Swedish University of Agricultural Sciences
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Examensarbete / Swedish University of Agricultural Sciences, Department of Animal Breeding and Genetics

424

Uppsala 2013

Examensarbete, 15 hp
– Bachelor Thesis

Agriculture programme
– Animal Science

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
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Fenotypning av Bali-kor och intervjuer med lantbrukare i Indonesien- en fältstudie

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Credits: 15 hp
Course title: Bachelor Thesis – Animal Science
Course code: EX0563
Programme: Agriculture programme – Animal Science
Level: Basic, G2E

Place of publication: Uppsala
Year of publication: 2013
Cover picture: Ida Clemensson
Name of series: Examensarbete / Swedish University of Agricultural Sciences Department of Animal Breeding and Genetics, 424
On-line publication: http://epsilon.slu.se

Key words: Phenotyping, Indonesia, Bali cattle

List of abbreviations

AI= Artificial Insemination
BL= body length
BP = backline profile
BW= body weight
CG= chest girth
DS = dewlap size
EL= ear length
FAO= food and agriculture organization
FP = facial profile
HL= horn length
HW= height at withers
MC= muzzle circumference
PW= pelvic width
RP = rump profile
TL= tail length

Sammanfattning

Bland Indonesiens inhemska nötkreatursraser föredrar majoriteten av lantbrukarna Bali-kon, en köttras som anses ha många fördelaktiga egenskaper samt är väl anpassad till landets hårda tropiska klimat och miljöförhållanden med torka och regn. Syftet med den genomförda studien var att fenotypa Bali-kor från olika geografiska platser för att dokumentera utseendemässig variation inom rasen samt jämföra djur mellan olika platser och skötselsystem för att se hur dessa faktorer påverkar fenotypen. Sammanlangt fenotypades 107 kor och tjurar av rasen Bali-ko med ursprung från följande fyra olika regioner i Indonesien: Kalimantan, Sumatra, Lombok och Bali. Enligt riktlinjer från Food and Agriculture Organization (FAO) togs linjära mått för kroppslängd, mankhöjd, bröstkorgens omkrets, öronlängd, hornlängd, mulens omkrets och bäckenets bredd. Även kroppsvikten uppskattades med hjälp av ett kalibrerat viktmåttband. Svanshårstrån samlades in för preparation av DNA i syfte att användas i framtida forskning. Lantbrukare intervjuades i varje by som besöktes för att få mer information om bland annat skötsel, produktion och avel. Resultaten analyserades genom att studera korrelationer mellan de olika linjära måtten samt jämföra medelvärden hos djuren från de olika platserna. Resultaten från de statistiska analyserna kombinerades med resultaten från intervjuerna för att undersöka om storleksskillnader hos djuren mellan de olika platserna kunde bero på skötsel och/eller ha en genetisk bakgrund. Även avelsstrategier och hantering av djurens genetiska resurser i byarna undersöktes. Resultaten indikerade att storleksskillnader mellan kor från Kalimantan, Sumatra och Lombok troligtvis var ett resultat av olika skötsel medan storleksskillnaden mellan tjurar från Bali och Lombok kunde tänkas vara resultatet av skötsel men även ha en genetisk bakgrund. Svaren på intervjufrågorna indikerade problem med inavel hos djuren i byarna samt bristande kunskap om avel och avelsstrategier, vilket skulle kunna innebära ett framtida hot mot Bali- kons genetiska mångfald.

Abstract

Among the Indigenous cattle breeds in Indonesia, the Bali cattle is the most preferred by small farmers. The Bali cattle is a beef breed, and is considered to have several advantageous characteristics and to be well adapted to the country's harsh environmental tropical conditions with drought and rain. The main aim of this project was to phenotype of Bali cattle from different locations in order to identify and document diversity within the Bali cattle breed based on their observable characteristics, to compare cattle from different areas and production systems to see the effect of management on phenotype. In this study, 107 cows and bulls of the breed Bali cattle, from Kalimantan, Sumatra, Lombok and Bali were phenotyped. According to directions from the Food and Agriculture Organization (FAO) measurements were taken with focus on body length, height at withers, chest girth, ear length, horn length, muzzle circumference, body weight and pelvic width. Hairs from the tails were collected for future preparation of DNA. The farmers at each location were interviewed about management, breeding and production. Correlations between the linear measurements were analyzed and animals from the different locations were compared to each other with regards to the mean values of the linear measurements. The results from the statistical analyses were analyzed together with the results from the interviews to examine whether the differences between locations could be due to management or also have a genetic background. The breeding strategies and management of genetic resources in the rural villages were also investigated. The results indicated that differences in size between cows from Kalimantan, Sumatra and Lombok were more likely to be the result of management, whereas size differences between bulls from Bali and Lombok could be the result of both management and genetic factors. Interviews revealed problems with inbreeding and lack of knowledge

regarding breeding and breeding strategies in all villages which could pose a future threat to the genetic diversity of the Bali cattle breed.

Introduction

Indonesia is a country consisting of 33 provinces and with a population of approximately 237 million people. Livestock husbandry is essential in the country and 4.5 million households keep livestock, mainly in smallholder farming systems (Martojo, 2012). The farming systems are often characterized by being mixed, where crops and animals are integrated on the same farm in order to increase the output and better utilize the available resources. Indonesia has the smallest average size of the livestock holdings in Asia, with a size of 0.4 ha per farm (Devandra, 2002). By possessing livestock, the farmers gain benefits through sale of products such as milk or meat and the nutritional status of the household is improved as a result of increased consumption of animal products. Larger livestock such as cattle gives the farmer a financial security since the animals can be sold when need arises (Riethmuller, 1999). The indigenous cattle breeds that can survive and produce under harsh environmental conditions are considered the most suitable for smallholder farmers because of their favorable characteristics (Baker, 1994). The most preferred cattle breed among the small farmers is the Bali cattle (*Bos javanicus)*, a beef breed thought to be domesticated from the wild Banteng (*Bos banteng*) still living free in some areas in Southeast Asia (Mohamad et al., 2009; Martojo, 2012). Today, the meat consumption in Indonesia is increasing with 6-8% per year and the demand for beef meat is bigger than what the country has possibility to produce from its local beef cattle production. The outcome of this is a declining Bali cattle population, a problem that is worsened by the increased export of bulls and cows as well as high slaughter rates for pregnant cows and a shortage of available bulls (Talib et al., 2003a; Lisson et al., 2010). Animals with less superior genes in terms of for example growth have been used for breeding, and in combination with poor nutritional management, the genetic quality and productivity of the breed has deteriorated (FAO, 2003).

The aim of this study was to phenotype Bali cattle from different locations in Indonesia in order to survey the status of the breed. The phenotypic data was used to identify breed characteristics and also to examine within breed differences due to management practice and location. Hair samples were collected from each phenotyped animal and were used to prepare DNA for future research. As a complement to the phenotypic data farmers were also interviewed at each location in order to gain more qualitative information regarding management, production and breeding practices.

Background

Origin and distribution

Bali cattle (Bos javanicus) belongs to the family *Bovidae*, to which also the taurine cattle (*Bos taurus)*, which is the type of cattle most common in Europe, and Zebu (*Bos indicus)* cattle belongs (Talib et al., 2003a). The Taurine and Zebu cattle had a common ancestor more than three million years ago called Aurochs (*Bos primigenius)*, but through sequencing of mitochondrial genes it has been stated that Bali cattle had a different ancestor than the European and Zebu cattle (Kikkawa et al., 1995). There are no official arachaeozological or historic records of the Bali cattle's relationship to the wild Banteng, though domestication probably took place around 3500 years BC (Mohamad et al., 2009; Martojo, 2012). The name Bali cattle is a result of the fact that domestication probably took place on the island of Bali. Since the first import of Bali cattle took place to Sulawesi in the 1890s and to Timor 1912, the breed has become widely distributed all over Indonesia and has also been introduced to

Malaysia as well as Australia where the population is feral and not used in the beef industry. Today Bali cattle is claimed to be the national breed of Indonesia due to its origin and advantageous characteristics. Because of this, export for breeding purposes is restricted and sometimes prohibited (Payne& Rollinson, 1973; Toelihere, 2003). Data from 2010 estimated the Bali cattle population to 3 271 000 animals (Gunawan et al., 2011) and the breed has its largest density on South Sulawesi as well as East and West Nusa Tenggara, where the number of Bali cattle today is larger than on Bali. The Bali cattle are also found in Sumatra and Kalimantan (Purwantara et al., 2012).

