati, 2012).

***Average daily gain*:** The low DM, protein, and Ca consumption caused low ADG in young female cattle, male calves, and female calves in extensive rearing management. The ADG of bulls obtained in this study was ranged from 150.4-164.1 g/day, lower than ADG of young bulls (206.8-246.9 g/day) and male calves (157.4-236.4 g/day). The differences in ADG in various cattle age shows that beef cattle's age affects growth. Bali cattle's growth increased rapidly from weaning to sexual maturity (Sri Rachma *et al.*, 2011).

Average daily gain obtained in this study was relatively low due to the low DM, protein, and Ca consumption in young cows and calves. Bali cattle have a low growth rate even during the calf period (Made *et al.*, 2020). However, this breed is superior in reproductive efficiency (Pribadi *et al.*, 2015) and the ability to adapt to extreme conditions (Martojo, 2012). Therefore, Bali cattle are suitable for smallholder farmers and non-intensive rearing systems (Martojo, 2012). Average daily gain of Bali cattle on oil palm-cattle integration can be improved by fermentation feed (Ibrahim *et al.*, 2013).

***Conclusion:*** Smallholder farmers implementing the integration of livestock-oil palm in Central Bangka Regency were dominated by inexperienced novice farmers. The farmer's reason for choosing a rearing management system was determined by the area and location of the land and the presence or absence of compost processing. The majority of the farmer choose semi-intensive rearing management as this system produces by-products and gives higher weight gain to Bali cattle due to it being supported by better feed quality. The consumption of DM in the semi-intensive system was the highest compared to other systems, especially in young bulls, heifers, male calves, and female calves. Therefore, it can be concluded that the semi-intensive management system is the best model in the Bali cattle-oil palm integration system in the rural dryland area, in accordance with nutritional status and the characteristics of smallholder farmers in Indonesia. This system can be an alternative for sustainable agriculture, especially in oil palm plantation areas on dry land.

***Conflict of interest***: The authors declare no conflict of interest.

***Authors' contribution statements*:** Z.H. designed the experiment; Z.H. Wrote the original draft with the help of S.S. (Suyatno); Z.H. and S.S (Suyatno) reviewed and edited the manuscript; Z.H., S.S (Suharyanto) and S.S. (Suyatno) field study and supervision of the cattle-oil palm integrated project in Central Bangka Regency; R.P., H.N., and L.A. supervised the study. All authors read and approved the final manuscript.

## REFERENCES


Abdel-Hamid, A.M., J.O. Solbiati and I.K.O. Cann. 2013. Insights into Lignin Degradation and its Potential Industrial Applications. Adv Appl Microbiol 82:1-28.

Adenugba, A.O. and N.O. Raji-Mustapha. 2013. The Role of Women in Promoting Agricultural Productivity and Developing Skills For Improved Quality of Life In Rural Areas. IOSR Journal of Engineering 3:5-51.

Agus, A. and T.S.M. Widi. 2018. Current situation and future prospects for beef cattle production in Indonesia - A review. Asian-Australas J Anim Sciencs. 31:976.

Ahearn, M.C. and D.J. Newton. 2009. Beginning Farmers and Ranchers. *SSRN Electronic Journal*, doi: 10.2139/SSRN.1408234.

Ali, A.I.M., S. Sandi, Riswandi and Muhakka. 2019. Seasonal influence on mineral concentration of forages on flooded pastures in South Sumatra, Indonesia. *Tropical Grasslands-Forrajes Tropicales* 7:527–532.

Amrawaty, A.A., S.N. Sirajuddin, V.S. Lestari and A. Abdullah. 2017. Gender Analysis on Beef Cattle Farm. *American-Eurasian Journal of Sustainable Agriculture* 11:43–45.

Asikin, Z., D. Baker, R. Villano and A. Daryanto. 2020. Business Models and Innovation in the Indonesian Smallholder Beef Value Chain. *Sustainability 2020, Vol. 12, Page 7020* 12:7020.

BPS Statistic Indonesia. 2020. *Indonesian Palm Oil Statistics* Suwarti. Happy Hardjo, S. Setiawati, Rita. Hariyanto, Sulistina (ed.). BPS - Statistics Indonesia.

