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Research Article

Reproductive Performance of Beef Cows in Peatlands of Central Kalimantan, Indonesia

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Abstract | The reproductive performance of beef cows is highly contingent on the calcium (Ca), phosphorus (P) and copper (Cu). The aim of this study was to evaluate the availability of Ca, P and Cu in peat soil, forage, blood serum and their impact on reproductive performance of beef cows. This study was carried out at peatlands of Pulang Pisau district, Central Kalimantan Province through observation method supported by laboratory analysis. Reproductive performance data were obtained through direct interviews and recording cards. Soil and forage samples were taken from the main forage source locations. A total of 138 blood samples were taken through the jugular vein from Bali cows and their crossbred cows with different physiological status. Soil and blood serum samples were analyzed in laboratory using Atomic Absorption Spectrophotometry (AAS) method, while forage samples were analyzed according to the Association of Official Analytical Chemists (AOAC) method. The results showed that the availability of Ca and Cu both in peat soil and forage was very low, while that of P was quite high. The crossbred cows showed significantly higher concentration of Ca, P and Cu in blood serum if compared to Bali cows. However, the blood serum analysis of minerals suggested that there were Ca and Cu deficiency the beef cows raised in peatlands. In general, Ca and Cu deficiency in breeding cows raised in peatlands of Central Kalimatan Province had negative impact on reproductive performances including delayed age at puberty and first calving, delayed postpartum estrus and longer calving interval.

Keywords | Calcium, Phosphorus, Copper, Peatland, Reproductive Performance

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INTRODUCTION

Indonesia is the country with the largest peatlands in the Southeast Asia and these areas cover almost 20,200,000 hectares (>80%) of total peatlands in Southeast Asia (Asean-Secretariat, 2021). In Central Kalimantan, it ocuppies 2,659,234 hectares (13.16%) of Indonesia's peatland areas (Ritung et al., 2011). Peatlands are one of the agro-ecosystems that are widely used for beef cattle farming in Central Kalimantan. Peat soil has specific characteristics, namely; acidic, contains pyrite, high porosity, low nutrient availability, and low mineral content (Fahmi et al., 2014; Masganti et al., 2017; Setiadi et al., 2016; Szajdak et al., 2007).

Minerals are micronutrients which play a significant role in growth, health and productivity of livestock (Velladurai et al., 2016) and essential for maintaining growth, reproduction and health (Jones & Tracy, 2013). The need of beef cattle minerals must be continuously fulfilled since they cannot be synthesized in the body (Sharma et al., 2002). Cow's reproductive performance is obviously dependent on their mineral status (Kumar et al., 2011; Pradhan &

Nakagoshi, 2008), so that excess or deficiency of minerals can cause reproductive disorders/failures. Reproductive failure might occur due to a deficiency of one or several types of minerals and an imbalance between minerals (Gupta et al., 2005; Sharma et al., 2007).

The vast potential of land with abundant forage has not been in line with the development of beef cattle population in Central Kalimantan. This may be seen from the slow population growth, only 1.68% per year. There was even a fairly large population decline of approximately 17.27% from 2017 to 2018 (BPS-Kalteng, 2020). Characteristics of peatlands that are acidic, fragile and lack minerals are thought to be the major causes of the suboptimal productivity of beef cattle in that area.

Studies related to mineral content in soil, forage and in the body of cows have been carried out by a number of research groups including Gartenberg et al. (1990), Gizachew et al. (2002), Ndebele et al. (2005), Kumaresan et al. (2010), Besung (2013), Pujiastari et al. (2015), and Fridjayanti et al. (2019). They generally carried out studies specifically in their respective regions on various land typologies but conducted on mineral soils. To date, no specific study has been conducted on peat soils. This study aimed to evaluate the availability of Ca, P and Cu in peat soil, forage, blood serum and their impact on the reproductive performance of beef cows raised on peatlands in Central Kalimantan.

MATERIALS AND METHODS

Ethical Approval

All treatments in this study have been approved by the Experimental Animal Welfare Commission (KKHB) of the Agricultural Research and Development Agency with registration number; Balitbangtan/BPTP Kalteng/Rm/01/2021.

