Rooms for genetic improvement in Indonesian Bali cattle population

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Abstract. Bali cattle is a species of *Bos javanicus d'Alton*, a local cattle in Indonesia. They are loaded with potential as meat producer and well adapted to tropical climate and limited feed resources. Studies have been made to characterize the species. This paper presents a rough estimate of the opportunity to improve the Bali cattle population genetically. Our aim is to endorse that the Bali cattle could be both superior and efficient as tropical meat producer cattle. Results shows that Bali cattle population size is decreasing for the last years with a possibility to be accompanied by genetic quality decline. However, there is hope in improving Bali cattle genetically by a proper breeding strategy. This could also be an answer to the challenge of climate change which leads to global warming; where species adaptable to such environment is more beneficial in the future.

1. Introduction

Bos javanicus d'Alton is an indigenous species in South-East Asia. It is known for its robustness against tropical environment. Despite the harsh habitat with low quality feed resources, they manage to have distinguishable performances. Studies have been made to document their performances on high fertility [1–4], good growth and excellent carcase quality [2,5–11]. In Indonesia, *Bos javanicus d'Alton* spread all over the archipelago, they, however, have an exclusive habitat in the island of Bali. These animals reside and evolved in Bali Island over a long period of time. They had undergone domestication in this area since ten to five thousand years ago [3] and thus are specifically called the Bali cattle.

Conservation program has been established for Indonesian Bali cattle in the island of Bali. The rules prohibited the intrusion of new genetic resources from outside Bali while selling out cattle to other part of the country is allowed. Because better cattle make better money, the conservation policy leads to selection against genetically superior individuals in Bali cattle population [4]. Not only did the Bali cattle population decrease in number [12], we suspected that the genetic quality of the cattle population itself is also deteriorating. On the other hand, Indonesian government fixed a plan to obtain meat self-sufficiency and endorses mass production of meat from local breeds [13,14]. In order to achieve long term success of the program, superior local genetic resources are needed. Hence, attempts are needed to be made in order to improve the genetic status of Bali cattle; an option is by implementing a proper and well assessed breeding program.

Bali cattle is evolutionary distant from both *Bos taurus* and *Bos indicus* [15], underlying the species unique characteristics which have not been much studied. Their crosses with *Bos taurus* and *Bos indicus*

are potential of exhibiting heterosis on production traits [5,16,17], but other studies revealed poor reproductive performance on the F1 crosses [1,3,4] to the extreme that male crosses are infertile. This fact provides reason that straight breeding program is favoured. In this paper, we presented opportunities in genetically improve production traits of Bali cattle within the juridical area of Bali Province. Further we predicted the coming year's performance increase due to the genetic improvement through straight breeding program.

2. Study methods

This paper used published data on Bali cattle population inside and outside the Province of Bali [2,6,8,10,12,18–21]. The information originated within Bali were grouped into two populations: 1) Balai Pembibitan Ternak Unggul (BPTU) is a population inside the Pulukan breeding centre; and 2) Population outside BPTU or from over the island. We focused our analysis on body weight traits with the following variables: birth weight (BW), weaning weight adjusted for 205 days (WW), yearling weight adjusted for 365 days (YW) and mature weight (MW) which is the weight of mature cattle above 2 years of age. Least square means and standard deviation of the pooled data along with the heritability of the traits is presented in table 1.

Table 1. Means, standard deviation and heritability of Bali cattle production traits

Location	Weights (Kg)			
	BW	WW	YW	MW
Mean ± sd[1]				
BPTU Bali	17.63 ± 0.64	92.67 ± 2.30	138.00 ± 2.82	338.00 ± 97.89
Bali Province	16.77 ± 0.94	92.10 ± 5.75	140.63 ± 9.69	330.76 ± 88.57
Outside Bali	12.79 ± 0.88	84.69 ±15.19	134.17 ± 26.39	271.17 ± 21.86
All population	13.46 ± 1.81	85.61 ± 14.30	135.09 ± 24.22	278.62 ± 29.21
Heritability[2]	0.245	0.43	0.565	0.65[3]

[1]Means and standard deviations summarized from various studies
[2]heritability of BW, WW and YW are averaged across studies in Bali cattle
[3]Heritability for MW is taken from reference [22] for beef cattle, as no specific information available

