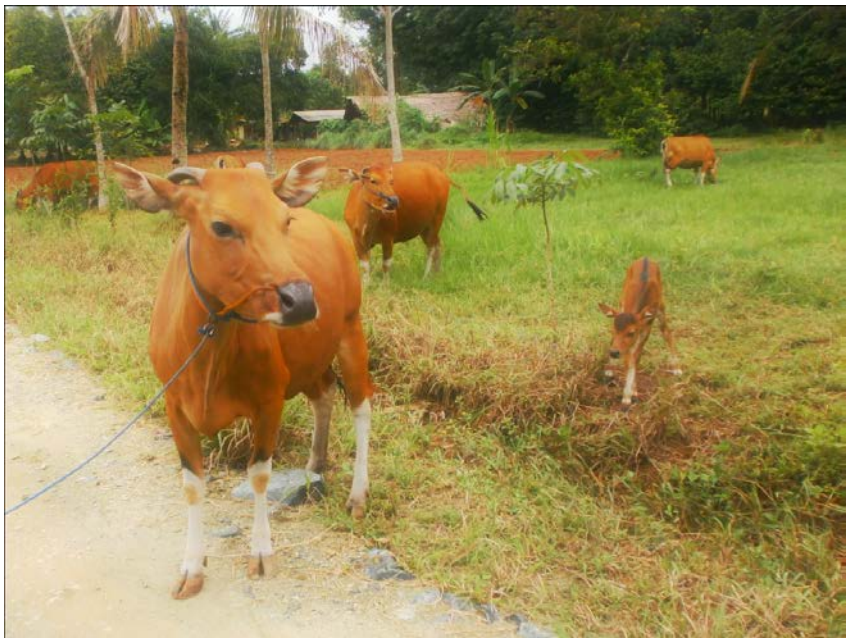
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
Department of Animal Breeding and Genetics

Increasing the knowledge of Bali cattle management- The key to maintain genetic variation and improve animal welfare

Ann Eriksson



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Increasing the knowledge of Bali cattle management- The key to maintain genetic variation and improve animal welfare

Ökad kunskap om Baliboskap möjliggör bevarande av genetisk variation och djurvälfärd

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Abbreviations

AFC = Age at first calving
AI= Artificial insemination
BCS= Body condition score
BL= Body length
BP = Backline profile
BW = Body weight
CG = Chest girth
DS = Dewlap size
FAO = Food and agricultural organization
FP = Facial profile
HL = Horn length
HW = Height at withers
IPB = Institut Pertanian Bogor (Bogor Agricultural University)
LIPI = Indonesian Institute of Sciences Bogor
NAV= Nordic breeding evaluation
NTB= Nusa Tenggara Barat or, Lesser Sunda islands is a region in Indonesia including inter alia Lombok
NTT= Nusa Tenggara Timur
PH = Pelvic height
PW =Pelvic width
RP = Rump profile
SCC=Somatic cell count
SLU = Swedish University of Agricultural Sciences

