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Phenotype Measurements of Bali Cattle Combined with Interviews of Farmers from Multiple Locations in Indonesia as a Resource for Development of Breeding Programs

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ABSTRACT: Bali cattle is an important breed for Indonesian farmers. However, the breed is threatened by isolation of populations and cross breeding with exotic breeds. Here we aim to increase the knowledge of Bali cattle phenotypic diversity and management. Based on this information we suggest breeding strategies suitable for small scale farmers that can help to maintain diversity and also lead to improved animal health and welfare. Animals from Bali, Sumatra, Lombok and Kalimantan were phenotyped for; body length, whiters height, chest girth, body weight, pelvic height, pelvic width and horn length. Furthermore, stature, coat color, fur and horns were described. In total 94 animals >2 years of age were phenotyped. The gathered data will be critical for selection of individuals for future genomic studies aimed at identification of genetic factors. A total of 68 farmers were interviewed focusing on management and breeding. The interviews revealed a willingness to learn about breeding and how to breed for certain traits such as size and appearance. ANOVA analysis of the phenotypic measurements showed significant differences between females on Sumatra compared to those on Lombok and Kalimantan. Females on Sumatra were significantly lighter ($P<0.0001$) compared to females on Lombok and Kalimantan. Females on Sumatra also had significantly ($P<0.01$) narrower pelvic width and shorter horns ($P<0.001$) compared to females from Nusa Tenggara Barat (NTB). For males, management could explain many of the observed differences. Abnormal colored, white spotted animals were sighted and comparisons were made with the standard colored. These spotted cattle were smaller in all phenotypic measurements and significantly lighter in body weight ($P<0.0001$) compared to standard cattle and regardless of origin. The phenotypic recordings may provide a realistic estimate of the Bali cattle on the locations investigated. The results from interviews and phenotyping can be used when developing breeding programs for Bali cattle.

Keywords: Bali cattle, Phenotyping, ANOVA, Breeding

INTRODUCTION

For small domestic animal holders in Indonesia, the world's 4th most densely populated country, Bali cattle (*Bos javanicus*) constitute the most important breed. Due to their high feed efficiency these cattle can live and produce well on very low-quality feed. They also have good fertility and show resistance against many occurring diseases (Mohamad *et al,* 2009). These features makes Bali cattle the economically most important cattle breed used for meat production out of the four indigenous cattle breeds in Indonesia (Martojo, 2012). Bali cattle constitute about 27 % of Indonesia's total cattle population and are most common on the eastern islands. In 2004, the population of Bali cattle was estimated to be approximately 11 million heads (Purwantara *et*

al, 2012). Genetic analysis of Bali cattle revealed low rates of heterozygosity, which is a sign of inbreeding (Mohamad *et al*, 2009) which is a well- known problem for domesticated animals (Barker, 2001; Talib *et al*, 2003).

Here we aim to increase the knowledge of how Bali cattle are managed by collecting phenotypic recordings and investigate how to approach the problem with a decreased genetic diversity.

MATERIALS AND METHODS

Phenotypic recordings

The field study and phenotyping were conducted during February and March 2015, which is at the end of the rain season.

Phenotype measurements were recorded for each individual according to guidelines from the Food and Agriculture Organization of the United Nations (FAO) (FAO, 2012). The measurements taken on each individual were: body length (BL), height at withers (HW), chest girth (CG), horn length (HL), body weight (BW), pelvic height (PH) and pelvic width (PW). Qualitative variables noted were: gender, age, dewlap size (DS), rump profile (RP), backline profile (BP) and facial profile (FP).

In order to minimize the risk that difference in phenotype was due to age the comparisons in the study were made on adult animals >2 years of age. All individuals were photographed in order to keep track of which animal that had been sampled and to be able to connect phenotypic measurements to the ID. There was also a description of the color of: eyelid, hoof, horn, skin, muzzle and coat. The coat color pattern and type of the fur were also recorded.

The measurements were performed with folding-rulers and a measuring-tape. A calibrated European weight measuring-tape for cattle was used to record weight. Animals were sampled at four different locations - Bogor on Java, Kampar on Sumatra, Paremas on Lombok and Pleihari on Kalimantan. The number of animals >2 years of age sampled at each location is shown in Table 1.

Table 1. Locations and numbers of phenotyped animals at each location

	Bulls	Cows
Feedlot Gunung Sindur, Java (Originating from Bali)	5	0
Sumatra, Kampar	0	17
Kalimantan, Pleihari (originating from Lombok)	1	40
Lombok, Paremas	2	28
Total	8	85

Interviews

Interview questions were composed using a standardized questionnaire and guidelines from Bell (1999). The questionnaire considered desired traits, the farmer's prior knowledge about breeding, management and problems with for instance calf mortality and health. The answers to the questions were analyzed and compared between locations. A total of 68 farmers were interviewed on the same four different locations as was used for the phenotype recordings; Bogor on Java, Kampar on Sumatra, Pleihari on Kalimantan and Paremas on Lombok.

Statistical analysis

Statistical analysis were performed using Graph pad Prism version 6.00 for Windows and

Microsoft Office Excel 2010. Mean values, max/min values, standard deviations, and variance for mean values were calculated for linear measurements and age. Correlations were estimated for males and females and for white spotted animals compared to standard colored individuals. ANOVA was used to determine if there were significant differences for the phenotypic values between the individuals depending on origin and location. The null hypothesis (H_0) stated that the difference was equal to zero and the alternative hypothesis (Hi) stated that there was a difference (a =0.05). A P-value <0.05 indicated a significant difference. Animals were divided by gender and tested depending on *location* and *origin*.