Production systems and management

The production involving Bali cattle in Indonesia is essentially organic in its nature and can be considered sustainable (Martojo, 2012). The management systems can be divided into two groups, those under pasture management, also described as extensive, and those under a cut and carry system, also described as intensive or semi-intensive. In the cut and carry system animals are held in simple stalls or yards and grass is cut by the farmer and brought to the animals. They sometimes receive supplements. The animals can also be tethered in grazing areas during the day and confined at night. Keeping the animals tethered makes it easier to collect manure. Cattle under pasture management systems are in some areas permitted to run free in specific areas during cropping season and graze crop residues in the dry season. The quality and availability of feed varies between wet and dry season and no other feed is normally given. The productivity, with regards to beef production, and also milk production of these animals is usually low. This system requires close supervision of the animals and they are sometimes housed during night for security reasons. The performance of the cattle varies depending on system and what feed they are given within the system. Therefore environmental effects play a large part in the productivity, and performance- traits cannot directly indicate the genetic quality or potential of the animals. (Riethmuller, 1999; Talib et al., 2003b). Today more and more green areas are used for housing due to the increasing human population, and the development of tourism is also reducing the available areas for feed production to the cattle (Oka, 2003).

Physical characteristics

The appearance of Bali cattle has changed little from their wild ancestor, the Banteng. Differences can be found in size and temperament where Bali cattle are smaller and more docile than the Banteng as a result of domestication (Martojo, 2012). The breed has been described as deer like in appearance and temperament (Payne & Rollinson, 1973; McCool, 1992). They usually have a reddish-brown coat color with white socks reaching from the hooves to just above the hocks and a defined white area on the hindquarters extending along the belly (Figure 1). They also have white hair in the ears, around the muzzle and on the tail (Payne & Rollinson, 1973). A well-defined black band runs along the back. The coat color of the bulls darkens after their sexual maturity at 12-18 months of age and they turn almost black, keeping their white markings and the black band on the back. Castrated bulls regain their red coat color again a few months after castration. Females keep their red color also as adults (Talib et al., 2003a). Some calves are born with black hair and white pattern; these are called *bulu indjin* in Balinese. An adult *bulu indjin* will have grey hair in the ears and pigmented skin in the jaw. Females with white color interspersed in the red hair can also be seen, these are called *bulu tultul* and are usually not used for breeding (Payne & Rollinson, 1973). Based on information from Bali´s AI-centre (Jatu, 2013) white interspersions in the coat color, seen as spots or larger white areas indicate that the animal is inbred. Sometimes dark brown females are found. This is unusual and these animals are never slaughtered but rather used at ceremonies since they are considered special (Jatu, 2013).

The average live weight for mature bulls is 335-363 kg and for mature cows 224-234 kg on Nusa Tenggara Barat, Nusa Tenggara Timur and South Sulawesi, while the weight on Bali is 395 kg for bulls and 264 kg for cows (Talib et al., 2003a). The height of bulls ranges from 1,3-1,5 m at the shoulders and cows are about 1,2 m high. They are humpless cattle with a short neck and a small dewlap. The face is narrow with large ears pointing forward. On males, the horns grow outward, sideward and up, from a horny mass on the forehead. On females the horns usually grow upward and back with a curl down toward the head. The horn size and shape differs between males and females, on the male they are 20-25 cm long while females have smaller horns (Payne & Rollinson, 1973; Popenoe, 1983).

Figure 1: The standard coat colors of a Bali cattle cow from Kalimantan (left) and a bull from Bali (right).

Production and adaption characteristics

Adaption is a term used to describe the indigenous breeds' ability to adjust in order to become more suitable for living under specific environmental stresses such as high ambient temperatures, high humidity and high or low rainfall (Baker, 1994)**.** Bali cattle have many advantageous adaption characteristics and high figures in many production traits compared to other indigenous breeds. The breed is highly efficient in utilizing low quality feed and their fertility reaches nearly 80 %, meaning that 80% of the females that were mated became pregnant (Purwantara et al., 2012). They are well adapted to the tropical conditions and can maintain their body weight and achieve high conception rates even under harsh nutritional conditions. The Bali cattle have developed a survival strategy when nutritional conditions are poor and this is seen in their reproductive biology. Bali cattle conceive when they are relatively young and have high pregnancy rates compared to taurine and indicine cattle breeds as well as water buffalo held in the same environment. However, when there is a nutritional stress, they abandon their calves, either physiologically by not producing enough milk, or by behavioral abandonment (McCool, 1992). Compared to *Bos taurus* breeds in the temperate zones, Bali cattle has low figures in performance in traits such as calf birth weight, milk production and calf growth rate (Martojo, 2012). The milk production is around 164 kg per 6 months on Nusa Tenggara Timur and south Sulawesi, while on Bali the milk production is 274.5 kg per 6 months (Talib et al, 2003a). The Bali cattle also have a lower birth rate and higher calf mortality under stressful climatic conditions due to low milk production. The smaller average growth rate and weight are the result of adaptation and among the indigenous breeds in Indonesia, the Bali cattle still has the highest figures in these traits (Martojo, 2012). The Bali cattle breed is resistant to many diseases and parasites but has a weakness in its unique susceptibility to Malignant Catarrhal fever and the Jembrana disease. The diseases have a high morbidity rate and there has been no economically effective vaccine developed (McCool, 1992; Martojo, 2012).

Current breeding strategies and genetic status

The genetic status of the Bali cattle population in Indonesia is a result of the population management and breeding strategies that are being used. Most smallholders use natural mating with available bulls when breeding their cattle. Also in more intensive rearing systems natural mating is the most predominant method but Artificial Insemination (AI) is sometimes used. The farmers usually keep all cows while the biggest bulls are assigned to a fattening program and exported or slaughtered without being used for mating. When need arises also fertile females are sold for slaughter. The bulls that remain in the herd are the younger and inferior in terms of growth and size, and these bulls are used for breeding at herd level. Few bulls are introduced to a herd from the outside (Talib et al., 2003b). Because the fact that the bulls used for mating are unselected and with lower performance in production traits, the prerequisites for genetic improvement is low and there is also a risk of inbreeding in herds where new animals are not introduced from other herds (Talib et al., 2003c). In order to stop the declining Bali cattle population and the negative selection, some local governments in the country such as in Nusa Tenggara Timur, have made preventing efforts. This has been done for example by banning export of the best bulls and heifers, and only dispose lower quality and culled animals. Productive cows have been bought from the slaughterhouses and distributed to smallholders through a contract system (Talib et al., 2003c).

Selective breeding of Bali cattle for beef production has mainly been conducted in order to improve production traits, such as the average daily gain and growth rate. Reproduction traits have rarely been in focus even though reproduction traits appear to be economically important, regardless of production system. The low fertility is the main cause for production losses and consequent economic losses, since this result in a prolonged calving interval, increased insemination costs, reduced return from calves born and higher replacement costs. The low heritability of reproductive traits is considered to limit the genetic progress in this trait. However, selection of females with high fertility could improve the reproductive performance of females since it has been stated that these traits have a moderate to high heritability and therefore could be included in a breeding goal. On Bali cattle cows, the traits age at first calving, calving interval and pregnancy rate had estimated heritability's of 0.22, 0.41 and 0.40 respectively (Gunawan et al., 2011)**.** The animals in Bali are managed under different and better conditions compared to other Indonesian provinces. They therefore have a higher weight and do not seem to have the same weaknesses such as slow growth rate, small body size and high calf mortality as Bali cattle on other locations in Indonesia. A study carried out by Mastika (2003) suggested that differences within the breed may not only be related to genetic factors, but also environmental, nutritional and management factors. He found that an improved feed quality and management could probably increase growth, feed conversion efficiency and meat quality of Bali cattle .

