THE REPRODUCTIVE PERFORMANCE OF BALI CATTLE AND IT'S GENETIC VARIATION

A REVIEW

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ABSTRACT

Bali cattle (Bos sondaicus) is one of the Indonesia native cattle which is the result of wild banteng domestication. The advantages of Bali cattle, among others, are having a high fertility rate (80-82 %) and good adaptability to the new environment. It was found that there are genetic variation in several genes associated with reproductive function in Bali cattle. Some studies have reported an association between genetic variation in reproductive function of cattle. However, studies on the correlation between genetic variation reproductive genes with reproductive performance of Bali cattle are still low. This article aims to provide an overview of Bali cattle genetic variation reproductive genes and making it possible as candidate marker for selection and improving reproductive performance of Bali cattle.

Key words: Bali cattle, reproductive performance, genetic variation.

INTRODUCTION

Indonesia is one country that has a relatively high biological diversity, including farm animal diversity. Some of Indonesian native cattle, namely Bali, Madura, Aceh, and PO (Peranakan Ongole) cattle. These cattle have spread widely in Indonesia (Siregar, 2008). Among the Indonesia native cattle, Bali cattle (*Bos sondaicus*) is one of the Indonesia native cattle which have quite large population. Bali cattle population in Indonesia was recorded 2.632.125 in 1988 (Tanari, 2001), 2.914 million in 2006 (Siregar, 2008), 3.271 million in 2010 (Direktorat Jenderal Peternakan, 2010 sit Gunawan et al., 2011) and 4.8 million or 32.31 % in 2011 (Kementrian Pertanian, 2011).

Bali cattle have a high economic potential because it has several advantages compared with cattle from elsewhere. The advantages of Bali cattle, among others, are have a high fertility rate, low calf mortality, good adaptability to the new environment, and high carcass production (Siregar, 2008; Purwantara et al., 2012). However, there were also drawbacks that is sensitive to the Jembrana disease and Malignant Catrrhal Fever (MCF) (Hardjosubroto, 1994).

Reproductive performance is one of the most important factor in the efficiency of livestock production. Several genes involved in reproductive performance including BMP-15 (Otsuka et al., 2000), OPN (Kang et al., 2004; Hao et al., 2006), GH (Zhang et al., 2011; Rabassa et al., 2014) and IGF-1 (Velazques et al., 2009; Mani et al., 2010) gene. The Genetic variation of these gene have been reported to affect the reproductive performance of cattle (Sun et al., 2014; Zhang et al., 2011; Liron et al., 2012). It was found that there are genetic variation in several genes associated with reproductive function in Bali cattle. However, studies on the correlation between genetic variation reproductive genes with reproductive performance of Bali cattle are still few. This article aims to provide an overview of Bali cattle genetic variation reproductive genes and making it possible as candidate marker for selection.

ORIGIN AND DISTRIBUTION

Bali cattle are one of the Indonesian cattle as the result of the domestication of wild Banteng. Domestication of Bali cattle occurred before 3500 years ago in Indonesia (Garick and Ruvinsky, 2015). According to Maijer (1962) sit Handiwirawan, 2003, the process of domestication occurred in Java. It was based on the fact that in Java there is a wild Banteng. This opinion was latter supported by Namikawa et al. (1987) who found that there were similarities between the blood types of Bali cattle with wild Banteng.

The spread of Bali cattle include in some areas of Indonesia, among others, NTT, Bali, NTB, South Sulawesi, Lampung, Bengkulu, Central Kalimantan (Purwantara et al., 2012). Bali cattle are also distributed in Papua (Samberi et al., 2010). The spread of Bali cattle were not only limited in Indonesia, but already had spread to many foreign countries including Malaysia, Philippines and Australia (Neijman et al., 2003; Sumantra & Sumitayati, 2005).

Bali cattle have characteristics in color. Bali calves are born with reddish-brown. The coat color is unchanged in females but its color turn almost black in adult males (Figure 1). In male the red covering the body begin darken at 12-18 months age (Purwantara et al., 2012). There are special marks owned by pure Bali cattle that are white on the back of the thigh called 'telau'. They also have white socks, white hair in the ears (Hardjosubroto, 1994). The body weight of male Bali cattle are 350-400 kg with a height between 130 cm-140 cm, while the weight of female between 200 to 300 kg (Garick and Ruvinsky, 2015).

