

CHARACTERISTICS OF POLLED BALI CATTLE AND POTENTIAL FOR DEVELOPMENT IN SOUTH SULAWESI

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Abstract

Some cattle breeds that have evolved hornless versions include indigenous cattle. This research aimed to identify phenotypic and morphometric traits in indigenous Polled Bali cattle (PBC). This research is a crucial component of breed characterization. The number of subjects used in this qualitative analysis was 58 animals, consisting of 29 males and 29 females. The technical coefficient analysis employed a sample of 165 cows, including 60 bulls and 105 females. The lack of horns in PBC causes the interaction of the poll gene (*P*) and the scur gene (*Sc*). The PBC coat color is mainly reddish-brown (>40%), with black color on the hoof (>90%), switch of the tail (>68%), eyelid (>100%), and muzzle (>96%), with reddish-brown color on the mouth lash (>82%), and white color on legs (>50%), and rump patch (>50%). PBC are mainly humpless (100%), small on the dewlap size (100%), a thick line on the dorsal (>48%), and poll in males (82.76%), in females (52.27%), and scurs in males (17.24%) in females (47.73%). Net Replacement Rate (NRR) values were 145% (male) and 140% (female), which indicated that South Sulawesi Province is still capable of producing seed stock per year.

Keywords: phenotypic, morphometric, polled allele, population structure.

KARAKTERISTIK SAPI BALI POLLED DAN POTENSI PENGEMBANGANNYA DI SULAWESI SELATAN

Abstrak

Beberapa bangsa sapi telah berevolusi menjadi tanpa tanduk termasuk sapi-sapi lokal. Penelitian ini bertujuan untuk mengidentifikasi karakteristik fenotipik dan morfometrik pada sapi Bali Polled (PBC). Penelitian ini merupakan komponen penting dalam upaya mengetahui karakterisasi suatu bangsa ternak. Jumlah sample yang digunakan dalam analisis kualitatif ini adalah 58 ekor, terdiri dari 29 jantan dan 29 betina. Analisis koefisien teknis menggunakan sampel 165 sapi, termasuk 60 jantan dan 105 betina. Sifat polled pada PBC disebabkan oleh interaksi gen poll (*P*) dan gen scur (*Sc*). Warna bulu PBC didominasi oleh merah kecokelatan (>40%), dengan warna hitam pada kuku (>90%), ujung ekor (>68%), kelopak mata (>100%), dan moncong (>96%), warna merah kecokelatan pada bulu mulut (>82%), dan warna putih pada kaki (>50%), dan pada warna cermin pantat (>50%). PBC umumnya tidak berpunuk (100%), ukuran gelambir kecil (100%), garis tebal pada punggung (>48%), dan jumlah kejadian poll pada jantan (82,76%), dan betina (52,27%), serta kejadian scurs pada jantan (17,24%) dan betina (47,73%). Nilai Net Replacement Rate (NRR) adalah 145% (jantan) dan 140% (betina), yang menunjukkan bahwa Provinsi Sulawesi Selatan masih mampu memproduksi stok benih per tahun.

Kata kunci: fenotipe, morfometrik, alel poll, struktur populasi

INTRODUCTION

Horns in cattle traditionally benefit them in providing a capacity to repel predators, demonstrate territorial dominance, and compete for resources. However, with modern livestock management avoiding herd competition, horns are no longer needed and instead associated with wildness in cattle (Qayyum *et al.*, 2020). The development of

beef cattle is currently focused on horn removal to ease handling during rearing and slaughter (Zulkharnaim *et al.*, 2023). An animal welfare issue that has attracted attention is the practice of stopping the growth of horn buds (disbudding) or dehorning cattle. Horn removal is performed to improve safety and decrease the risk of injury to other cattle and human handlers through aggressive behaviors, as well as to

reduce the incidence of carcass wastage due to bruising.

Polled genetics is one option for replacing dehorning in cattle, and phenotypic selection for polled animals is the best cost-effective method (Mueller *et al.* 2019; Oliveira *et al.* 2023). Breeding programs for polled (hornless) cattle have been developed in certain European countries. For example, Germany and France introduced the investigated alleles into the Charolais and German Fleckvieh beef cattle breeds (Götz *et al.*, 2017). The polled alleles have also been successfully introduced into Shuxuan cattle, a synthetic cattle breed from China (Chen *et al.* 2017).