In 1976, the government established a breeding program on Bali, called P3Bali, to be able to develop the genetic potential of the breed in terms of for example growth. The breeding centre uses an open nucleus to avoid inbreeding depressions. Sires are selected by progeny testing and performance testing and their superior genes are to be transferred from selected animals and downwards to the commercial herds. Females from the second layer are used for replacement of the top-layer. The genetic progress from P3Bali has been slow due to technical constraints which have made it impossible to fulfill all the steps in the selection process (Supriyantono, 2011). In Bali, there is also an open nucleus AI-center selling semen to Sulawesi, Sumatra and Kalimantan. However, Lombok gets semen from an AI-center on east Java where the bulls are known to be smaller than the ones from Bali. The bulls at the AI-

centre are selected from national exhibitions and they are assumed to be pure bred. To avoid inbreeding, the AI-center never buys bulls continuously from the same location (Jatu, 2013).

Materials and Methods

Phenotypic characterization

*"The process of identifying distinct breed populations and describing their external and production characteristics within a given production environment"(*FAO, 2012)

The phenotypic characterization of Bali Cattle in this study was based on the Food and Agriculture Organization (FAO)´s guidelines for phenotypic characterization (FAO, 2012). Since only one visit to each location was done and the information collected was basic, the study was considered as primary, in opposite to an advanced phenotypic study which requires several repeated visits and measurements over an extended period to the different locations. Because there is already existing basic information about the Bali cattle breed and its distribution, the approach of this study was confirmatory. The objective of a confirmatory study is to validate breed identity and provide systematic description of a breed that has already been identified. This type of study presumes that the breed has a defined geographical distribution and some common phenotypic characteristics and pattern of utilization. According to FAO (2012), the term advanced characterization is used when conducting a confirmatory study, though the present study is considered to be primary. Before the study in Indonesia was carried out, a pre-study had been conducted on the dairy cattle at Jälla agricultural high school, on two occasions. The pre-study aimed at designing an easy to use-protocol and to test what instruments were most suitable for the various measurements. Since the pre-study was performed on Swedish dairy cows, all measurements could not be taken, such as horn length.

Males and females were phenotyped in three villages; Pleihari on Kalimantan, Kampar in Sumatra and Paremas on Lombok. On Java, males at a slaughterhouse, originating from Bali and males at a feedlot, originating from Lombok were phenotyped. At each location, the number of animals measured can be seen in table 1.

Table 1: Survey locations

Location	Bulls	Cows
Kalimantan, Pleihari	2	22
Bali (located on Java, Bogor Slaughterhouse)	20	0
Lombok (located on Java Bogor feedlot)	20	0
Sumatra, Kampar	7	16
Lombok, Paremas	5	15

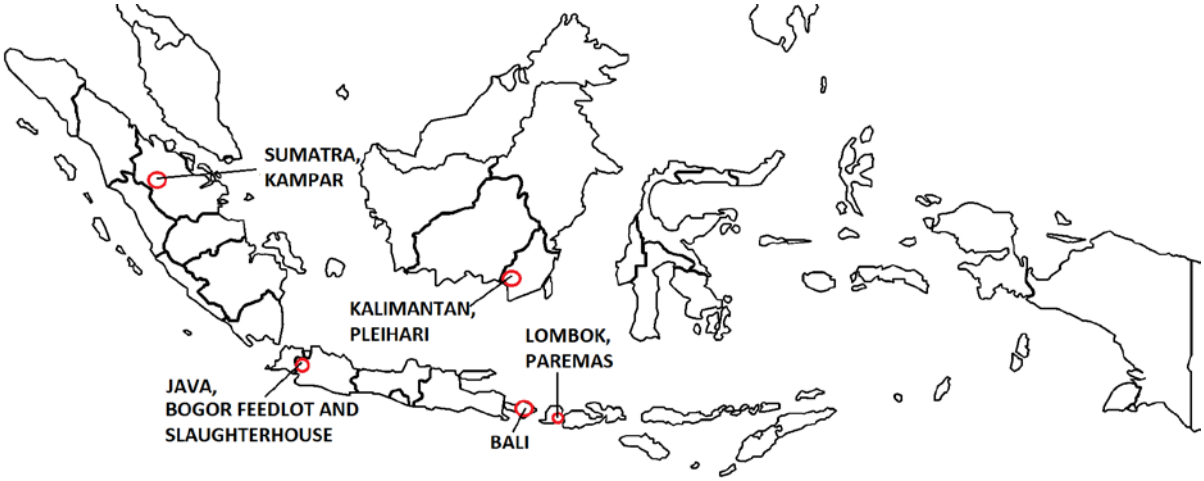

Figure 2: Map of survey locations. Modified from Wikimedia.org

Collaboration with Indonesian counterparts was crucial for making initial contact with the local authorities at each location, who had to be informed in advance and accept the study. The contact with the local authorities was also important in order to ensure that cattle would be available at the date of each visit, as well as to ensure the presence of the farmers since interviews were performed with them. A number of measurements were taken based on the FAO guidelines. The linear and quantitative measurements taken on each cattle were: body length (BL), height at withers (HW), chest girth (CG), ear length (EL), horn length (HL), muzzle circumference (MC), body weight (BW) and pelvic width (PW). Qualitative variables were: sex, age, dewlap size (DS), tail length (TL), rump profile (RP), backline profile (BP) and facial profile (FP). Color descriptions were defined for eyelid, hoof, horn, skin, muzzle and coat. The coat color pattern was also stated. Some variables were stated at herd level, separate for males and females, these were: horn presence, horn shape, ear shape, ear orient, hair type, hair length, horn orientation and horn attachment. The age at first calving, current pregnancy status and number of born calves was also noted for each cow. For a more detailed description of each measurement taken, see appendix 1. The material used for these measurements were a regular measuring-tape and a folding ruler. To get an estimate of the weight and chest girth, a calibrated weight band was used, where chest girth was converted to body weight. In this specific study a regular European weight band designed for beef breeds was possible to use, since Bali cattle are hump less. Although the weight band only gives an estimate, it makes it possible to compare the relative difference in weight between animals. Focus was put on adults above 2 years old since younger animals are not yet fully grown. The measurements were taken by the same person to avoid faults in the data. A photograph of each measured animal was taken at each location and a photo of the production environment at each location was also taken.

Interviewing

Complementary information was collected by interviewing the farmers about management, breeding and production. The interview questions for the farmers were prepared in advance and translated to Indonesian. The questions were based on the FAO guidelines (FAO, 2012) concerning additional information that needed to be collected when performing a phenotype study. For all interview questions, see appendix 2. At first, a questionnaire was created with open answers, however this turned out to be too difficult after the first visit. Instead a new questionnaire was created in order to make interviewing, translation and understanding of the

questions easier. This questionnaire contained the same questions as before, but was created with multiple choice questions which could easily be translated and was less time consuming than the open answer option.

DNA- sampling

In the study, hair samples were collected for preparation of DNA for future research. This was done by pulling hairs from the tail, ensuring that the bulbs were present. At least 40-50 hairs from each animal were collected to ensure to obtain enough DNA. The hairs were taped to a paper-card and put in an envelope, marked with the ID of the animal. At the slaughterhouse, the whole tails from the bulls measured were obtained the day after slaughter. This was done to avoid stressing the animals before slaughter. The tails could be connected to the measurements through the bulls specific IDs. From these animals it was therefore possible to collect large amount of hair.