Study Area

This study was conducted in Pulang Pisau district, Central Kalimantan Province, Indonesia from April to August 2021. The location was determined using purposive sampling approach with several considerations involving existence of peatlands, population size and availability of research materials.

Pulang Pisau district is located in Central Kalimantan Province with geographical position between 113030'00"-114015'00" EL and 1032'00"-3028'00" SL and it is located in the lowlands with an altitude of 0-100 m above sea level. The dominant agroecosystem in this area is tidal swamplands with dominant soil types peat and alluvial soil. The area of peatlands covers almost 604,033 ha (67.14%) of the total area (Ritung et al., 2011). This region generally has a tropical and humid climate. The average temperature and humidity during the study period were 27.51°C and 86.19%, respectively.

Research Material

The cows used in this study include Bali cows and crossbred cows (crossing local cattle with Bos taurus through Artificial Insemination) in a cow-calf operation that are intensively reared on peatlands. Cows are grouped according to their physiological status, namely; heifers, dry period, lactation and gestation.

A total number of 138 cows; 80 Bali cows and 58 crossbred cows (Local X Bos taurus) had been included in this study. Reproductive performance study involved 116 cows; 57 Bali cows and 59 crossbred cows (Local X Bos taurus). And blood samples had been collected from 138 cows; 80 Bali cows and 58 crossbred cows (Local X Bos taurus). A total of 4 soil samples were collected, which are composite samples representing 4 locations where forage grows, namely irrigation bunds, plantations, fodder gardens and vacant land. There were 6 forage samples collected, which were composite samples, as a representation of the 6 main forage species growing at the soil sampling site.

Research Methods

This research uses observation method supported by laboratory analysis. Respondents were determined by purposive sampling with several considerations involving location of farm on peatland, type of business cow-calf operation, duration of raising cattle ≥5 years. The number of respondents involved in this study were 39 smallholder farmers.

Data Collection

Reproductive Performance Data Collection: Cow's reproductive performance data were obtained through direct interviews with farmers, recording cards and information from inseminators.

Soil and Forages Sample Collection: Soil and forage samples used for laboratory analysis were composite samples of sub-samples collected from 5 villages. Soil and forage samples from each village were taken at the main locations where forage grows, namely irrigation bunds, plantations, fodder gardens and vacant land.

Soil sampling at each location used diagonal spot sampling technique according to Budi (2015). Soil samples at each location were taken at 9 points. The amount of soil taken at each point was 200 g at a depth of 10-20 cm. Soil samples from each point were then grouped based on differences in location. A collection of soil samples from the same location was then mixed homogeneously and taken as much as

1000g. Composite samples from each location were then packaged and analyzed in the laboratory.

Forage sampling technique at each location is done according to Soejono (2007). A total of 200 g of fresh forage was taken randomly at 10 points at each location. Forage samples from each point then separated and grouped by type of forage. A collection of similar samples from each location were chopped into 3-5 cm pieces and mixed homogeneously. A total of 1000 g of each type of forage was taken to be dried and analyzed in the laboratory.

Blood Serum Sample Collection: A total of 3-5 ml blood was taken through the jugular vein of each cow, then accommodated in a vacutainer tube without anticoagulant. The blood-filled tube was then tilted to widen the surface area for 20 minutes until the serum separates from the clot. Serum was then transferred to an Eppendorf tube and put in an icebox to be transported to laboratory. Upon arrival at the laboratory, the serum samples were stored at -20°C until analysis.

Laboratory Analysis

The analysis of mineral content in the soil was carried out at the Laboratory of Soil Research Institute (BALITTANAH) Bogor, using the Atomic Absorption Spectrophotometry (AAS) method. Analysis of mineral content in forage was carried out in the laboratory of the Center for Quality Testing and Certification of Feed (BPMSP) Bekasi, using the Association of Official Analytical Chemists (AOAC) method. Analysis of mineral content in blood was carried out at the Diagnostic Laboratory of the Veterinary Research Institute (BBLitvet) Bogor, using the Atomic Absorption Spectrophotometry (AAS) method.

Observed Variables

The observed reproductive performances include age at puberty, age at first calving, postpartum estrus, and calving interval. Variables observed for the evaluation of mineral content in soil, forage and blood include soil pH, pyrite content, dry matter content of forage, and Ca, P and Cu content.