Polled Bali cattle (PBC) are Bali cattle that are naturally hornless cattle. Based on previous research on phenotypic and genotypic characterization (Zulkharnaim *et al.* 2020, 2023), PBC has very similar characteristics to Bali cattle with horns. Horn loss in Bali cattle has become an impetus to produce new variations in local Indonesian cattle. However, conservation and breeding programs for PBC have been ineffective. This is due to a lack of sufficient scientific information on phenotypic and morphometric characteristics. As a native breed of cattle, it is necessary to describe the phenotypic and morphometric characteristics of the PBC. The baseline data will provide vital information for establishing the PBC breed standard. They will be submitted to the government as material to declare the PBC as an indigenous Indonesian breed. Furthermore, this study was conducted to determine PBC phenotypic characteristics and population structure analysis to determine South Sulawesi Province's potential as a PBC breeding center.

MATERIALS AND METHODS

Study Area

The research reviewed PBC data from April 2024 to March 2025. The data were collected from smallholder farmers in Barru District, South Sulawesi Province, Indonesia. PBC samples were obtained from two sub-districts: Tanete Riaja and Barru. The Barru district is at a latitude of 4°05'49" and 4°47'35"S and a longitude of 119°35'00" and 119°49'16"E. The humidity is 79% to 98%, with temperatures 26°C to 28°C and rainfall 245 to 860 mm/year.

The number of subjects used in qualitative analysis was 58 animals, consisting of 29 males and 29 females. The technical coefficient analysis employed a sample of 165 cows, including 60 bulls and 105 females. Animal data consisted of inheritance of the horn, qualitative traits, and population structure. The horn status included the presence of horns in cattle and polled type (polled and scurs).

Data on mating, birth and mortality of PBC were obtained from the records of partner breeders of PT Hasanuddin Agrivisi Internusa. The qualitative traits of PBC were measured using the measurement guide for the physical appearance of Bali cattle, Biotechnology Research Center, Indonesian Institute of Sciences (LIPI).

Procedures

The decline of horn traits was observed through the identification of livestock records, where PBC offspring were observed for the appearance of horns, with the determination of polled or horned starting at the age of 5-8 months. The process of PBC development started with selecting PBC males. After selection, the male PBC sperm was injected through artificial insemination (AI) into horned Bali cows. Artificial insemination was used to increase the number of PBC populations. PBC bulls used in AI have the *PPScSc* allele. Horned cows with the *ppScsc* allele as parents will produce polled offspring. Observations of qualitative traits of cattle offspring were made at 12 to 24 months of age.

PBC has a semi-intensive farmer group management system in Barru District. The feed ration consisted of elephant grass (*Pennisetum purpureum*) and nut grass (*Cyperus rotundus*), and water provided ad libitum. Cattle pregnancy and health were checked monthly. The cattle were artificially inseminated (AI) using the PBC straw method.

Variables

The variables of qualitative characteristics were physical coloration, including coat colors, hoof, tail switch, eyelid, dewlap size, mouth lash, muzzle, legs (stocking), and rump patch. The variables of population structure included the number of adult cattle, calving rate, mortality, Natural Increase (NI), number of young cattle,

requirement for cattle replacement, number of culled cattle, and Net Replacement Rate (NRR).

Measurement

The population structure was calculated and analysed based on Samberi and Ngadiyono (2010) as follows:

$$\begin{aligned} \text{Number of adult cattle (\%)} \\ &= \frac{\text{Number of adult cattle}}{\text{Number of population}} \times 100\% \end{aligned}$$

$$\begin{aligned} \text{Calving rate based on population (\%)} \\ &= \frac{\text{Number of calves}}{\text{Number of population}} \times 100\% \end{aligned}$$

$$\text{Mortality (\%)} = \frac{\text{Number of death cattle}}{\text{Number of population}} \times 100\%$$

$$\begin{aligned} \text{Natural increase (\%)} \\ &= \text{Calving rate based on population (\%)} \\ &- \text{Mortality (\%)} \end{aligned}$$