A B

Figure 1. (A) Female (courtessy of Sri Rahayu, 2004) and (B) Male Bali Cattle (https://www.flickr.com/photos/puslitbangnak/7988991046/)

REPRODUCTIVE PERFORMANCE

One of the advantages of Bali cattle is a good reproductive performance. Parameters of the reproductive performance factors that are important include: (1) age at first calving (2) calving rate (CR), (3) the distance lambing or calving interval (CI), (4) services per conception or S/C, and (4) the distance between bore get pregnant again (DO). Reproductive performance in beef cattle is influenced by several factors, including the quality of food, food and peripartum disease (Rhodes et al., 2003). Bali cattle are the most preferred cattle for small farmer because Bali cattle have good fertility, good conception and low mortality rate (Purwantara et al., 2012). Reproductive performance of female Bali cattle as shown in Table 1.

Table 1. Female Bali cattle reproductive performance in some provinces

Province	First Mating Age (month)	Parturition Percentage (%)	Calving Interval (month)	Pregnancy Rate	Service/ Conception	References
Bali			11.87	88.44 %		Gunawan et al. (2011)
West Nusa Tenggara	29.04		15.26			Soekardono et al. (2009)
East Nusa Tenggara	25.41	67.66	17.03			Tonbesi et al. (2009)
Papua	21.12	72.27	13.68		1.49	Samberi et al. (2010)
BPTU, Pulukan	23.62		11.52		1,65	Siswanto et al. (2013)
South Sulawesi	26.40		12.16		1.9	Lestari (2012)

The success of the increasing population, in addition, depends on the female reproductive performance, and also depends on the male reproductive performance. Reproductive performance of male individual is determined by the semen quality. Semen quality depend on age, environment, genetic (Brito et al., 2002), nutrition (Alonzo et al., 2009). Moreover, Brito et al. (2002) found that increased bull age was correlated with decreased sperm motility and increased minor sperm defects. Alonzo et al. (2009) reported that Selenium and Vitamine E can improve of semen quality of boar.

The parameters which are used to assess the quality of cattle semen include: sperm concentration, motility and viability spermatozoa. The characteristics normal semen are seminal volume 5-8 mL, pH 6.4-7.8 and sperm concentration is spermatozoa 800-2000.106/ml (Garner and Hafez, 2000). Arifiantini et al. (2006) found that seminal volume, motility and concentration of semen Bali cattle are

6.3 ml, 71,04 %, 1340.106/ml, respectively. Bali cattle semen quality in some areas are presented in Table 2.

Table 2. Male Bali cattle Reproductive performance in some provinces

Province	Consen-tration (juta/ml)	Motility (%)	Viability (%)	Abnormality (%)	Volume (ml/ejaculate)	References
Mardika, Ambon	11.222	75.00	86.75	10.50		Labetubun and Siwa (2011)
West Nusa Tenggara	1741.00	75.00-82.25	87.30	3.78	6.47	Yuliani and Lukman (2013), Said et al. (2014)
South Sulawesi	1817.00	68.00-73.75	58-81.25	7.50 -8.00	4.25	Salamah (2014), Payung (2015)
BIBD (UPTD) Bali	1309.30	80.30	66.10	1.10	4.50-5.26	Ratnawati et al. (2008)
UPTD, Baturiti Bali	1340.00	71,04		9.38	6.30	Arifiantini et al. (2006)

GENETIC VARIATION OF REPRODUCTIVE GENE IN BALI CATTLE

Genetic variation is a common trait found in a population. This diversity occurs not only between species but also within the same species, between populations and within populations, among these individuals. The genetic variation of an organism can be caused by several factors such as population migration, mutation, natural selection and mating process Genetic variation required for a population to face the environmental change. As a result, if there are no genetic diversity in a population or species it will heading to extinction because the inability to survive in environmental changes (Caliskan, 2012). Some of the studies showed that there are variation of Bali cattle reproductive gene, such as Bone Morphogenetic Protein-15 (Rahayu, 2010; Rahayu et al.,2012), Growth Differentiation Factor-9 (GDF-9) (Rahayu, 2012), Growth Hormone (GH) (Rahayu, 2009), Osteopontin (OPN) (Paramitasari, 2013), Insuline Like Growth Factor-1 (Muin, 2010) and SRY gene (Rahayu et al., 2009 and Winaya et al., 2011).

Bali cattle have a good reproductive performance compared with other Indonesia native cattle. Therefore, Bali cattle are potential to be developed in Indonesia. The efforts to improve the genetic quality of Bali cattle can be done through a selection by maintaining the superior characteristics of Bali cattle such as high reproduction capability properties. Individual female reproductive traits controlled by several genes include BMP-15, GDF-9 gene (Silva et al., 2004), osteopontin (OPN) (Khatib et al., 2009), GH (Langhout et al., 1991; Rabassa et al., 2014) and IGF-1 (Velazques et al., 2009; Mani et al., 2010).