Sammanfattning

I Indonesien finns cirka 4.5 miljoner hushåll som håller boskap och hälften av dessa är småskaliga bönder. Populärast är den inhemska rasen Baliboskap, en härdig ras, väl anpassad till de krävande förhållandena i ett tropiskt klimat.
Indonesiens topografi i kombination med böndernas bristande kunskaper inom avel har bidragit till skapandet av små sub-populationer som utvecklats till ett hot mot den genetiska mångfalden inom Bali-rasen. Försök har gjorts för att starta program med syftet att främja rasen, men inga framsteg har gjorts eller dokumenterats. Huvudsyftet med detta projekt var att öka kunskapen om hur Baliboskap hanteras, föreslå möjliga avelsstrategier som lämpar sig för småskaliga jordbrukare samt undersöka hur problemet med en minskad genetisk mångfald kan hanteras. Dessutom syftade projektet till att förse Indonesiska bönder med information och verktyg som kan användas för att öka produktionen, undvika inavel och upprätthålla djurvälfärden. Projektets mål var även att kartlägga avelsstrategier och ge en bild av kunskapsnivån bland de Indonesiska bönderna. Genom att öka kunskapen hos bönderna finns möjligheter att öka djurvälfärden samt att ett planerat avelsarbete inriktat på specifika egenskaper hos djuren även har potential att öka böndernas intäkter. Under projektet fenotypades 94 Baliboskap > 2 års ålder med härstamning från Bali, Sumatra, Lombok och Kalimantan. De mått som registrerades var; kroppslängd, mankhöjd, bröstomfång, kroppsvikt, korshöjd, korsbredd samt hornlängd. Utöver detta noterades; kroppskonstitution, färg, päls och horn. Svanshår samlades från varje enskild individ för extraktion av DNA. Intervjuer genomfördes med ägarna till de fenotypade djuren, totalt 68 bönder deltog. Intervjuerna fokuserade i huvudsak på avelsrelaterade punkter. Analysen av svaren visade på en bristande kunskap inom avel men också ett stort engagemang att lära sig mera. Dessutom bekräftades att de bästa djuren säljs och de sämre behålls och avlas vidare på. Detta eftersom djuren spelar en central roll som ekonomisk resurs för att till exempel täcka kostnader för skolavgifter. De fenotypiska måtten analyserades för att hitta potentiella korrelationer mellan de olika platserna som besöktes och de olika ursprungen. Resultaten analyserades sedan tillsammans med svaren från intervjuerna. ANOVA användes för att identifiera signifikanta skillnader. Under fenotypningen lokaliserades individer med avvikande prickig färgteckning. Dessa visade sig vara mindre i alla fenotypiska mått och signifikant skilja i vikt från djur med standardfärg. Den genetiska bakgrunden till skillnaden i färg är fortfarande outforskad. Hypotesen kring skillnaden i kroppsvikt är att den beror på inavel. Hornlängden var den parameter som varierade mest mellan-, men också inom mätplatserna. Korsningsavel och användandet av artificiell insemination har ökat i popularitet och Simmental och Limousin var de raser som var det populäraste valet. Det faktum att bönder uppgav i intervjuerna att det var svårt att få tag på renrasiga Baliboskap och att användningen av Baliboskap som dragdjur på risfälten har minskat är ytterligare ett hot som äventyrar Baliboskapens framtid.

Abstract

In Indonesia half of the 4.5 million households that keep livestock are small scale farmers. The most important cattle breed for these farmers is the Bali cattle, which is a dual purpose animal that is well adapted to demanding conditions. Small isolated populations and lack of knowledge about breeding have become a threat for the genetic diversity of the Bali cattle. Programs to promote the Bali cattle were established in the past but have not been successful. The main objectives of this project were to increase the knowledge of how Bali cattle are managed, suggest breeding strategies suitable for small scale farmers and how to approach the problem with a decreased genetic diversity. Furthermore, to provide Indonesian small scale farmers with information and tools to increase production, avoid inbreeding and maintain animal welfare. The project also aimed to obtain information concerning the breeding management and Indonesian farmers knowledge about breeding. This would also contribute to possibilities to increase animal welfare, ability to breed for desired traits and result in profit for the farmers. Animals from Bali, Sumatra, Lombok and Kalimantan were phenotyped in regards to; body length, height at whiters, chest girth, body weight, pelvic height, pelvic width and horn length. In addition, stature, color, fur and horns were also described. In total 94 animals >2 years of age were phenotyped and tail hairs were sampled from each individual for future preparations of DNA. Interviews were performed with the farmers on each location, 68 respondents in total. The interviews focused on management and breeding and revealed a lack of records and knowledge, but also a big willingness to learn more about breeding. The phenotypic measurements were analyzed to find potential correlations between measurements and location and ANOVA analyses showed whether or not the differences were significant. Abnormal colored, white spotted animals were compared to the standard colored ones and were smaller in all measurements and significantly differing in body weight. The genetics behind the differing color is still unknown, but the theory about the difference in weights was suspecting it to be due to inbreeding. The phenotypic record varying the most was horn length, both within, and between locations. Crossbreeding was popular and the breeds Simmental and Limousin were used frequently. Farmers stated that it was hard to get hold of pure bred Bali cattle and that the usage of Bali cattle for draught in the rice fields was decreasing. In combination with these statements, farmers selling the best animals and breeding on the poorer ones combined with an increased number of cross breedings can result in future threats for the genetic diversity of the Bali cattle.