$$\begin{aligned} \text{Number of young cattle (\%)} \\ &= \frac{\text{Number of young cattle}}{\text{Number of population}} \times 100\% \end{aligned}$$

$$\begin{aligned} \text{Requirement of cattle replacement (\%)} \\ &= \frac{\text{Number of adult cattle (\%)} \\ &}{\text{Breeding length (years)}} \end{aligned}$$

$$\begin{aligned} \text{Remains of young cattle (\%)} \\ &= \frac{\text{Percent of young cattle (\%)} \\ &}{\text{Requirement of cattle replacement (\%)}} \end{aligned}$$

$$\begin{aligned} \text{Number of culled cattle (\%)} \\ &= \text{Requirement of cattle replacement (\%)} \end{aligned}$$

$$\begin{aligned} \text{Output (\%)} &= \text{Number of culled cattle (\%)} \\ &+ \text{Remains of young cattle (\%)} \end{aligned}$$

$$\begin{aligned} \text{Net Replacement Rate (\%)} \\ &= \frac{\text{Number of young cattle (heads)} \\ &}{\text{Remains of young cattle (heads)}} \times 100\% \end{aligned}$$

Data Analysis

Data were analysed using Microsoft Office Excel 2019 to obtain percentage data. To avoid bias due to sex effects, all data were analysed separately for males and females.

RESULTS AND DISCUSSION

Inheritance of The Horn/Poll Condition in Bali Cattle

The assumed model of inheritance for the polled and scurred conditions, which reflects the interaction of the scur and polled genes in PBC, is as presented in Table 1.

In PBC bulls, the polled condition is obtained when the dominant *P* gene is homozygous and the *sc* gene is homozygous recessive; and all other conditions (heterozygous dominant *P* gene and heterozygous dominant *Sc* gene) produces scurs. In females, the scurs condition only occurs when *Sc* is homozygously dominant, regardless of the *P* gene condition (homozygous or heterozygous). The conditions in Table 1 were obtained from mating horned cows with the *PpScSc* allele, while the bulls with the *PPScsc* allele were polled. Intervention to produce polled cattle used artificial insemination (AI) of PBC bulls into horned cows.

Poll Gene

A polled cattle is a condition in which cattle do not have horns in their natural state. Calves are classified as polled at 6 months of age. The absence of tissue for horn precursors characterizes the polled trait. Poll is characterized by the complete lack of corneous appendages (Medugorac *et al.* 2012). This study showed that the peaked-poll cattle breed produces a significantly higher proportion of polled cattle than other breeds. Figure 1 shows the peak poll in PBC and *Bos taurus* breeds.

The presence of horns is regulated by the dominant *p* allele (Grobler *et al.* 2021; McConnachie *et al.* 2019). *P* is the completely dominant gene for the poll. The absence of horns, or the polled condition, was initially thought to be due to a single gene mutation (from *p* to *P*) in many cattle breeds (Prayaga, 2007; Falomir-Lockhart *et al.*, 2019; Hennig *et al.*, 2022). The polled condition was dominant over the horned condition in cattle. In PBC, horn traits are also regulated by the *p* allele. Mating between PBC bulls carrying the *PPScsc* allele and cows carrying *PpScSc* will produce polled offspring (Table 1).

Gowen (1918) suggested that testicular hormones could influence the presence or absence of horns (sex-linked inheritance). The single gene theory is extended to explain trait inheritance as follows:

- Homozygous dominant (*PP*), polled in both sexes
- Heterozygous (*Pp*), horned in males and polled in females
- Homozygous recessive (*pp*), horned in both sexes (Gowen, 1918; Prayaga, 2007).

The polled phenotype (polled that takes center stage on the head) is one in which the skull between the horns is rounded, with a slight bulge at the horn locus in most individuals. The peaked poll phenotype is characterized by an animal having a peaked, rather than rounded, frontal center of superiority (Fig. 1) (Prayaga, 2007).