Statistical Analysis

Data were analyzed using descriptive statistics and analysis of variance (ANOVA) followed by Duncan's multiple range test according to Kaps & Lamberson (2004). Data were processed using the SAS procedure (V. 9.1; SAS Institute Inc., Cary, NC, USA) with mathematical models

$$Yij = \mu + \alpha i + \epsilon\, ij$$

Where:

Yij = observations j in treatment i

μ = the overall means

αi = the effect of treatment i (i = 1, 2,…n)

Єij = random error with mean 0 and variance σ2

RESULTS AND DISCUSSION

The research site is characterized by shallow peat with a thickness of <50 cm. The peat type in this area is classified as tidal peat with a level of sapric decomposition (Setiadi et al., 2016). The cattle in the peatland area were raised by smallholder farmers who ran only few cows as a side business. Beef cattle were generally kept intensively in a barn with a cut and carry feeding system. Bali cattle were given forage without addition of concentrate and mineral supplement, except crossbred cattle. The forages were obtained from irrigation bunds, plantations, fodder gardens and vacant land. The dominant forage given to the beef cattle was *Brachiaria humidicola* grass. Other forages such as *Pogonatherum crinitum, Cyperus rotundus, Axonopus compressus, Pennisetum purpureum, Hymenachine amplexicaulis, Scleria sumatrensis,* and *Imperata cylindrical* were given only in a limited quantity. Artificial insemination technique was mostly applied in breeding cows since there was a very limited number of bulls.

Calcium, Phosphorus and Copper Contents in Soil, Forage and Blood Serum

The results of soil analysis showed that the peat soil in the study area had a pH 4.25 and pyrite 0.04%. The mean contents of Ca, P and Cu in soil, forage and blood serum are presented in Table 1. The availability of Ca and Cu in peat soil was very low, while P was quite high. The high acidity of the soil, the presence of pyrite, and the low mineral availability of this study indicated the specific characteristics of peatlands. Szajdak et al. (2007) reported that the most prominent chemical properties of peat were high acidity, low nutrient availability, high organic acid, and pyrite content. Setiadi et al. (2016) stated that the chemical characteristics of peat soils in Central Kalimantan were characterized by very acidic, low availability of Ca and high availability of P.

The low content of Ca and Cu in peat soils was closely related to high acidity and soil porosity. According to Nugroho and Widodo (2001) the porosity of peat soils was very high, around 83.62-95.13%. The metallic nature of the heavy Ca and Cu and the characteristics of acidic and porous peat soil would make it easier for these minerals to dissolve and enter the deepest soil layers so that the mineral content in the top soil was very low (Besung, 2013; Darmono, 2007; Gartenberg et al., 1990).

The high concentration of total P in peat soil in this study was closely related to the high organic matter in peat

(Salampak, 1999) and the nature of P element which was not easily lost due to washing (Barrow, 1972). Salampak (1999) stated that the process of decomposition and mineralization of organic matter might open the P bonds for the ion exchange process, so that cations were able to bind P element that was released from the mineralization process. The high availability of P in peat soil was also influenced by P fertilization by farmers, especially in plantations and fodder gardens.

As shown in Table 1, forage existed in the peatlands contained very low Ca and Cu, while the P concentration in forage was in the normal category. The low content of Ca and Cu in forage was closely related to their low availability in the soil. Mineral elements in peat soil are also tightly bound by organic matter which make them unabsorbable by plants (Armanto et al., 2019). According to Bationo et al. (2007) the availability of nutrients in plants is also greatly influenced by soil conditions and types. Besung (2013) stated that the mineral content in forage is dictated by soil mineral levels and its pH, and therefore forages found in peatland areas with acid soils usually have very low mineral content.

In contrast, the P concentration of the forage in this study was considered adequate and lied within normal category. This might be due to the high concentration P in within soil and the application of P fertilizer by farmers in the peat area. Setiadi et al. (2016) stated that the characteristics of the location with abundant vegetation could also affect the availability of P since plant roots are able to take advantage of the nutrients through the nutrient cycle. According to Fridjayanti et al. (2019) and Besung (2013), the mineral content in the soil greatly affects the mineral content in forage and thus cow's body.