Background

Indonesia is home to 247 million people, making it the world's 4th most densely populated country. Approximately 33% of the inhabitant's aliment comes from farming and agriculture (Utrikespolitiska institutet, 2014). 4.5 million Indonesian households keep livestock whereof half of the farmers practice small scale mixed farming (Martojo, 2012). The most important cattle breed for small holders in Indonesia is the Bali cattle (*Bos javanicus)*, due to its high feed efficiency, these cattle can live and produce well on very low-quality feed (Mohamad et al, 2009) and they also have a lower water turn-over than taurine cattle (*Bos taurus)* (Siebert and Macfarlane, 1969; Jenkinson and Nay, 1973). They also have good fertility and show resistance against many occurring diseases (Mohamad et al, 2009). Altogether, these features leaves the Bali cattle to be the most high producing out of Indonesia's four indigenous cattle breeds (Martojo, 2012). The 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). The consumption of beef in Indonesia is increasing with about 4 % per person and year and the Indonesian government has put a high prioritized self-sufficiency in beef cattle production through the program Pengembangan Swasembada Daging Sapi (P2SDS) (Indonesian department of agriculture, 2007).

Inbreeding is a well known problem for domesticated animals (Barker, 2001; Talib *et al*, 2003b) and Lindell (2013) also observed problems with inbreeding in Bali cattle. Genetic analysis from Bali cattle revealed low rates of heterozygosity, which is a sign of inbreeding (Mohamad *et al*, 2009). Interviews conducted by Lindell (2013) showed low knowledge about inbreeding and its effects but also a big desire for genetic progress in form of production- and health-related traits.

Lindell (2013) also revealed a lack of knowledge among the owners of Bali cattle regarding breeding in general, breeding strategies and traceability of the affinity of the cattle. A review of literature concerning inbreeding of various kinds of livestock shows no concrete ways of informing farmers on how to avoid inbreeding and preserve endangered livestock (Sandoe *et al*, 1999) and studies still seem to be lacking.

Project objectives

The main objectives of this project were to,

i. increase the knowledge of how Bali cattle are managed,
ii. suggest breeding strategies suitable for small scale farmers
iii. investigate how to approach the problem with a decreased genetic diversity.

Furthermore, the objectives were to provide Indonesian small-scale farmers with information and tools to increase production, avoid inbreeding and maintain animal welfare. Providing

information and tools that can be used to track affinity, avoid inbreeding and also help to keep track of traits that can be used in future breeding goals. For instance the farmers should be advised to record traits concerning calving abilities, growth rates and health aspects.

The project also aimed to map out the breeding management and Indonesian farmers knowledge about breeding. This will contribute to the possibility to develop future tools suitable for Indonesian farmers to help decrease and prohibit the rate of inbreeding in the Bali cattle population. This would also contribute to possibilities to increase animal welfare, ability to breed for desired traits and result in increased profit for the farmers.

Literature review

Bali cattle

Bali cattle play a central role in small scale farming in Indonesia. They are used for draft, as capital to pay school fees, accumulated socioeconomic status and as source of income (Padjung and Natsir, 2005). Bali cattle are thought to be a domestic descendant of the wild Banteng (*Bos javanicus*), though no official history records exist. There are lots of similarities between the wild Banteng and the Bali cattle. Although they differ in size and temperament the main appearance is the same. Infectious diseases are spread between the two populations and wild Bantengs can breed with feral Bali cattle, resulting in hybrids between the two (Martojo, 2012). Bali cattle are claimed to be a national breed of Indonesia and in 2010 the estimated population was 3 271 000 animals (Gunawan *et al,* 2011).