Scurs Gene

In PBC, there is also a condition where cattle have horn tissue, but it does not develop like standard horn. This condition is referred to as a scurs, which is an incompletely developed horn that is not fused to the frontal bone (Medugorac *et al.* 2012). As the horn core is not a product of the skull, scurs can be considered an intermediate phenotype between polled and horned. It originates from a separate ossification center in the tissues above the periosteum with subsequent fusion to the skull (Capitan *et al.* 2011; Medugorac *et al.* 2012). In *Bos taurus* and *Bos indicus*, cattle may have scurs or loose horn-like structures. However, unlike actual horns, these structures are not attached to the frontal bones of the skull (Ketel & Asai-Coakwell, 2020). Additionally, in PBC (*Bos javanicus*), the scurs are small in size, measuring 1 to 2 inches. Calves are classified as scur at weaning (6 to 9 months). Figure 2 shows that scurs in PBC and *Bos taurus* breeds.

The scurs in PBC are primarily found in bulls. This is consistent with the horn inheritance pattern in Table 1. PBC bulls (*PPScsc*) mated to females (*PpScSc*) can produce scurs in male offspring (*PpScsc*) while females are polled (*PpScsc*). Scurs are inherited as a sex-influenced trait (Aldersey *et al.* 2020; Gehrke *et al.* 2020; Prayaga, 2007). Scur occurs in males if they are homozygous (*ScSc*) or heterozygous (*Scsc*) for the scur mutation, but only in females if they are homozygous (*ScSc*). Genotypes at the horned/polled locus (P) also determine the presence of scurs (Ketel and Asai-Coakwell, 2020).

There are two horn loss theories in Bali cattle. The first is that the polled trait is the result of crossbreeding between *Bos indicus* cattle and horned Bali cattle (Baco *et al.*, 2020). The second is due to the occurrence of natural genetic mutations at the polled locus, which is similar to natural mutations in the Celtic polled (*Pc*) type (Hennig *et al.* 2022). However, PBC cattle do not have a hump and have a smaller

dewlap, which are both characteristic features of the *Bos indicus* cattle breed (Table 3, Fig 3-A; B and Fig 6-A). Currently, there is no specification of the polled type in PBC. Molecular research on the specific genes mutated in PBC is still needed. The polled type in PBC follows *Bos taurus* and *Bos indicus* in general (Table 1). The hornlessness trait is influenced by the *P* gene and the *Sc* gene, the interaction of which causes polled and scurred (Fig. 6-C; D). Most PBC offspring have heterogeneous alleles, so it is still possible to produce horned offspring if the offspring have homozygous recessive alleles. For this reason, PBC breeding should be planned.

Color Characteristics

PBC color characteristics in 12 to 24-month-olds are shown in Table 2. The coat color of PBC bulls is more variable, with reddish-brown (48.27%) and dark brown (24.14%) being the most common (Fig. 3). The coat color of PBC in females was most commonly reddish-brown (70.45%), followed by yellow-brown (20.45%). The coat color of Wayanad desi cattle is primarily dark brown (59.09%) (Prem *et al.* 2023). There is discoloration in PBC cows due to very low testosterone levels. Black is the most common color in both males and females for the hoof, switch of the tail, eyelid, and muzzle. The dewlap size was small in both males and females (Table 2 and Fig. 6). This contrasts with *Bos indicus* cattle, who have reddish-brown mouthlash. All Wayanad desi cattle (*Bos indicus*) have small dewlaps and a hump (Prem *et al.* 2023). However, in bulls, it can also be whitish. In both males and females, the color of the leg (stocking) is predominantly light brown. Bulls have a mostly whitish rump patch, while females have a light brown one.

Each animal has distinctive characteristics that define its identity. Unique characteristics that can be passed on to offspring are the initial capital for the animal to be proposed as a new breed. To determine PBC viability as a new local cattle breed in Indonesia, research on the specific PBC characteristics is essential. This study used a sample of PBC cattle between the ages of 12 and 18 months to demonstrate the PBC cows' breed characteristics. The primary color in PBC is reddish-brown. In males, the color changes from reddish-brown to dark brown and then to

black. By the age of 12 to 24 months, bulls had started to change to a blackish coat color. PBC bulls change color after puberty from a reddish-brown to a darker brown. The color change is believed to be caused by fluctuations in testosterone levels. Some PBC bulls go from dark brown to reddish-brown after being castrated. The PBC sample was 12 to 24 months old, or approaching puberty, so it was in the transitional stage of changing color from reddish-brown to dark brown.