Casler, M.D. and H.J.G. Jung. 2006. Relationships of fibre, lignin, and phenolics to in vitro fibre digestibility in three perennial grasses. Anim Feed Sci Technol 125:151-161.

Castro-Montoya, J.M. and U. Dickhoefer. 2020. The nutritional value of tropical legume forages fed to ruminants as affected by their growth habit and fed form: A systematic review. Anim Feed Sci Technol 269:114641.

Cherian, G. 2019. A Guide to the Principles of Animal Nutrition. Oregon State University.

Costa E Silva, L.F., S. De Campos Valadares Filho, T.E. Engle, P.P. Rotta, M.I. Marcondes, F.A.S. Silva, E.C. Martins and A.T. Tokunaga. 2015. Macrominerals and Trace Element Requirements for Beef Cattle. PLoS One 10:e0144464.

Devendra, C. 2011. Integrated Tree Crops-ruminants Systems in South East Asia: Advances in Productivity Enhancement and Environmental Sustainability. Asian-Australas J Anim Sciences 24:587–602.

Diiro, G.M., G. Seymour, M. Kassie, G. Muricho and B.W. Muriithi. 2018. Women’s empowerment in agriculture and agricultural productivity: Evidence from rural maize farmer households in western Kenya. PLoS One 13:e0197995.

Dixon, R.M., S.T. Anderson, L.J. Kidd, M.T. Fletcher, R.M. Dixon, S.T. Anderson, L.J. Kidd and M.T. Fletcher. 2020. Management of phosphorus nutrition of beef cattle grazing seasonally dry rangelands: a review. Anim Prod Sci 60:863–879.

Gartenberg, P.K., L.R. McDowell, D. Rodriguez, N. Wilkinson, J.H. Conrad and F.G. Martin. 1990. Evaluation of the trace mineral status of ruminants in northeast Mexico. *Livestock* Research for Rural Development 2:34–42.

Goering, H.K. (Harold K. and P.J. Van Soest. 1970. Forage fiber analyses:apparatus, reagents, procedures, and some applications.

Grabber, J.H. 2005. How Do Lignin Composition, Structure, and Cross-Linking Affect Degradability? A Review of Cell Wall Model Studies. Crop Sciences 45:820–831.

Harper, K.J. and D.M. McNeill. 2015. The Role iNDF in the Regulation of Feed Intake and the Importance of Its Assessment in Subtropical Ruminant Systems (the Role of iNDF in the Regulation of Forage Intake). Agriculture 5:778–790.

Harris, D. and S. DeBolt. 2010. Synthesis, regulation and utilization of lignocellulosic biomass. Plant Biotechnol Journal 8:244–262.

He, Y., T.M.B. Mouthier, M.A. Kabel, J. Dijkstra, W.H. Hendriks, P.C. Struik and J.W. Cone. 2018. Lignin composition is more important than content for maize stem cell wall degradation. *J Sci Food Agric* 98:384–390.

Ibrahim, M.S., U. Budi and T.H. Wahyuni. 2013. Utilization of Oil Palm Frond Fermented by Aspergilus niger on Performances of Bali Cattle Males. *Jurnal Peternakan Integratif* 2:66–74.

Ishida, M. and O. Abu Hassan. 1997. Utilization of Oil Palm Frond as Cattle Feed. *Jpn Agric Res Q* 31:41–47.

Janusz, G., A. Pawlik, J. Sulej, U. Świderska-Burek, A. Jarosz-Wilkolazka and A. Paszczyński. 2017. Lignin degradation: microorganisms, enzymes involved, genomes analysis and evolution. *FEMS Microbiol Rev* 41:941–962.

Li, L., Y. Zhu, X. Wang, Y. He and B. Cao. 2014. Effects of different dietary energy and protein levels and sex on growth performance, carcass characteristics and meat quality of F1 Angus × Chinese Xiangxi yellow cattle. *J Anim Sci Biotechnol* 5:21.

Made, N., A. Gemuh and R. Astiti. 2020. Birth Weight and Growth Rate of Bali Cattle Calf. *Technium* 2:436–441.

Martojo, H. 2012. Indigenous bali cattle is most suitable for sustainable small farming in Indonesia.