Statistical analysis

The statistical software program by R core team (2013), version 3.0.0, was used for the analyses of the data. Mean values, maximum and minimum values, standard deviations and variances were derived for all linear measurements as well as for the age. An approximation of the average number of calves born per year and cow was calculated based on age at first calving and number of calves born per cow. Animals less than 2 years old were removed from the dataset since they are not yet fully grown

T-test

A t- test was used to determine whether there were any significant differences between mean values of the linear measurements at the different locations. The null hypothesis stated that difference in mean values was equal to zero, and the alternative hypothesis stated that the differences between the mean values were not equal to zero. Females from Kalimantan, Sumatra and Lombok were tested against each other and males from Lombok and the ones originating from Bali were tested against each other. A p-value less than 0.05 indicated a significant difference.

Correlations

Females from all locations were grouped together and all males were grouped together. Correlations between linear measurements were estimated as well as the significance level of the correlation. Correlations larger than 0.7 was considered as strong and a correlation larger than 0,4 considered moderate. The p-value indicated if the correlation was significant or not.

Results

The results of this study will focus only on the linear measurements and the interviews. Regarding other data that was collected, only results deviating a lot from the standard of Bali cattle will be brought up. The name of the island of origin will be used when referring to location.

Summary from interviews

A short summary of the performed interviews with only the most important aspects is brought up here. For the full compiled interviews, see appendix 4.

The management system between the three locations differed where Kalimantan and Lombok had semi- intensive management systems, whereas Sumatra had an extensive system. Only in

Kalimantan the bulls were sometimes given concentrates. The temperament of the animals was described as everything from docile to wild. The most common health problem in all villages was diarrhea but also Jembrana, fever, limp and eye-problems was common. In Kalimantan and Sumatra the animals were vaccinated for Jembrana, but in Lombok the cattle were immune to Jembrana as well as the bacterial disease Anthrax, and they did not need vaccination. When mating, the use of AI varied between the locations. In Kalimantan and Sumatra about half the farmers used AI and half natural mating, whereas in Lombok all farmers used natural mating. Stillbirths, abortions and birth defects did not seem to be a big problem in any village, and in Lombok the farmers stated that they never experienced this. In Kalimantan, none of the farmers had any breeding strategy and about half of them did not know how they would avoid inbreeding whereas the other half of them said they would not mate within the family. One farmer mentioned that he avoided animals with white hairs on the body or tail since that would be an indication of inbreeding. In Sumatra all but one farmer took consideration to inbreeding by not mating related animals, though most of them did not really know how to keep track of which animals were related. In Lombok inbreeding seemed to be a problem in the village and none of the farmers took any consideration to inbreeding, though they said they knew which animals were related by memory. In all villages, the most important traits for cows were reproductive traits and for the bulls, traits related to growth, appearance and health were the most important. The farmers wished reproductive traits, growth, health and temperament to improve.

Comparison of mean values between locations

Females from Kalimantan, Sumatra and Lombok were compared and males from Bali and Lombok were compared since the number of males from Kalimantan and Sumatra was too small to analyze. Since the males from the feedlot originated from various villages in Lombok, they were grouped together with males from Paremas village in Lombok in order to get a larger dataset. Animals less than two years of age were removed from the dataset. This resulted in 22 females from Kalimantan, 16 from Sumatra and 12 from Lombok. There were 18 males in the dataset from Lombok and 20 from Bali.

T-test

The mean values for females differed between the three locations, where animals from Lombok had the largest values for most linear measurements and animals from Sumatra had the smallest values. In Kalimantan many of the cows measured were pregnant between 3-8 months, however, there was no consideration taken to this when linear measurements were compared. For all female mean values, see Table 2. Statistically significant differences ($p<0.05$) were found for BL between Kalimantan and Sumatra as well as between Lombok and Sumatra. The mean values for CG and BW differed significantly between Kalimantan and Sumatra. Also the PW differed significantly between Lombok and Sumatra. EL and HL differed significantly between all three locations. For all other measurements, the null hypothesis was true and the differences between means were equal to zero. The males from Bali had over all larger values for almost all linear measurements, with the exception for EL which was larger on Lombok. For all male mean values, see Table 3. Significant differences were found between the two groups for BL, HW, CG, BW and MC. For all p- values and t-values for males and females, see Tables 8 and 9, appendix 3.

Table 2: Phenotypic data from females in the three provinces

	Kalimantan				Sumatra				Lombok			
	Mean	sd	Min/max	var	Mean	sd	Min/max	var	Mean	sd	Min/max	var
Age(years)	5.8	2.3	3/10	5.0	3.9	1.5	2.5/8	2.2	3.9	0.8	3/5	0.7
BL (cm)	116. 9	6.3	110/135	39.1	111. 2	4.5	100/118	20.0	119. 0	7.7	110/132	59.2
HW(cm)	112. 4	3.8	104/119	14.5	110. 8	2.7	106/116	7.5	115. 3	9.3	103/131	86.6
CG(cm)	154. 5	7.8	143/171	61.1	145. 3	7.0	134/157	49.4	151. 3	15.5	130/174	240. 8
BW(kg)	300. 2	47.2	246/408	2223. 0	253. 1	30.5	206/314	931. 3	291. 6	82.0	190/414	6730. 5
TL(cm)	66.1	4.1	58/76	16.6	67.5	5.7	59/80	32.1	67.8	8.5	52/83	72.4
PW(cm)	21.4	2.1	17/25	4.3	20.4	1.9	15/23	3.9	23.3	3.1	18/28	9.5
EL(cm)	20.2	2.7	15/25	7.1	22.7	2.2	20/28	4.9	25	2.1	22/29	4.6
HL(cm)	15.6	3.2	10/22	10.3	12.6	2.6	8/18	6.8	18.8	4.4	13/26	19.1
MC(cm)	40.3	2.8	35/44	7.6	40.4	3.4	36/47	11.9	40.7	3.0	36/46	8.8

Sd= standard deviation. Var= variance. BL= body length, HW= height at withers, CG= chest girth, BW= body weight, TL= tail lengt, PW= pelvic width, EL= ear length, HL= horn length, MC= muzzle circumference

Table 3: Phenotypic data from males originating from Bali and Lombok

	Lombok				Bali			
	Mean	sd	Min/max	var	Mean	sd	Min/max	var
Age(years)	2.1	0.2	2/3	0.06	2.7	0.3	2/3	0.1
BL(cm)	104. 6	5.9	97/120	34.6	119. 0	8.0	108/138	63.3
HW(cm)	110. 6	3.5	103/118	11.9	126. 7	5.6	115/138	31.8
CG(cm)	147. 6	4.7	140/158	22.3	178. 7	10.9	159/204	118. 1
BW(kg)	262. 4	21.7	235/320	472. 0	466. 8	87.0	325/690	7560. 0
TL(cm)	69.6	6.7	56/82	45.3	71.3	7.9	48/89	62.8
PW(cm)	22.7	1.6	19/25	2.7	23.4	4.4	18/33	19.0
EL(cm)	26.2	2.2	24/33	4.9	25.3	3.2	18/30	10.2
HL(cm)	23.6	2.3	20/30	5.3	24.4	2.8	20/30	7.9
MC(cm)	40.1	2.8	35/46	7.9	46.5	4.5	38/57	20.3

For abbreviations, see Table 2

Correlations

Because a calibrated weight band was used to estimate the weight from the chest girth, CG and BW are grouped together. For females, moderate significant correlations were found between HW and BL, CG/BW and BL, CG/BW and HW, TL and CG/BW, as well as between HW and EL. No strong correlations were found other than between CG and BW (Table 4).