The results of blood serum analysis in this study also suggested that beef cows reared on peatland had Ca and Cu deficiency due to their low availability in the forage and soil, and an adequate P concentration which was in normal category (Table 1). Therefore, environmental conditions greatly affect the availability of minerals in forage, if the soil where the forage grows is deficient in minerals, the livestock that consume the forage will also show symptoms of mineral deficiency (Darmono, 2007; Gartenberg et al., 1990).

In Table 2, significant between breed differences occurred in Ca, P and Cu content of blood serum. The mineral content in the blood serum of crossbred cows was significantly ($P<0.05$) higher than that of Bali cows. These differences in blood serum minerals between the two breeds were closely related to their different feeding methods. The Crossbred cows were generally given better quality forage and sometime with concentrate and mineral supplementation, while Bali cows were merely fed forage without concentrate or mineral supplementation.

Statistical analysis showed no significant between physiological status differences in Ca and Cu content (Table 2). A significant difference ($P<0.05$) was observed only in P content between cow's physiological statuses, the P content of heifers was higher than that of the other cows. However, it was noticed that all the female cattle suffered from greater Ca and Cu deficiency. Gestating cows need more minerals for fetal growth, otherwise they would distribute their body minerals to the fetus and suffer from greater mineral deficiencies. According to Hostetler et al. (2003) minerals play a meaningful role in enzymatic and metabolic functions during pregnancy since the supply of minerals to the fetus is completely dependent on the cows. Mineral deficiency in pregnant cow could disturb the growth of the fetus and the health of the cows. Adequate minerals intake is required for the cows to meet the need for fetal growth during pregnancy and form milk synthesis during lactation period (Fadlalla et al., 2020).

Reproductive Performance

Based on field observations, the reproductive performance of cows reared on peatland were presented in Table 3. Overall, the cows had poor reproductive performance including delayed age at puberty, delayed age first calving and postpartum estrus and longer calving interval. Nevertheless, Bali cattle showed better reproductive performance than crossbred cattle.

The reproductive performance of beef cows is influenced by many factors. This study provide evidence that the low reproductive performance of beef cows in peatlands might be due to a marked deficiency of Ca and Cu minerals, and an inappropriate Ca and P balance. Macro minerals including Ca and P have a very important role in the process of animal reproduction (Kumar et al., 2011; Pradhan & Nakagoshi, 2008). Deficiency and imbalance minerals may cause reproductive failure (Gupta et al., 2005; Sharma et al., 2007). Bindari et al. (2013) stated that Ca deficiency would have a negative impact on livestock production and fertility. Cows with Ca deficiency will have impaired ovarian function, resulting in delayed estrus and first ovulation (Yosathai, 2014). Macro mineral deficiency also has an impact on delayed postpartum ovulation, pregnancy failure and abortion (Santos et al., 2010), decreased conception rates, lengthened calving interval, embryo and calf mortality after birth, and delayed sexual maturity (Ceylan et al., 2008).

In addition, micro minerals such as Cu also play a meaningful role in the reproduction of beef cows. Cows that are deficient in this mineral will show poor reproductive performance (Yosathai, 2014). Cu deficiency has an impact

Table 1: Calcium, phosphorus and copper contents of soil, forage and cows blood serum in Pulang Pisau peatlands

Description	Mineral type					
	Calcium	Unit	Phosphorus	Unit	Copper	Unit
Soil						
Total availability	64.00±23	ppm	67.5±12.6*	$mg100g^{-1}$	21.50±1.29	ppm
Normal	1.200-2.000**	ppm	15-60**	$mg100g^{-1}$	14-109***	ppm
Level	Very low		High		Low	
Forage						
Content	0.07±0.02	%	0.23±0.03	%	3.72±2.23	ppm
Normal****	1.36-1.74	%	0.23-0.34	%	9.26-11.10	ppm
Level	Very low		Normal		Very low	
Blood serum						
Content	2.50±0.63	$mgdL^{-1}$	5.20±1.71	$mgdL^{-1}$	0.16±0.09	μgmL^{-1}
Normal	8-11*****	$mgdL^{-1}$	4.5-6*****	$mgdL^{-1}$	0.7-0.9******	μgmL^{-1}
Level	Deficiency		Adequate		Deficiency	

*P_2O_5 ($HClO_4$-HNO_3), **(Eviati and Sulaeman, 2009), ***(Kabata-Pendias, 2010), ****(NRC, 2000), *****(Kincaid, 2008), ******(Kincaid, 2000).