Physical Characteristics

PBC's physical characteristics are shown in Table 3 and Figs. 3 to 6. Table 3 shows the typical characteristics found in Bali cattle and PBC, except for the status of polled horns. The five physical traits evaluated in PBC are also typical of Bali cattle. The backline is not found in *Bos taurus* cattle, while the slight dewlap is not characteristic of *Bos indicus* cattle. Thus, PBC is still closely related to Bali cattle (*Bos javanicus*); the only difference is the absence of horns, along with associated traits such as docility and growth potential.

The backline is often considered a distinguishing feature of Bali cattle, which is also present in its descendants such as Pasundan, Madura, Aceh, and Pesisir cattle (Said *et al.* 2017). The PBC horn profile indicates the presence of two types of hornless conditions: polled and scurs (Fig. 6). In PBC males, polled was the dominant trait, with 82.76% of the population. In females, although the polled presentation was also high at 52.27%, 47.73% of the cows had scurs.

Despite living in the tropics, the PBC does not have a hump. This distinguishes it from *Bos indicus* cattle, in which the hump is one of the main distinguishing features. Previous studies have shown a close relationship between PBC and Bali cattle based on microsatellite information (Dagong *et al.* 2023; Zulkharnaim *et al.* 2023). This information also confirms that PBC does not belong to the breeds of *Bos indicus* and *Bos taurus*. The primary habitat of the PBC cattle is in the tropics of Indonesia, so it will likely become a new local breed of cattle.

Population structure

In this research, the Natural Increase (NI) value was in the low category (30.30%), as presented in Table 4. As reported by Samberi

and Ngadiyono (2010), the NI value consists of three categories: low (NI < 50%), medium (51% < NI < 80%), and high (NI > 80%). A low NI value was reported in several Indonesian native cattle, such as Bali (16.35%), Pesisir (27.80%), Pasundan (18.46%), and 16.22% for Ongole grade (Putra *et al.*, 2015; Said *et al.*, 2017; Susanti *et al.*, 2015). NI depends on calf harvest and mortality rate. An increased calf crop and decreased mortality values in PBC will result in a higher NI value. The NI of PBC remains low because intensive PBC development has only been implemented over the last 5 years. The mortality rate was low (3.03%), particularly during the outbreaks of foot-and-mouth disease and Jembrana disease in South Sulawesi. However, more research is needed on PBC resistance to these two diseases.

The number of young cattle from PBC male (10.91%) and female (18.79%). Male presentation in PBC remains low and needs improvement. The use of technologies such as semen sexing for AI needs to be considered. A 2-year-old condition in cattle affects their economic potential as replacement and feedlot animals (Gurina *et al.*, 2019). The Net Replacement Rates (NRRs) in males and females in South Sulawesi Province were more than 100% (Table 8), indicating there were more males and females than needed for replacement. According to Table 8, the total ideal livestock output per year was 28 heads (11.50%) for males and 39 heads (17.71%) for females.

The initial stage of PBC development involves increasing the number of AI births from selected polled bulls and determining the development centers. It is essential to control PBC breeding and not to disturb Bali (horned) cattle. The second stage involves optimizing polled female cows to become dams for natural mating, thereby increasing the number of polled cattle born. This study's results also showed that PBC is a hornless version of *Bos javanicus*, characterized by better growth traits and docility associated with the absence of horns. This breed variant is expected to become a new variety of local beef cattle in Indonesia.

We conclude that allele in PBC poll type for males (*PPScsc*) and (*Ppscsc*), for females (*PPScsc*), (*Ppscsc*), and (*PpScsc*), and Scur type for males (*PpScSc*) and (*PpScsc*), for females only (*PpScSc*). Polls and scurs are inherited as sex-influenced traits. PBC's physical characteristics are mainly humpless

with a small dewlap size, which indicates that PBC does not belong to the breeds of *Bos indicus* and *Bos taurus*. The population structure in PBCs in South Sulawesi shows that

calf harvest and natural increase values are low. However, they can still produce seedlings per year.