Table 4: Phenotypic correlations between conformation measurements, females, N=50

	BL	HW	CG	BW	TL	EL	HL	MC
BL	1	0.67	0.390	0.40	0.28	0.067	0.27	0.19
HW	8.80E-08	1	0.390	0.42	0.28	0.43	0.28	0.19
CG	0.0051	0.005	1	0.99	0.45	0.028	0.17	0.17
BW	0.004	0.002	2.2E-16	1	0.42	0.087	0.18	0.14
TL	0.051	0.047	0.001	0.002	1	0.068	0.037	0.32
EL	0.64	0.002	0.85	0.55	0.64	1	0.34	0.021
HL	0.057	0.052	0.23	0.22	0.80	0.015	1	0.096
MC	0.18	0.18	0.23	0.32	0.024	0.89	0.51	1

Correlations are above the diagonal and p-values are below the diagonal. For abbreviations, see Table 2.

For males, significant, strong correlations were found between CG/BW and BL as well as CG/BW and MC. Significant, moderate correlations were found between HW and BL, CG/BW and HW, EL and HW, EL and TL, HL and BL, CG/BW and HL, MC and BL as well as between MC and HW. For all male correlations, see Table 5.

Table 5: Phenotypic correlations between conformation measurements, males, N=54

	BL	HW	CG	BW	TL	EL	HL	MC
BL	1	0.49	0.73	0.74	0.34	0.05	0.45	0.68
HW	0.0002	1	0.66	0.62	0.35	0.46	0.38	0.56
CG	3.2E-10	5.3E-8	1	0.99	0.38	0.27	0.47	0.85
BW	2.2E-10	7.3E-7	2.2E-16	1	0.37	0.23	0.45	0.86
TL	0.01	0.009	0.004	0.006	1	0.42	0.27	0.38
EL	0.71	0.0004	0.05	0.09	0.002	1	0.19	0.26
HL	0.0006	0.005	0.0003	0.0007	0.05	0.18	1	0.42
MC	7.6E-9	1.1E-5	4.4E-16	2.2E-16	0.006	0.06	0.002	1

Correlations are above the diagonal and p-values are below the diagonal. For abbreviations, see Table 2.

Notes on other traits

In Kalimantan, one of the cows had white coat color spots and some of the cows had horns that deviated from the standard by being curled or pointing in other directions than backward. Two animals had loose horns. One of the cows in Kalimantan had a dark brown coat, similar to the color of an adult male. In Sumatra some of the males were red, whereas some of them where brown and for the cows there were many different shades of the standard color red. The size of the dewlap appeared on average larger in Sumatra than in Kalimantan or Lombok. In Lombok, there was one spotted cow and also one cow with large areas of white all over the body, and according to the owner this cow was inbred. Some of the males in Lombok were red and some brown. In Lombok all the animals were immune to Jembrana and the bacterial disease Anthrax. The Bali bulls from the slaughterhouse were much more uniform in size and color than the bulls from Lombok at the feedlot. The average number of calves born per year

was estimated to 1.05, based on age at first calving and total number of calves per cow (Table 10, appendix 3).

Figure 3: White cow from Lombok

Figure 4: Red male from Lombok

Figure 5: Dark brown cow from Kalimantan

Figure 6:Spotted cow from Kalimantan

Discussion

Differences between locations

It was an expectation that the BW/CG would be significantly lower for the females from Sumatra as a result of the more extensive management system and poorer nutrition status. However, the only significant difference for this measurement was found between females from Sumatra and Kalimantan and not between Sumatra and Lombok. This could be because many of the females from Kalimantan were pregnant and therefore had a significantly higher mean value for BW/CG compared to Sumatra where much fewer cows were pregnant. It could also be because the poorer nutritional status of the cows from Sumatra simply did not affect the results that much. A larger dataset with consideration taken to pregnancy status would be necessary to evaluate these possibilities. The differences in HW between the three locations were equal to zero and this indicates that females from all three locations have the potential to reach the same height if fed enough. The BL was however also significantly smaller for the females from Sumatra. When measuring BL it gave quite approximate results since a tensed animal will bend their back upwards and get a shorter body length, which in turn affects the result. To determine whether the smaller BL on the animals from Sumatra is

due to faults in measuring, an average smaller size influenced by genetic background, or because of their poorer nutritional status, or a combination of these environmental and genetic factors, it would require a much larger dataset. Future phenotype-genotype correlations of such data sets may provide further knowledge regarding these possibilities. The significant differences in the measurements of EL, HL and PW are most likely the result of chance since they did not follow the same pattern as the other measurements.

The significant differences found between the males from Bali and the ones from Lombok, were all related to the body measurements BL, CG, HW, BW and MC. Since no significant differences were found between HL at the two locations, this indicates that the correlation found between HL and other body measurements was only due to chance. When analyzing the background of the bulls from Bali and the bulls from Lombok (see appendix 4), it indicates that the differences in size might not only be due to management system, but also to genetic factors. However, the much smaller size of the Lombok bulls is most likely a result of both management and genetic status. There is a question if the animals from Lombok have the capacity to grow to the same size as the Bali bulls in 6 months. The capacity might be restricted due to genetic factors, but also to the fact that they might have had a "worse start" due to e.g. worse management. To know which factor lies behind the difference between the Bali bulls and the Lombok bulls, one needs to know their origin and management before they arrived to the feedlot/slaughterhouse. The information from the AI-center on Bali strengthens the argument that Lombok bulls have a smaller body size due to genetic factors since they are not inseminated with AI from the large Bali-bulls, but rather the smaller bulls from the AI-center on Java. The larger color variations of the Lombok bulls indicates that they had a greater variety in the genetic diversity and this is why they their appearance had more variety than the appearance of the bulls from Bali.

Correlations

For the females, most of the correlations that could be considered moderate were found between the linear measurements HW, BL and BW/CG. However, the correlation between BW/CG and HW as well as between BW/CG and BL was lower than the correlation between HW and BL and this is probably because the nutritional status of the animals varied, with some being thinner and others more fat and/ or pregnant. If all animals would have had an equal nutritional status, I would have expected the correlations involving BW/CG to be stronger. The fact that EL and TL have moderate correlations to HW and BW/CG is difficult to explain and the correlation is likely to have appeared just by chance since the data set was rather small. With a larger dataset, these odd correlations might not be found again.

For the males, strong and also moderate correlations were found between the body-measurements BL, CG, HW, BW, but also between body measurements and MC. When studying the appearance of a mature Bali cattle bull, the size of the muzzle is much larger on a large bull, therefore this makes sense and MC could be grouped together with the other body-measurements. The moderate correlations where HL is involved could have happened just by chance. This is because bulls studied at for example the AI-center and the slaughterhouse, sometimes would have rather small horns despite their large size. Moderate correlations between EL and TL are also more likely to be explained by chance.

Differences in the interviews

Based on the results from the interviews, valuable information was attained that could help explain differences in the phenotypic measurements and also help getting a better understanding of how to improve the management of the breed. Information about preferable traits, traits in need of improvement and the largest health problems could also be valuable if designing a breeding program in the rural villages in order to take consideration to the traits most important to the farmers. Among the three locations where farmers were interviewed, reproductive traits, health and growth traits seemed to be of most importance and in need of genetic improvement. Today, there does not seem to be any breeding to directly improve reproductive traits or health; however growth and body size traits are in the focus at the AI-center in Bali. In the future it could be possible to breed for improved reproductive traits since this has a moderate heritability. Breeding for immunity against Jembrana could also be possible if the genetics behind this immunity was revealed. However, in order to do this, a system with registration of these traits would be necessary at the breeding centers' as well as in the villages. All farmers experienced problems with diarrhea and it would be interesting to know how this affects the status of their animals when it comes to size and growth, and if diarrhea is a problem that could be eased.