Genetic gain or response to selection for each trait was estimated as the parameter describing the genetic improvement of each trait after selection. Assumptions and variables for simulation were based on the previous published studies and scenario following progeny testing program held in BPTU Bali cattle. Annually, BPTU kept around 90 male candidates for progeny test where only four will be chosen as elite bulls. In addition, around 900 females are kept and 120 were chosen as elite dams. Following this scenario, we obtained selection intensity of 2.15 for males and 1.76 for females. Estimated breeding value accuracy of 70% was obtained from progeny test analysis [22] with 30 offspring each candidate, while female accuracy was obtained based on mass selection as much as the square root of the traits' heritability ($\sqrt{h^2}$). Phenotypic standard deviation for each trait is presented in table 1 and average generation interval is 5 years for beef cattle. Genetic gain is estimated with the following formula:

$$\Delta G = \frac{i_m . r_m . \sigma_g + i_f . r_f . \sigma_g}{L_m + L_f} \qquad (1)$$

where *m* and *f* subscript indicate male and female selection part, i is selection intensity, r is the accuracy, σ_g is the additive genetic standard deviation for each traits obtained from $\sqrt{\sigma_P^2 \times h^2}$ and L is the generation interval. We assume linear genetic gain over years.

3. Results and discussions

Conservation policy of Bali cattle in the island of Bali had backfired the local population with selection towards less superior individuals; where the local performance decrease as people sold the best cattle. The Bali cattle population had undergone decreasing trend over recent years of time (Table 2) while the genetic impact of this statement needs further justification.

Table 2. Bali cattle population from 2003 - 2015

Year	District								
	Klungkung	Gianyar	Bangli	Badung	Buleleng	Jembrana	Kr.asem	Tabanan	Denpasar
2003	43315	0	0	42526	0	0	0	0	0
2004	41822	55324	0	43413	0	0	0	0	0
2005	43688	56168	0	45844	0	0	0	0	0
2006	43943	56279	0	49450	0	0	0	0	8599
2007	44059	56433	0	55092	0	0	147388	0	9311
2008	44272	57236	93725	65671	144821	0	148385	67037	9370
2009	44664	57815	95818	65118	142736	0	152437	68157	9393
2010	44724	57022	97830	67390	150857	0	149268	67027	9812
2011	46615	47282	94058	48049	136189	54114	135506	66333	8710
2012	46905	53809	96733	49051	145600	54306	136957	59616	7990
2013	33914	40302	74327	36662	120127	52014	132231	53800	7586
2014	37250	42456	75164	37862	121613	52306	122369	52916	7241
2015	38732	44615	72880	30771	119473	51825	121637	51567	6689

Source: BPS Bali

We suspected that not only the population is decreasing but the genetic quality of the cattle also deteriorated. The decrease in population's genetic quality could be caused by inbreeding and/or as an impact of selection against superior genetic resources within the species. Precautions need to be made by designing a proper genetic improvement program. We estimated genetic improvement of production traits using response to selection.

Scenario implied for the genetic gain simulations are based on the condition picturing the progeny test program in BPTU. Following the scenario, we could obtain an increase of 0.21 Kg of birth weight every year after the first generation; followed by the increase of 2.48; 5.08 and 6.90 Kg of weaning weight, yearling weight and mature weight, respectively. These estimates only hold if we were to keep the superior animals to disseminate the genetic improvement achieved by selection into the population inside the BPTU.

Table 3. List of variables used in the simulation

Simulation variables	BW	WW	YW	MW	Total
Selection intensity (*i*)					
Male					2.15
Female					1.76
Phenotype sd (σ_g^2)	1.81	14.30	24.22	29.21	
Heritability (h^2)	0.25	0.43	0.56	0.65	
Generation interval (*L*)					
Male					5
Female					5
ΔG/Year (Kg)	0.21	2.48	5.08	6.9	

The estimated improvements are quite remarkable; however, selection was done in a very strict manner that the size of elite (breeding) herd is very small. This is where the effect of inbreeding kicked in. According to the number for breeding population, the rate of inbreeding will reach 15.5% per generation [22,23], which is very high. This simulation was based on the population in BPTU while the number of actual population is a lot higher of more than 500,000 animals. Nevertheless, this paper was written in order to give an overview that there are rooms for genetically improving Bali cattle population into more efficient beef cattle breed through a properly measured breeding program. Further observations and analysis need to be done while accommodating all aspects in a breeding program to get more detailed and accurate insights for genetic improvement program in Bali cattle.

4. Conclusions

Bali cattle population size in Bali had decreased for the past seven years (2008 – 2015), which might be accompanied with decline in genetic quality due to selection against superior genetic resources. However, based on our simulated estimation, there is still room to improve the genetic quality of Bali cattle by properly assessed breeding program.

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