Table 1. Inheritance model for the PBC polled and scurred condition

Genotype	Males	Females
<i>PP Scsc</i>	Polled	Polled
<i>Pp ScSc</i>	Scurred	Scurred
<i>Pp Scsc</i>	Scurred	Polled
<i>Pp scsc</i>	Polled	Polled

Description:
P = dominant allele of polled *Sc* = dominant allele of scurs
p = recessive allele of polled *sc* = recessive allele of scurs

Table 2. Proportion of color characteristics in Polled Bali cattle

Variable	Color	Sex (%)	
		Male	Female
Coat	Reddish-brown	48.27	70.45
	Light brown	3.45	2.27
	Yellowish-brown	13.79	20.45
	Pale-brown	10.34	6.82
	Dark brown	24.14	0.00
Hoof	Black	96.55	97.73
	Gray	3.45	2.27
Switch of tail	White	10.34	2.27
	Brown	20.69	13.64
	Black	68.97	84.09
Eyelid	Black	100.00	100.00
Dewlap size	Small	100.00	100.00
Mouth lash	Whitish	17.24	0.00
	Reddish-brown	82.76	100.00
Muzzle	Black	96.55	100.00
	Spotted black-white	3.45	0.00
Legs (stocking)	Whitish	51.72	50.00
	Light brown	34.48	43.18
	Nothing	13.79	6.82
Rump patch	Whitish	55.17	40.91
	Light brown	37.93	56.82
	Nothing	6.90	2.27

Table 3. Frequencies (%) of each level of the five physical characteristics assessed in Polled Bali cattle

Variable	Characteristics	Sex (%)	
		Male	Female
Hump	Humpless	100.00	100.00
Dewlap size	Small	100.00	100.00
Backline	Thin line	24.14	6.82
	Medium line	27.59	25.00
	Thick line	48.28	68.18
Horn status	Polled	82.76	52.27
	Scurs	17.24	47.73

Table 4. Technical coefficient for output estimation of PBC at South Sulawesi Province of Indonesia

Component	Value
Number of adult females (%)	43.03
Calving rate based on population (%)	33.33
Mortality (%)	3.03
Natural increase (%)	30.30
Percentage of young cattle (%)	
• Male	18.79
• Female	10.91
First mating age (years)	
• Male	3
• Female	2
Breeding length (years)	
• Male	7
• Female	8
Sex ratio (male/female)	40/36
Number of populations observed (heads)	165

Table 5. The output estimation of PBC at South Sulawesi Province of Indonesia

Component	Heads	Percent (%)
Number of young cattle (2 years age)		
• Male	18	10.91
• Female	31	18.79
Total	49	29.70
Requirement of cattle replacement		
• Male	6	3.38
• Female	9	5.38
Total	14	8.76

Component	Heads	Percent (%)
Remains of young cattle (2 years age)		
• Male	12	7.53
• Female	22	13.41
Total	35	20.94
Number of culled cattle		
• Male	15	3.97
• Female	16	4.30
Total	32	8.27
Net Replacement Rate		
• Male		145
• Female		140
Total		285
Output estimation		
• Male	28	11.50
• Female	39	17.71
Total	66	29.21



Figure 1. Peaked-poll condition in PBC (A)
Peaked-poll condition in Holstein (Gehrke *et al.* 2020) (B)



Figure 2. Scurs condition in PBC (A);
Scurs condition in Holstein and French Charolais (Capitan *et al.* 2011; Gehrke *et al.* 2020) (B)



Figure 3. The coat color (reddish-brown) of Polled Bali cattle male (A) and female (B)

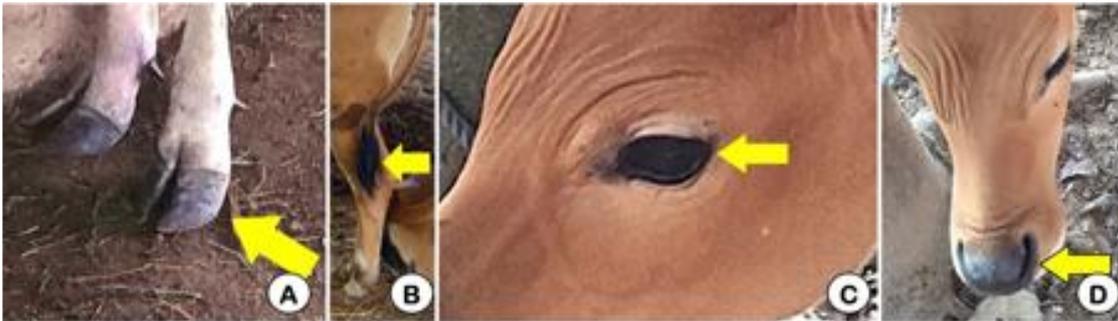


Figure 4. The main black colors of PBC were found on hoof (A), switch of tail (B), eyelid (C), muzzle (D)