Genetic management and inbreeding

Based on the interviews inbreeding appears to be a problem, mostly in Lombok where farmers did not take any consideration to inbreeding at all. White color interspersed in the coat was considered among farmers, staff at the livestock field offices as well as at the AI-center as an indication of inbreeding and this characteristic was found among the animals at nearly all locations and especially in Lombok. Only in Sumatra and on the Bali bulls, this was not seen, however, in Sumatra it is possible that this was only due to the small number of animals studied. To know whether the white interspersions are due to inbreeding, one would need to analyze the genetic material from the animals as well as their pedigree. The fact that farmers in rural areas are unaware about the term inbreeding, does not take consideration to it and does not know what animals are related, poses a possible threat to the genetic status of the Bali cattle. Inbreeding could lead to a smaller genetic diversity in the rural areas, and since a large part of the Bali cattle in Indonesia are from these areas, it would mean a threat to the breed as a whole. This could be extra critical in the future since Indonesia is in need of increased meat production and therefore larger animals with a good genetic status, reproduction and health. I believe there is a need for more education and information in the rural villages regarding breeding. If farmers became aware of the threats and also the possibilities and benefits a good breeding strategy could bring for their cattle, the genetic status of animals on the countryside could probably increase. If farmers cooperated within and between villages with local breeding schemes, inbreeding could be diminished, with or without the use of AI. If the farmers learned that it is possible to achieve a gain in size, better reproductive performance and health through breeding, it is likely that they would be interested in this since it could positively affect their economy. However, it is important to keep such a breeding scheme at a local level considering the available resources, such as financial resources and available infrastructure.

Strengths and weaknesses with the study

Regarding the phenotypic measurements, the method and protocol worked very well. A problem was that the animals were easily stressed, which is not beneficial since it might affect the results. The half-wild nature of the Bali cattle also made it difficult to get more than approximate measurements. This is because the cattle constantly fought against the person measuring and never stood still. The best conditions for measuring took place in Kalimantan where a special enclosure was put up for the animals, in which they could not move around too much. If such an enclosure could be used in every village, the results would have been more exact. The same person did all the measuring at each location which was important so that measurements were taken in the same way every time. However, the stressed animals and the time limit restricted us from getting a mean value of each measurement based on 2-3 measurements. This would also have helped in getting more precise results.

There were both advantages and disadvantages with changing the interview questions in to a questionnaire with options. In this study, it was not possible to keep the questions open due to translation difficulties. Having the questions open also led to misunderstanding of some questions as well as some answers that could not be interpreted at all. Some of the original questions also turned out to be too difficult for the farmers. By using options, the difficulties with translations disappeared, and also most of the misunderstanding of questions. However less information was attained by the questionnaire method. Follow up questions were not possible in this study, since the interviews were performed by other collaborators. The optimal interview would have been one where the researcher could take part in the interviews and have the answers directly translated to be able to ask further questions. This would however take much more time and effort, and time was always a limit when visiting the villages.

Future potential

The phenotypic characterization study performed can be seen as a pilot study and the beginning of a collection of genetic and phenotypic material where more data can be added to create a pool of phenotypes and genotypes. A larger dataset with information from different areas and management systems could possibly reveal the true characteristics of Bali cattle and explain why some traits might be expressed differently and whether they are a result of e.g. climate or geographic isolation from each other. This could be important for the conservation of the Bali cattle genetic resources. The number of cattle measured in this study was too small to give sufficient amount of data to conclude whether or not there are differences between locations, but rather an indication of differences between management systems. The performed study evaluated what type of analyzes that could be done and the interviews serves as an important complement to the collected data to be able find out more about management of the cattle and the breeding strategies in rural villages. In the future, the use of breeding values is likely to become more common, and a large pool of genetic and phenotypic data can be useful for this purpose. With the combination of phenotypic and genetic information, a lot more analyzes can be done. In future research, the genetic data from this study will be used to study the initial steps of domestication and to study the genetics underlying adaption traits such as heat adaption. Also the evolutionary relationships between *Bos taurus*, *Bos indicus* and *Bos javanicus* will be studied. The larger research project can contribute to conserving and managing the domestic and wild Banteng.

Conclusion

The number of animals in the study was too small to draw any firm conclusions regarding differences between locations. The results however indicated differences in size due to different management system. There were large differences between bulls that might not only be the result of management but also genetic factors, however, this need to be confirmed by further analyzes. Interesting information regarding management of genetic resources in rural villages was given through the interviews. Answers from the interviews in combination with phenotypic deviations from e.g. hair color showed that inbreeding in rural villages could be a problem. This can be a threat to the genetic diversity of the Bali cattle population and there is a need for a plan of action. The genetic and phenotypic data collected in this study serves as a starting point for a larger pool of material that can be complemented with data from other villages.

Acknowledgements

I would like to especially thank the following persons for all their support and for making this project possible:

My supervisors Prof. Göran Andersson at the Swedish University of Agricultural Sciences (SLU) and Dr. Emma Svensson at DPI, Victoria, my Indonesian supervisor and collaborator Prof. Endang T. Margawati at The Indonesian Institute of Sciences (LIPI), Prof. Ronny R. Noor at Bogor Agricultural University (IPB) and field assistants Indriawati and Handrie from LIPI.

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Appendix 1. Description of conformation measurements

Table 6: Description of measurements

Measurements	How to take measurement
Body Length (cm, using caliper)	Measure from point of the shoulders to the point of the buttocks (pinbone). Both points have a protruding bone that can be located for correct measurement (FAO, 2012; Gilbert et al., 2013). An average of measurements from left and right side can be used, or the mean value of three measurements, since this variable tends to vary between measurements. The correct standing position for the animal, with the hind legs close together.
Height at withers (cm, use two calipers)	Measure from the ground to the highest point of the withers (Soares et al., 2011; FAO, 2012).
Ear lenght (cm, use measuring tape)	Measure the length on the back side of the ear, from the root to the tip (FAO, 2012).
Chest girth (cm, weight-band)	Girth measurement is taken by passing the tape behind the forelegs. Hold the tape close to the chest (Soares et al., 2011; FAO, 2012).
Horn length (cm, measuring tape)	Measure the longest distance from the root of the horn to its tip along the outer curvature. (FAO, 2012).
Muzzle circumference (cm, measuring tape)	Take the measurement a little above the nostrils and around the point where the dewlap meets the chin (FAO, 2012).
Body weight (kg, weight band)	Use weight-band and measure at the same time as chest girth. Body weight can also be estimated through a formula (Soares et al., 2011)
Color pattern	Describe pattern.
Coat color	Describe color.
Skin color	Describe color.
Muzzle color	Describe color
Eyelid color	Describe color
Hoof color	Describe color
Horn color	Describe color
Horn attachment	Percent of loose horns, percent of fixed horns (on herd level, separate for males and females)
Horn shape	Straight/curved/lyre shaped/loose/stumps/polled (on herd level, separate for males/females)
Horn orientation	Indicate at which direction they point (on herd level, separately for males and females)
Hair type (herd level)	glossy/dull
Hair length (mm)	medium/ long >2mm
Ear shape (herd level)	rounded/straight edged
Ear orientation (herd level)	erect/lateral/drooping
Facial profile	straight/concave/convex
Dewlap size (visual measurement)	absent/small/medium/large: The dewlap can be related to physical condition (Soares et al., 2011). The size of the dewlap can also be related to heat resistance. Measure the maximum width (cm) or: 1(absent) = non-existing or very small, 2(small) = loose skin situated near the brisket, 3(medium) = a thin flap extending along the neck, 4(large) = a large flap of skin underneath the neck, becoming up to approximately 10 cm wide near the brisket (Soares et al., 2011)

Backline profile (use caliper or vision)	Straight/ slopes up towards the rump/ slopes down from withers/dipped) 1= highly lowered back 7= straight back 9= bent back Values according to Svensk Mjölk (2000)
Rump profile (caliper+vision)	flat/sloping/roofy Can be judged from the side by looking at the slope from the hip to the pinbone. You judge by looking at the centre of each lump to avoid extremely protruding lumps to affect the results. 1= straight line 5= slightly sloping/sloping line, 9= strong slope (can be due to bad back)(Svensk Mjölk, 2000)
Tail length	Measure in centimeters from the base to the tip.
Pelvic width	Measure from inside of one hip bone to inside of the other (FAO, 2012)