Matondang, R.H., A. Priyanti, I.W. Mathius, S. Bahri, Z. Hidayat, C.T. Rahayu and A.M. Sari. 2019. *Perjalanan panjang integrasi sawit-sapi di Bangka Belitung*, 1st Ed. IPB Press, Bogor.

Mittal, S. and M. Mehar. 2015. Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model. *The Journal of Agricultural Education and Extension: Competence for Rural Innovation and Transformation* 22:199–212.

Mohamad, K., M. Olsson, G. Andersson, B. Purwantara, H.T.A. van Tol, H. Rodriguez-Martinez, B. Colenbrander and J.A. Lenstra. 2012. The origin of Indonesian cattle and conservation genetics of the Bali cattle breed. *Reprod Domest Anim* 47 Suppl 1:18–20.

Mookiah, S., W.N. Wan Mohamed, 'Abidah Md Noh, N.A. Ibrahim, M.A. Fuat, S.K. Ramiah, E.L. Teik Chung and N.L.H. Mat Dian. 2020. Treated oil palm frond and its utilisation as an improved feedstuff for ruminants–An overview. Asian-Australas Journal Anim Sciences doi: 10.5713/ajas.20.0360.

Nanda, D.D., A. Purnomoadi and L.K. Nuswantara. 2014. Production Performance of Bali Cattle Fed With Various Levels of Oil Palm Frond. AGROMEDIA: Berkala Ilmiah Ilmu-ilmu Pertanian 32.

Ntshangase, N.L., B. Muroyiwa and M. Sibanda. 2018. Farmers' Perceptions and Factors Influencing the Adoption of No-Till Conservation Agriculture by Small-Scale Farmers in Zashuke, KwaZulu-Natal Province. Sustainability 10:555 10:555.

Oktaviani, L. 2022. Converting Ex-Mining Site Into Plantation Land in the Province of the Bangka Belitung Island. *Proceedings of the International Conference on Sustainable Environment, Agriculture and Tourism*

Ooi, Z.X., Y.P. Teoh, B. Kunasundari and S.H. Shuit. 2017. Oil palm frond as a sus(ICOSEAT 2022) 26:692–695.tainable and promising biomass source in Malaysia: A review. *Environ* Prog Sustain Energy 36:1864-1874.

Poorkasegaran, S. and A.T. Yansari. 2014. Effects of different sources of carbohydrates on intake, digestibility, chewing, and performance of Holstein dairy cows. Journal Anim Sciences Biotechnol 5:1-11.

Pribadi, L.W., S. Maylinda, M. Nasich and S. Suyadi. 2015. Reproductive efficiency of Bali cattle and it's crosses with Simmental breed in the lowland and highland areas of West Nusa Tenggara Province, Indonesia. *Livestock Research for Rural Development* 27.

Priyanto, R., H. Nuraini, . M., M. Ismail and H. Wijayanto. 2019. Slaughter, Carcass and Non-Carcass Characteristics of Local Cattle and Buffalo in Indonesia. Pakistan Journal of Nutrition 18:117–124.

Pujiastari, N.N.T., P. Suastika and N.K. Suwiti. 2015. Level Of Mineral Calcium and Iron on the Bali Cattle Being Farmed in the Rice Field. Buletin Veteriner Udayana 7:66–72.

Rahayu, S., N. Jamarun, M. Zain and D. Febrina. 2015. Pengaruh Pemberian Dosis Mineral Ca dan Lama Fermentasi Pelepah Sawit terhadap Kandungan Lignin, Kecernaan BK, BO, PK dan Fraksi Serat (NDF, ADF, Hemiselulosa dan Selulosa) menggunakan Kapang Phanerochaete chrysosporium (In-vitro digestibility of Nutrients Components of Palm Frond fermented by Phanerochaete chrysosporium supplemented with Calcium). *Jurnal Peternakan Indonesia (*Indonesian Journal of Animal Science 17:151–162.

Raidimi, E.N. 2014. The Roles and Activities of Women in the Six Selected selected agricultural projects in Thulamela Local Municipality of Vhembe District Municipality in the Limpopo Province. South African Journal of Agricultural Extension 42:10–23.