Bone morphogenetic proteins-15 (BMP-15) gene variation

Bone morphogenetic proteins-15 (BMP-15) also known as GDF-9B (Growth Differentiation Factor-9B) is a growth factor that belong to the TGF-β superfamily which play a role in follicular development (Hosoe et al., 2011). These proteins are expressed in the mouse ovary (Dube et al., 1998), ovary and cumulus cells of calves and cows, testis of bulls (Hosoe et al., 2011; Pennetier et al., 2004). BMP15 expression in the oocytes of calves and cows was higher than in the cumulus cells (Hosoe et al., 2011). Otsuka et al. (2000) reported that the function of this protein is to stimulate the proliferation, differentiation of granulose cells. In addition, BMP-15 protein also as modulator effect of FSH (Follicle stimulating hormone) action.

BMP-15 gene is located on the X chromosome of human, mouse (Dube et al., 1998) and bovine (GenBank Accession number : NM_001031752). Previous studies had reported the genetic variations in BMP-15 gene of Iranian Baluchi sheep (Moradband et al., 2011), Indonesian PO cattle (Rahayu et al., 2014) and Chinese goat (Wang et al., 2011). The variation of BMP-15 gene were correlated with Chinese goat litter size (Wang et al., 2011), ovulation rate of sheep (Barzegari et al., 2010). In Chinese Holstein bulls, BMP-15 genotype have significant effect on fresh sperm motility. CT genotype bulls had significantly lower fresh sperm motility than CC or TT genotype bulls (Sun et al., 2014). Through the PCR method used a restriction enzyme AluI-RFLP, it was known that BMP-15 gene in Bali cattle was polymorphic (Figure 2A), suggested the existence of two kind haplotype (Rahayu et al., 2010). By using different population Rahayu et al (2011) also found that polymorphism of Bali cattle BMP-15 gene (Figure 2B).

Osteopontin (OPN) gene variation

Osteopontin (OPN) or Secreted Phospoprotein 1 (SPP1) phosphoprotein, with molecular weight 44-75 kDa. Osteopontin was first identified as bone matrix (Hao et al., 2006), but then osteopontin was also found in the uterine endometrium of rabbits (Apparao et al., 2003), the seminal plasma and cauda epididymis of Holstein bull (Erikson et al., 2007) and oviduct of bovine (Gabler et al., 2003). Osteopontin has several biological roles, include a role in the prevention polyspermy on pig oocytes (Hao et al.,

2006), fertilization rate (Khatib et al., 2009), interacts with a protein itegrin αvβ3 in the process of implantation (Kang et al., 2014) and proinflamatory cytokine (Wang and Denhardt, 2008).

In cattle Osteopontin (OPN) gene is located on chromosome 6 (Leonard et al., 2005) which consists of seven exons with a size of about 12300 bases (GenBank Accession number: AY878328). OPN gene variation associated with the nature of milk production in Holstein cows (Khatib et al., 2007), the nature of the post-weaning growth in beef cattle (White et al., 2007). GG and TG genotype of Angus and Balancer have higher sperm cell progressive (59% vs. 37%) and rapid (77% vs. 46%) motility than TG and TT genotype (Williams et al., 2011). Through PCR-RFLP method using restriction enzymes BSRI known that the intron 4 of OPN| BSRI gene in Bali cattle are monomorphic (Figure 3), but the result of sequencing showed mutations in the base cytosine (C) and thymine (T) (Paramitasari, 2013).