RESULTS AND DISCUSSION

Interviews

A total of 68 farmers were interviewed on the four locations. None of the farmers used planned mating but mated their cows throughout the year regardless of season. By recommending farmers to perform planned matings animal welfare effects are possible. The possibility to plan the gestation with regards to the season could have beneficial effects since it would minimize heat stress and optimize access of feedstuff.

The majority of the farmers preferred to use artificial insemination (AI) and to use crossbreeding between Bali cattle cows and bulls from other cattle breeds. Limousin and Simmental were the preferred breeds to mate with, due to their large size and good growth. Size was also mentioned as the most desired trait to improve. The posture and conformation was also mentioned as important. The popularity of crossbreeding and desire for large animals might pose a threat for the purity of the Bali cattle breed and may also increase the risk of calving difficulties since crosses with the exotic breeds result in much greater birth weights compared to Bali cattle. Taylor and Murray (1988) stated that smaller individuals tended to cope better with heat-stress. The heavier beef cattle have much higher energy requirements compared to the Bali cattle and are not suited for the Indonesian small-scale farmer conditions. This might result in malnourishment and increased disease prevalence, thus leading to loss of income and animal welfare problems.

On Kalimantan, all the 31 interviewed farmers responded that they had a breeding strategy and all of them answered that the goal with the strategy was to breed for getting larger animals. The fact that farmers also stated that they sold the largest animals since they brought in the best pay, contradicts with this breeding goal and may result in that the largest animals are excluded from breeding. The most common health problems were caused by infections and resulted in fever and diarrhea. On Sumatra, 13.3 % of the farmers stated that they had problems with Jembrana disease. Close to all farmers, 98.6 %, wanted to learn more about breeding and the fact that they were eager to learn more opens future possibilities for further education and collaborations.

Phenotypic recordings

A total of 93 animals >2 years of age were phenotyped, 8 males and 85 females. For all mean values, see Table 2.

Table 2. Descriptive statistics of phenotypic measurements from all males and female

	All males N=8			All females N=85		
	Mean	Min/Max	sd	Mean	Min/Max	sd
Age (years)	2.00	2	0	5.55	2/7	2.79
BL (cm)	123.25	104/149	13.97	110.66	95/130	7.09

HW (cm)	120.38	110/129	6.7	110.42	100/125	4.6
CG (cm)	165.75	133/181	16.02	150.32	130/166	8.13
BW (kg)	389.13	205/492	99.96	285.00	192/381	41.9
PH (cm)	119.13	112/131	6.73	111.27	101/128	4.67
PW (cm)	33.00	18/40	7.62	23.96	10/36	7.8
HL (cm)	23.75	19/28	2.96	21.26	8/35	8.76

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PH=Pelvic height, PW=Pelvic width, HL=Horn length. sd= standard deviation and var=variance

Abnormally colored, white spotted animals were sighted on all the locations on Bali, Lombok, Sumatra and Kalimantan. According to information given in the present study, white color or spotted color pattern appeared mostly on inbred animals. Since all the white spotted individuals were females they were compared to standard colored females to avoid differences depending on gender.

Statistical analysis

The ANOVA-test comparing phenotypic measurements for males originating from Bali and males originating from NTB showed that the ones from Bali were larger in all phenotypic measurements except from HL. These differences could probably be explained by differences in management because the males originating from Bali were housed in a feedlot. Comparing females on Sumatra with the females located on Lombok showed significant ($P<0.0001$) differences in the BW where the females on Sumatra on average weighed 45.6 kg less compared to the ones located on Lombok. Comparing females from Sumatra with the ones located on Kalimantan (originating from NTB) showed significant differences for BW where the ones on Sumatra weighed 25.3 kg less, had significantly ($P<0.01$) narrower PW and also got significantly ($P<0.001$) shorter HL.

Comparisons between the females located on Lombok and Kalimantan showed significant ($P<0.001$) differences in HL where the average difference was 15.4 cm shorter on Lombok. Significant differences were also found for PW ($P<0.01$) and BW ($P<0.0001$) where the females on Lombok were heavier and having wider hips. When comparing females from Sumatra with all females originating from NTB, significant ($P<0.0001$) differences were found for the BW where females from Sumatra on average weighed 33.6 kg less.

Analyses of the white spotted animals

The performed ANOVA comparing white spotted cows with the standard colored cows showed that the white spotted cows were smaller in all measurements and significantly ($p<0.0001$) differed in BW where the white spotted cattle on average weighed 48.0 kg less compared to the individuals with standard color, regardless of the origin and location. Since inbreeding results in smaller phenotypical measurements this could be the explanation to the smaller measurements. According to Sponenberg (2015) the spotted coat color is most likely not a result of inbreeding and this type of spots have been recorded on horses that are cross bred and also in out-bred horse breeds. However, if white spotting is a recessive trait in Bali cattle, it could be used as a marker for inbreeding since it would occur more frequently due to increased homozygosity. Perhaps the inbreeding is not the reason for the spotted color as such, but the reason to an increased frequency of the color appearing in an inbred stock.

No literature could be found about the genetics behind the white spotting and according to Sponenberg (2015) the genetic background to the color pattern is still unknown. The information from the farmers stating that it was due to inbreeding did not indicate at what degree of inbreeding the white color appears. Since the degree of inbreeding of the white spotted animals in this study

was unknown, this theory could not be studied further. The dataset of white spotted individuals was small and thus not large enough to draw reliable conclusions from, further data from white spotted and white individuals is thus needed.

CONCLUSIONS

This study may be a first step in developing tools suitable for improved breeding of Bali cattle at the small scale farm level. Thus helping to preserve the genetic integrity of this important cattle breed.

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