Appendix 2. Interview Questions

Table 7: Interview questions

No.	Question	Options
	MANAGEMENT	
1	How many males and females are there in the herd?	
2	What are the animals fed?	a) elephant grass b) legume leaves/ grass weed c) grass/leaves + concentrates d)…
3	Do the animals have access to feed at all times?	a) limited b) free access c) sometimes free, sometimes limited d) …
4	Do the animals have access to drinking water at all times?	a) limited b) free access c) sometimes free, sometimes limited d) …
5	Are any climate modifiers used(such as shelters)	a) yes b)no d)…
6	What is the level of confinement	a) continuously unconfined b) confined at night c) confined seasonally d) continuously confined e)…
7	How time consuming is the management of the animals?	a) 3-4 hrs/day b) less than 3 hrs/day c)
8	Which people are involved in the management (family, relatives etc.)	a) close family members b) other relatives c) friends d)…
9	What is the use of the animal?	a) work on the field b) source of income for school fees, weddings etc. c)…
10	What is the economic importance of keeping cattle at a family-level?	a) primary source of income b) secondary source of income c) …
	TRAITS AND ADAPTION	
11	Describe their basic temperament	a) docile b) half wild c) wild d) …
12	Do you experience any health issues from for example parasites or ticks?	a) often b) sometimes , from diarrhea, worms, eye problems c) never d)…

13	Are the animals vaccinated?	a) yes (if so, state what they are vaccinated for) b) no c) sometimes d)…
14	Are the animals provided with veterinary treatment when they are sick?	a)yes b)no c) sometimes d)…
15	What are the most common health problems with your cattle?	a) jembrana b) diarrhea c) fever (also worms and eye problems) d) parasites e) ticks f)…
16	What are the most important/preferable characteristic/ attribute with your cows?	a) reproductive traits (such as good mother abilities, high calving rate, etc.) b) good temperament c) health traits (don't get sick) d) growth traits (grow fast, large size) e) …
17	What are the most important/preferable traits with your bull?	a) good temperament b) high growth c) appearance d) good health e)…
18	What traits do you wish could be better?	a) Reproductive traits (maternal abilities, high calving rate etc..) (good maintenance) b) Temperament (e.g. calmer, more easy to handle) c) health traits (don't get sick) e) growth traits (grow bigger, grow faster etc..) f)…
19	What type of behavior do they prefer in their cows /bulls?	a) docile b) moderately tractable c) wild d) …
	BREEDING STRATEGIES	
20	Where do you get bulls for mating with your cows?	a) using own bulls b) from neighbor d)…
21	How do you avoid inbreeding?	a) don't mate related animals b) not aware of the term inbreeding c) don't take consideration to inbreeding e)…

22	How do you know what animals are related?	a) by memory b) pedigree c) by looking at their performance
23	When buying a new animal, or when breeding, which traits or characteristics are you looking for?	a) good size and weight b) other appearance traits (e.g. large horns, color etc.) c) a pregnant animal d) good price e)…
24	What mating practice is used?	a) AI b) natural mating c) both d)…
25	During which months does mating occur?	a) dry season b) wet season c) anytime d)…
26	How long is the approximate lactation length?	
27	How often do you experience abortions, stillbirth or defect calves?	a) often b) sometimes c) never
28	Is the cow's milk used for anything else than for the calf?	a) yes (for other calves) b) no c) sometimes d)…
29	What is the expected life-length of the animals?	a) 10 years b) more than 10 years
30	At what age do you normally sell/slaughter your animals and why?	
	ADDITIONAL QUESTIONS ASKED IN KALIMANTAN	
	- What roles do the family members have in the animal keeping? - Do you have any breeding strategy and how do you plan your breeding? - When buying a new animal, or when breeding, which traits or characteristics are you looking for? - What traits do you find most valuable with your animals, and how do you interpret these in breeding? - How do you select bull-calves for breeding?	

Appendix 3. Values for comparison between locations and calving rate

Table 8: Comparison of females from Kalimantan, Sumatra and Lombok

Measurement	t-value	df	p-value
BL			
Kalimantan and Lombok	-0.839	19.07	0.412
Kalimantan and Sumatra	3.287	35.99	0.002
Lombok and Sumatra	3.175	16.51	0.006
HW			
Kalimantan and Lombok	-1.058	13.05	0.309
Kalimantan and Sumatra	1.460	36	0.153
Lombok and Sumatra	1.631	12.44	0.128
TL			
Kalimantan and Lombok	-0.654	13.81	0.524
Kalimantan and Sumatra	-0.875	25.80	0.390
Lombok and Sumatra	0.088	18.08	0.931
CG			
Kalimantan and Lombok	0.653	14.12	0.524
Kalimantan and Sumatra	3.801	34.30	0.0006
Lombok and Sumatra	1.264	14.40	0.226
BW			
Kalimantan and Lombok	0.334	15.06	0.743
Kalimantan and Sumatra	3.729	35.62	0.0007
Lombok and Sumatra	1.546	13.30	0.146
PW			
Kalimantan and Lombok	1.909	16.74	0.074
Kalimantan and Sumatra	1.487	33.21	0.146
Lombok and Sumatra	2.847	17.53	0.011
EL			
Kalimantan and Lombok	-5.751	27.35	3.90E-06
Kalimantan and Sumatra	-3.159	35.29	0.003
Lombok and Sumatra	2.795	24.31	0.01
HL			
Kalimantan and Lombok	-2.202	17.59	0.041
Kalimantan and Sumatra	3.209	35.47	0.003
Lombok and Sumatra	4.356	16.77	0.0004
MC			
Kalimantan and Lombok	-0.379	21.38	0.708
Kalimantan and Sumatra	-0.098	27.97	0.923
Lombok and Sumatra	0.240	25.43	0.812

Df= degrees of freedom. For other abbreviations, see Table 2.

Table 9: Comparison of males from Bali and Lombok

Measurement	t-value	df	p-value
BL	-6.357	34.76	2.7E-07
HW	-10.688	31.91	4.5E-12
TL	-0.712	35.89	0.48
CG	-11.614	26.49	6.7E-12
BW	-10.167	21.61	1.1E-09
PW	-0.599	24.76	0.55
EL	0.981	33.82	0.33
HL	-1.015	35.71	0.32
MC	-5.189	30.38	1.3E-05

df= degrees of freedom. For other abbreviations, see Table 2.

Table 10: Age at first calving (years), number of calves and number of calves per year for cows from all three villages. Cows where information about Age first calving or Number of calves is missing have been removed from this dataset in order to be able to calculate an average of number of calves per year. ID 1-21 are cows from Kalimantan, ID 67-87 are cows from Sumatra and ID 88-107 are cows from Lombok. N=44

ID	Age	AFC	NoC	calves/yr
1	8	1,4	6	1,1
3	4	1,4	1	2,6
4	4	2	1	2
5	3,5	3,4	2	0,05
6	4	2	2	1
7	7	2	5	1
9	10	2	8	1
10	8	2	6	1
11	9	2	7	1
12	4	2	2	1
13	8	2	6	1
14	4	2	2	1
15	8	2	5	1,2
17	8	2	6	1
18	8	2	6	1
19	3,5	2,4	1	1,1
20	4,5	2,4	2	1,05
21	6	2,4	4	0,9
67	3,5	2	1	1,5
68	2,5	2	1	0,5
70	7	2	4	1,25
71	3	2	1	1

72	3,5	0,7	1	2,8
73	3	2	1	1
74	3	2,5	1	0,5
75	3,5	3	1	0,5
76	3,5	2	2	0,75
77	3	1,5	1	1,5
82	3,5	3	1	0,5
83	3,5	3	1	0,5
84	8	2	5	1,2
86	3,5	2,5	1	1
87	4,5	2	2	1,25
88	5	2	3	1
90	5	3	4	0,5
91	5	2	4	0,75
93	3	2	1	1
94	3	2	1	1
97	3	2	1	1
99	4,5	2	3	0,83
101	4	2,5	1	1,5
102	4	2	1	2
106	3,5	2,5	2	0,5
107	3,5	3	1	0,5