Riswandi, Muhakka and M. Lehan. 2015. Evaluasi Nilai Kecernaan Secara In Vitro Ransum Ternak Sapi Bali yang Disuplementasi dengan Probiotik Bioplus. *Jurnal Peternakan Sriwijaya* 4:35-46.

Sari, A., W. Manguwardoyo and I. Sugoro. 2017. Degradation of Waste and Fresh Citronella (Cymbopogon nardus L) using In Sacco Method in Rumen Fistulated Buffalo. *Conference: Prosiding Seminar Nasional Teknologi*

*Peternakan dan Veteriner*. Indonesian Center for Animal Research and Development (ICARD). pp.118–124.

Sirajuddin, S.N., Hastang, St. Rohani and M.E. Kurniawan. 2016. Level technology adoption and characteristic cattle breeders who following Bachelor Village Building. *American*-Eurasian Journal of Sustainable Agriculture 10:28-33.

Sri Rachma, A.B., H. Harada and T. Ishida. 2011. The Estimation of Growth Curve of Bali Cattle at Bone And Barru Districts, South Sulawesi, Indonesia Using Ten Body Measurements. J Indones Trop Anim Agric 36:228-236.

Steel, R.G.D. and J.H. Torrie. 1993. *Prinsip dan prosedur statistika : suatu pendekatan biometrik alih bahasa Bambang Sumantri (Principles and procedures of statistics: a biometrical approach)*, 2nd Ed. Gramedia Pustaka Utama, Jakarta.

Suryapratama, W. and F.M. Suhartati. 2012. Fermentasi Jerami Padi Menggunakan White rot fungi dan Suplementasi Saccharomyces cerevisiae Pengaruhnya terhadap Kecernaan Nutrien Secara In Vitro. Jurnal Agripet 12:1-6.

Suyatno, Z. Hidayat, Suharyanto and W. Wibawa. 2021. Integrated livestock and oil palm plantation as sustainable agricultural bioindustry in Bangka Island, Indonesia. *E3S Web of Conferences* 306:05008.

Tahuk, P.K., S.P. S Budhi, Panjono and E. Baliarti. 2018. Carcass and Meat Characteristics of Male Bali Cattle in Indonesian Smallholder Farms Fed Ration with Different Protein Levels. Tropical Animal Science Journal 41:215-223.

Tauer, L.W. 2017. Farmer Productivity By Age Over Eight U.S. Census Years.

Viegas, I. de J.M., M.G. Costa, E.V. de O. Ferreira, N.L.P. Perez, H. da S. Barata, J.R. Galvao, H.E.O. da Conceicao and S.D. do E. Santo. 2021. Contribution of Pueraria phaseoloides L. in the Cycling of Macronutrients in oil Palm Plantations. Journal of Agricultural Studies 9:1–13.

Wan Zahari, M., O. Abu Hassan, H.K. Wong and J.B. Liang. 2003. Utilization of oil palm frond - Based diets for beef and dairy production in Malaysia. Asian-Australas J Anim Sci 16:625–634.

Widi, T.S.M. 2015. Mapping the impact of crossbreeding in smallholder cattle systems in Indonesia. Wageningen University, Wageningen.

Widodo, W., F. Wahyono and S. Sutrisno. 2012. Kecernaan Bahan Kering, Kecernaan Bahan Organik, Produksi VFA dan NH3 Pakan Komplit Dengan Level Jerami Padi Berbeda Secara in Vitro. Animal Agriculture Journal 1:215-230.

Wulandari, S. and S. Deciyanto. 2020. Strategies for Increasing the Use of Organic Fertilizers in the Palm Cattle Integration System. Perspektif, Rev.Pen. Tan. Industri 19:136–148.

Xing, B.S., Y. Han, S. Cao, J. Wen, K. Zhang, H. Yuan and X.C. Wang. 2020. Cosubstrate strategy for enhancing lignocellulose degradation during rumen fermentation in vitro: Characteristics and microorganism composition. *Chemosphere* 250:126104.

Zhou, J., J. Zhang, B. Xue, S. Yue, C. Yang and B. Xue. 2021. Effects of Premating Calcium and Phosphorus Supplementation on Reproduction Efficiency of Grazing Yak Heifers. Animals (Basel) 11:1-9.