Table 2: Mean (±SD) content of calcium, phosphorus and copper in blood serum of beef cows in peatland based on breed differences and physiological status

Breed/physiological status	Mineral content		
	Ca ($mgdL^{-1}$)	P ($mgdL^{-1}$)	Cu (μgmL^{-1})
Breed			
Crossbreeds (n=58)	2.76±0.66[a]	5.71±1.94[a]	0.20±0.11[a]
Bali (n=80)	2.32±0.53[b]	4.83±1.43[b]	0.12±0.05[b]
Physiological status			
Heifers (n=30)	2.53±0.67	5.73±2.35[a]	0.15±0.09
Dry period (n=30)	2.50±0.60	5.48±1.98a[b]	0.17±0.09
Lactation (n=42)	2.46±0.63	4.97±1.24a[b]	0.16±0.08
Gestation (n=36)	2.54±0.62	4.79±1.15[b]	0.15±0.10
Normal	8-11*	4.5-6*	0.7-0.9**
Level	Deficiency	Adequate	Deficiency

*(Kincaid, 2008), **(Kincaid, 2000)

[ab]Different superscripts in the same column showed significant differences (P<0.05)

Table 3: Mean (±SD) reproductive performance of beef cows on peatland in Bali and crossbred cattle

Reproductive performance	Breed		Normal*	Level
	Bali (n=57)	Crossbreeds (n=59)		
Age at puberty (month)	25.86±5.68[a]	30.78±5.08[b]	18-24	Delayed
Age at first calving (month)	35.79±5.43[a]	41.64±5.26[b]	27-34	Delayed
Postpartum estrus (day)	70.72±12.80[a]	84.73±14.62[b]	50-60	Delayed
Calving interval (day)	455.68±38.52[a]	552.88±61.08[b]	360-420	Long

[ab]Different superscripts on the same line showed significant differences (P<0.05)

*Adapted from research in other regions of Indonesia (Bakhtiar et al., 2015; Boda et al., 2020; Desinawati & Isnaini, 2010; Heryani et al., 2019; Mahasanti et al., 2021; Novita et al., 2018)

on the disruption of the process of estrogen metabolism which is necessary for fertility and pregnancy (Darmono, 2011), interferes with ovarian activity (Ahmed et al., 2009) and affects age at first puberty (Utomo et al., 2013).

The differences in reproductive performance between Bali and crossbred cows is closely related to genetic potential and adaptability to the environment. Bali cattle are known to have high adaptability to tropical climate and poor forage quality (Suretno et al., 2017; Sutarno & Setyawan, 2015). It has a high reproductive capacity (Noor et al., 2001; Purwantara et al., 2012). Bali cows with poor nutritional status can still reproduce (Diwyanto & Inounu, 2009). On the other hand, crossbred cows with more than 50% *Bos taurus* blood are very sensitive to nutritional deficiencies and the crossbred cow which are deficient in nutrients will have poor reproductive performance (Diwyanto & Inounu, 2009).

CONCLUSION

The soils and forage in Central Kalimantan peatlands have very low availability of Ca and Cu minerals and the cows reared in these areas are deficient in Ca and Cu minerals. The availability of P mineral in peat soil is quite high and P content in forage and cow blood serum are considered at normal level. Deficiency of Ca and Cu, and Ca and P imbalances have an impact on the low reproductive performance for beef cows raised in peatlands.

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CONFLICT OF INTEREST

The authors have declared there was no conflict of interest related to the material discussed in this manuscript.

AUTHORS CONTRIBUTION

The authors; Adrial, Rudy Priyanto, Salundik, Ahmad Yani, Luki Abdullah contributed to the design and implantation of the research, to the analysis of results and to the writing of the manuscript.

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