AFC= Age first calving, NoC= Number of calves

Appendix 4. Results from interviews

Kalimantan, Pleihari

Pleihari is a village in South Kalimantan near the city of Banjarbaru. The climate is tropical with an average temperature of 29-34 °C. Heavy rainfall occurs year-round and the annual rainfall is about 3000 mm per year (Indonesia Travel Guide, 2013). In the village, 11 farmers were interviewed, using an open- answer questionnaire. The farmers possessed between two and 10 cattle, where females were the dominating gender. All cattle were fed elephant grass; many of them were also given grass from the field, while only one farmer sometimes gave his animals concentrates. The males were treated a bit different from the females, since they were in some cases given concentrates, vitamins, cassava or extra feed. They all had free access to feed and water and the management system was semi-intensive, where cattle were kept in a stall during night and released outside about half of the day. The time spent on the cattle each day varied from 2-4 hrs/day and it was the nearest family who was involved in the management of the cattle by cutting grass and cleaning the stable. All farmers stated that the purpose of keeping cattle was as a means of saving for marriage of children, school fees and home improvements. Keeping cattle was considered important on a family-level since they could be sold for money. The farmers described their animals as obedient with a high calving rate and easy calvings. Some mentioned that they were easy fed and would eat anything. One farmer said they had a wild nature. All farmers had vaccinated their cattle against Jembrana virus disease, and they mentioned diarrhea, Jembrana, limp and eye-problems as the most common health problems. When an animal got sick, this was handled by the livestock field officer, or in one case traditional treatment with plants. When mating, about half of the farmers used AI and half used natural mating with own bulls or other bulls. Mating could occur any month of the year. No farmer had any breeding strategy and about half of them did not know how they would avoid inbreeding, whereas half said they would not mate within the family. One farmer mentioned that he avoided animals with white hairs on the body or tail. The most important traits for the farmers were related to body size, growth and health. A short calving interval and a docile temperament were also mentioned. According to the farmers, the cow was usually 3 to 3.5 years when calving for the first time; she would then have a lactation period for 2-6 months. The milk was only to be used for the calf, though sometimes calves from other mothers would get some. When it came to abortions, stillbirths and defect calves, this was not considered to be a big problem. Half of the farmers had sometimes experienced a miscarriage, an abortion or a defect calf. The expected life length was between 12-19 years and the cow would then have given birth to between 8-16 calves according to the farmers interviewed. Selling animals would depend on need, though one farmer mentioned that bulls were sold at approximately the age of 4 years.

Sumatra, Kampar

Data was collected from animals in a village in the Kampar regency, located in the province of Riau in Sumatra. Riau has a tropical climate and a relatively high rainfall, from 2000 to 3000 mm per year on average. The average daytime temperature in the province is 30 °C and the dry season starts in July (Indonesia Tourism, 2013). Six farmers were interviewed in the village using questionnaires with options. The farmers owned between 3-5 animals, some of them only possessed females. They were all fed elephant grass and legume leaves and the access to feed was in most cases free, but sometimes restricted. The access to water was limited for half of the farmers and only one had free access to water. The management system was more extensive with the animals grazing freely during the day and then confined at night. A couple of the farmers had their animals continuously unconfined. Most of them spent 3-4

hours per day on the management of the animals and the management was done by close family members and in one case by friends. Keeping cattle was seen as a secondary source of income by all farmers, and the purpose of keeping them was as a source of income for school fees, weddings etc. Most of the farmers described their animals as docile in nature, though a couple stated that they were half-wild. They all sometimes experienced health issues from parasites, worms, ticks etc and all but one had their cattle vaccinated for Jembrana. The most common health problem varied between farmers, though diarrhea seemed to be the biggest problem followed by fever. They all got veterinary care for the animals in case of illness. All but one stated that the most preferable characteristic with their cows was reproductive traits, and one stated that the fact that they did not need concentrates was the most important. Regarding bulls, growth was the most important, though health, appearance and temperament were also mentioned. All farmers however wished that the growth traits would be better. When it came to mating, farmers with their own bulls would prefer to use these, others would use the bulls from neighbors. All but one took consideration to inbreeding by not mating related animals, though most of them did not really know how to keep track of which animals were related. Both AI and natural mating was used and mating could take place any month of the year. When buying a new animal or when breeding, the farmers would mostly look for characteristics related to size and weight as well as appearance traits such as large horns or color. Two farmers mentioned that they would look for a pregnant animal and also a good price, whereas one would look for a long tail and the mother abilities. The length of the lactation was approximated by the farmers to last from 3-7 months with the milk sometimes being used also for other calves. Most farmers had sometimes experienced stillbirths, abortions or a defect calf. They all stated that the expected life length would be more than 10 years and selling an animal would depend on need.

Lombok, Paremas

Lombok has a tropical climate with distinct rain and dry seasons and an average temperature of 27-32 °C. Lombok has a dryer climate compared with Bali with an annual rainfall of 1088 mm (Holiday weather, 2013). Paremas is a village located in east Lombok. Eight farmers were interviewed using a questionnaire with options. The farmers in Paremas possessed between 2 and 6 animals each and they were all fed legume leaves and grass weed, with free access to feed and water. Shelters were used and the animals would be confined there at night. Management of the animals took 3-4 hrs/day for most of the farmers, whereas for some it took less than 3 hrs per day. Close family members were the ones involved on management of the cattle. The use of the cattle was as a source of income for school fees, weddings etc, and all but one considered keeping cattle being a secondary source of income. One farmer had it as a primary source of income. Most farmers described their cattle as half-wild, one thought they were wild, whereas two thought they were docile. They all sometimes experienced health problems, mostly from diarrhea but also worms and bad eyes seemed to be a problem. No farmer vaccinated their cattle for Jembrana and in fact, all cattle in this village were apparently immune to Jembrana as well as the bacterial disease Anthrax. When the cattle got sick, most farmers got veterinary treatment for their animals, whereas one did not. Regarding the most important traits for the cows, all farmers but two stated that reproductive traits were the most important. The other two said growth traits. For the bulls most farmers thought appearance was the most important, two farmers thought a good health was the most important and one mentioned high growth. Most of them wished that the reproductive traits would be better, but also health traits and temperament. When buying a new animal, all of them would look at appearance traits such as large horns or color. Mating of animals would take place in the dry season, using bulls from neighbors and with natural mating. Inbreeding seemed to be a problem in the village, and none of the farmers took any consideration to

inbreeding, though they said they knew which animals were related by memory. After calving, the lactation period would last around 3 months, and the milk would sometimes be used also for other calves. The farmers interviewed never experienced problems with abortions, stillbirths or defect calves. The expected life-length was more than 10 years and animals would only be sold if there was a need for money.

Information from feedlot in Bogor, Java

The cattle at the feedlot originated from various villages on Lombok from which they had been bought by the owner of the feedlot. After fattening for 6 months they would be sent to slaughter. When measured, they had been approximately one week at the feedlot. To get a good price, small animals were chosen with the purpose of them gaining a lot of weight, and through that increase the value. Because they all originated from unknown villages it was not possible to know what type of management system they had been brought up in. They varied in appearance but were all quite small. It is not possible to know whether the bulls were derived through natural mating or AI.

Information from Slaughterhouse, Bogor, Java

The animals at the slaughterhouse in Bogor originated from Bali. At first they had been collected from various villages and then put in a feedlot for fattening. Therefore it was not possible to know what type of management system etc the animals had been managed in during their first years. If the bulls were born after AI, the semen would have come from the AI-center on Bali where bulls are known to be larger, not only because of a good nutritional status, but also because of a better genetic merit.