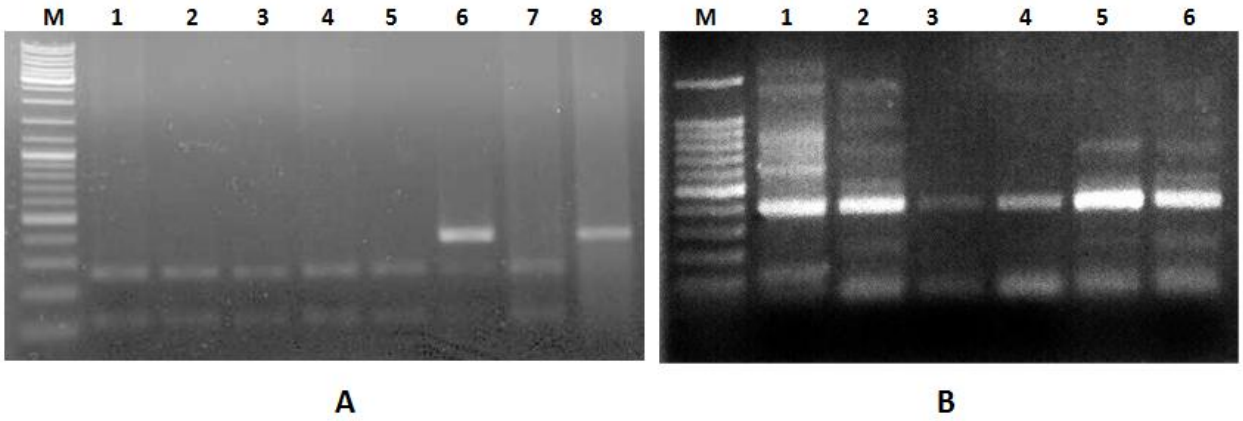

Figure 2. Bali cattle BMP-15 gene polymorphism A. AluI PCR-RFLP of BMP-15 gene (Rahayu 2010)., B. Amplifiation profile of BMP 15 gene (Rahayu *et al*., 2011).

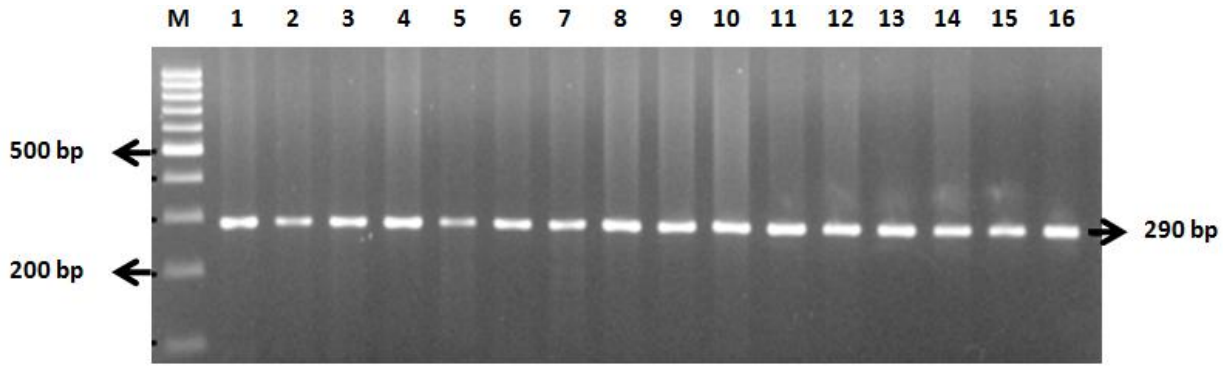

Figure 3. Electrophoretic profile for PCR RFLP in a 2 % agarose gel. M represented a DNA marker. Lane 1-16 represented a result PCR-RFLP fragmen gen *osteopontin* (OPN|*Bsr*I) (Paramitasari, 2013).

Growth hormone (GH) gene variation

Growth hormone (GH), also known as somatotropin is a peptide hormone synthesized in anterior pituitary that stimulates bovine granulose cell proliferation (Langhout *et al*., 1991), pig testicular development (Rabassa et al., 2014), milk production (Dybus, 2002). Growth hormone administration can increase the expression of proliferating cell nuclear antigen (PCNA) mRNA in the testis, this means an increase in cell proliferation in the testes (Rabassa et al., 2014). Bovine GH (bGH) is a single peptide of molecular weight about 22 kDa (Dybus, 2002), consist of 217 amino acid (GenBank Accession number: AAA30544).

The bGH gene is located in bovine chromosome 19 (Lee et al., 2013), approximately 2856 bp in size and contains 5 exon and 4 intron (GenBank Accession number: M57764). Previous studies found that there are genetic variations in GH gene. The substitution of Leucine by Valine in cross bread cattle (Bos taurus - Bos indicus) has a significant effect on libido score and sperm quality (Pal et *al*., 2013). In goat, single nucleotide polymorphism (SNP) of the GH gene is highly associated with prolificacy and superovulation response. When undergoing like superovulation treatments, the number of corpora lutea and ova were higher in the AB and CC genotypes than in AA and CD (Zhang et al., 2011). Rahayu et al. (2009) reported that there is genetic variation in GH gene of Bali cattle. While, Jakaria and Noor (2011) also found that there are different genotype between Bali cattle from Bali and Lombok island (Table 3).