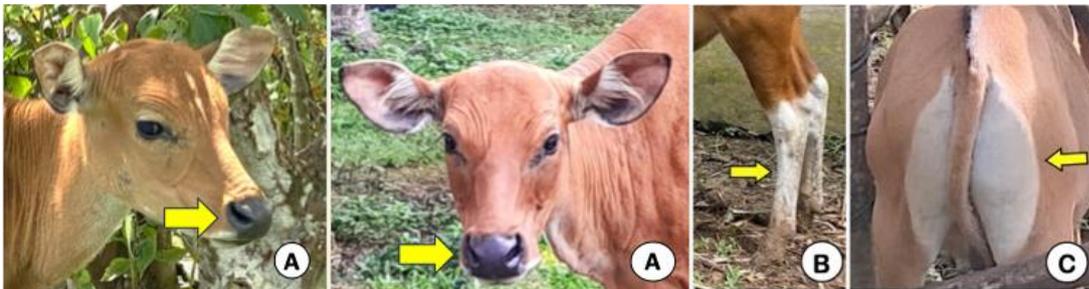


Figure 5. The main color characteristics on several body parts of PBC such as follows: reddish-brown on mouth lash (A); whitish on legs (B); and rump patch (C).

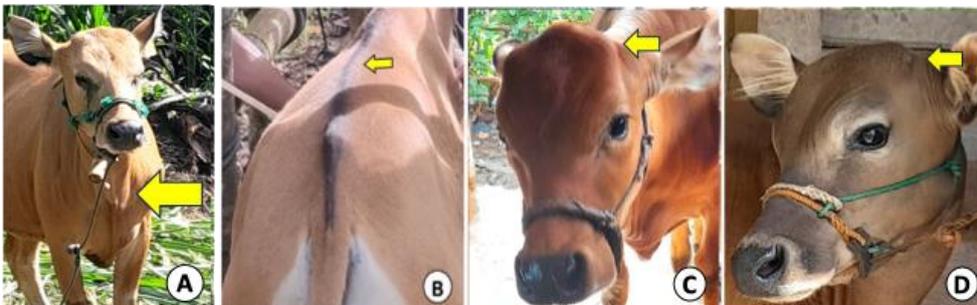


Figure 6. The primary physical characteristics of Polled Bali cattle are as follows: small dewlap size (A); thick line of backline (B); polled (C); and scurs (D).

CONCLUSIONS

PBC is an indigenous Indonesian breed of hornless cattle. The polled condition for PBC consists of polled and scurred, where the trait is sex-linked. The PBC coat color is mainly reddish-brown (>40%), with black color on the hoof (>90%), switch of tail (>68%), eyelid (>100%), and muzzle (>96%), with reddish-brown color on the mouth lash (>82%), and white color on legs (stocking) (>50%), and rump patch (>50%). PBC's physical characteristics are mainly humpless (100%), small on the dewlap size (100%), a thick line on the dorsal/back line (>48%), and poll in males (82.76%) in females (52.27%), and scurs in males (17.24%) in females (47.73%). Natural Increase (NI) and calving rate values were 30.30% (low category) and 33.33%, respectively. Net Replacement Rate (NRR) values were 145% (male) and 140% (female), which indicated that South Sulawesi Province was still capable of producing seed stock per year. It is necessary to designate specific PBC development areas to keep the germplasm of horned Bali cattle from being drastically reduced.

ACKNOWLEDGMENT

This research was supported by the RIIM LPDP Grant and BRIN, grant number (35/IV/KS/06/2022). We also thank PT. Hasanuddin Agrivisi Internusa, Local government in Barru regency, and smallholder farmers.

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