Table 3. Genotype Number and Allele Frequency of Bali Cattle from Bali and Lombok Islands (Jakaria and Noor, 2011)

Originated	n	Genotype			Allele	
		LL	LV	VV	L	V
Bali Island	200	200	0	0	1	0
Lombok Island	32	31	0	1	0.97	0.03

n = number of animal

Insulin-like growth factor-I (IGF-1) gene variation

Insulin-like Growth Factor-I (IGF-I) or somatomedin C is a small peptides consisting of 70 amino acids and with a molecular weight of 7649 Da (Laron, 2001). IGF-1 is secreted by many tissues, including liver, skeletal muscle, bone and cartilage. IGF1 synthesis is controlled by several factors, including the human pituitary growth hormone (GH, also known as somatotropin) (Clemmons, 2007). IGF1 plays an essential role in reproduction, such as in bovine follicular growth, acquisition of oocyte competence and embryo viability (Velazques et al., 2009), steroidogenesis and apoptosis of bovine granulose cell (Mani et al., 2010).

Bovine IGF-1 gene is located at chromosome 5 (Kim et al., 2008) consisting six exons (NCBI, 2015, GenBank ID number : 281239). The polymorphism of IGF-1 gene in cattle have been reported. SNP of IGF1-SnaBI associated with the puberty initiation and sperm cell concentration of male Angus cattle (Liron et al., 2012). Nicolini et al. (2012) found that SNP IGF-1/SnaBI in Holstein-Friesian cow correlated with postpartum ovarian cyclicity. Cows with AA genotype were more likely to resume ovarian cyclicity in the early postpartum period (before Day 45) than those with AB or BB genotypes.

Genotypic polymorphism of IGF-1/Rsa1 in exon 4 (Figure 4) has a significant influence on birth weight, weaning weight and average daily gain of Bali cattle. Individu with CC genotype had a birth weight rate, weaning weight and average daily gain higher than the TT and CT genotype (Maskur et al., 2012).

Different results were reported by Muin (2010). He found that the IGF-1 gene Bali cattle from P3Bali (Proyek Pembibitan dan Pengembangan Sapi Bali), the Bali island and South Kalimantan is monomorphic (Figure 5). This difference is due to differences in DNA primer sequences and restriction enzyme used.

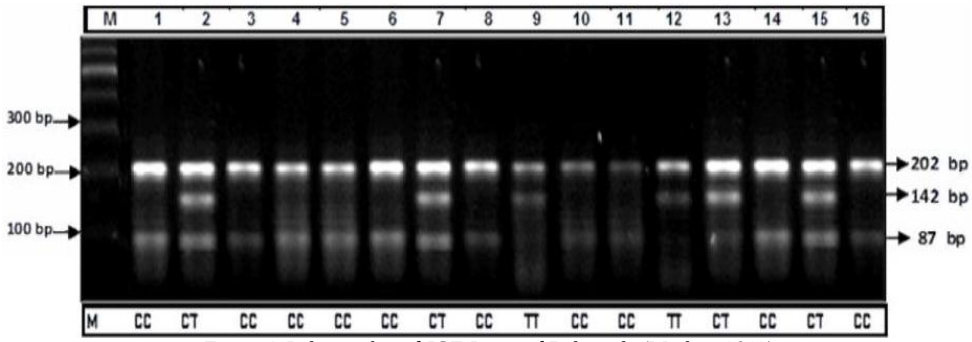

Figure 4. Polymorphic of *IGF-I* gene of Bali cattle (Maskur, 2012)

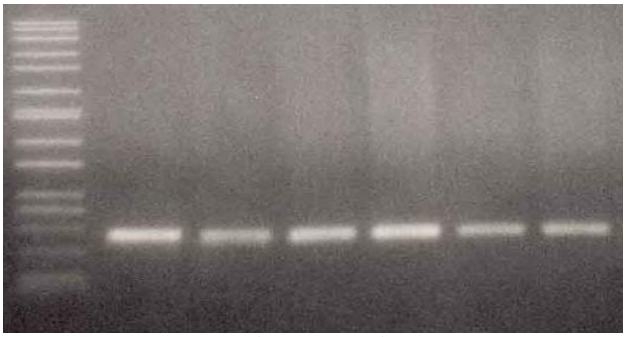

Figure 5. Monomorphic of *IGF-I* gene of Bali cattle (Muin, 2010)

Bali cattle have several advantages and genetic potential, mainly related to reproductive performance. There are genetic variation in several genes associated with reproductive function in Bali cattle. These genetic variation can be used as marker gene for the selection and improving reproductive performance of Bali cattle.

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