Phenotypic measures

Bali cattle are born reddish-brown with well distinguished white socks from claws to knees- and hocks. The rump is also white and the marking stretches along the belly. The inner ear, the area around the muzzle and the tail also contain white hairs (Payne and Rollinson, 1973) and the back is marked with a dark dorsal stripe. When bulls reach sexual maturity at the age of 12-18 months the coat color changes into a darker blackish color which is reversible if the bulls are castrated (Talib *et al,* 2003a). Individuals born with black hair and white pattern, called *Bulu indjinin* in Balinese, get grey hairs in the ears and pigmented skin in the face. There are also female individuals with white color in the red coat, called *Bulu tultul* (Payne and Rollinson, 1973). According to the interviewed farmers in the previous study (Lindell, 2013), the white markings are a result of inbreeding.

Figure 1a and 1b: Standard coat color and pattern of a bull (left) and a cow (right) both originating from Bali

The height at whiters for cows is about 1.2 m and bulls 1.3-1.5 m. They have a short neck and a small face with big ears pointing forwards. The orientation of the horns and their size differ between cows and bulls, cows have smaller horns growing upwards whit the tip curled pointing down toward the head , while bulls have bigger horns growing outward, sideward and up, and with a well distinguished horny mass on the forehead (Payne and Rollinson, 1973; Popenoe, 1983).

The calves weigh between 12-17 kg at birth and the average adult live weight that have been reported differs between studies. In a study conducted on Nusa Tenggara Barat (NTB), Nusa Tenggara Timur (NTT) and South Sulawesi the average for cows were 224-234 kg, and for mature bulls 335-363 kg. In another study performed on Bali the average was 264 kg for cows and 395 kg for bulls (Talib *et al,* 2003a). In the study conducted by Lindell (2013) on animals from Bali, Lombok, Sumatra and Kalimantan the weight for cows ranged between 190-414 kg and for bulls 235-690 kg. Body weight for Bali cattle bulls can be estimated by the usage of the formula: Lwt = 2.34G+1.86L-307.6 where G is measurement of the chest girth and L is the body length (Soares and Dryden, 2011).

The growth rate is low, the average daily weight gain for a yearling kept on a small scale farm is 0.2 kg (Panjaitan *et al*, 2008). Smaller animals tend to cope better than the larger ones with heat-stress and periods of low feeding and therefore it is not optimal to select only for bigger animals since they might not be suited to the production environment (Taylor and Murray, 1988). Bali cattle are well adapted to the demanding environment and can be productive on low quality feed stuff. A low efficiency of turnover from metabolizable energy to live weight gain make them unsuited for high input- high output systems but more suited for cow-calf production in small holder systems where the supplies of high quality feed are limited (Quigley *et al,* 2014).

White spotted Bali cattle

According to information given to Lindell (2013) the white color and white spotting of the fur in Bali cattle are a result of inbreeding. The genetics behind the white spotting that can be seen, on

for instance the Holstein and Simmental cattle, have been determined to have its origin in the receptor tyrosine kinase (KIT) gene on chromosome 6 (Reinsch *et al*, 1999). The spots on the Bali cattle look like Bird catcher spots that occurs in horses but no research have been published about the color or the genetics behind it. The spots have been observed on both purebred and crossbred animals and the spots can occur late in life and move around on the body (pers.message Sponenberg, 2015). According to Sponenberg (2015) no cattle breed has been documented with this type of spots and they appear very much like Bird catcher spots.

Socioeconomic and market value of the Bali cattle

The demand for protein sources are increasing by 4 % per year in Indonesia and the current production cannot meet the demands to be self-sufficient (Indonesian department of agriculture, 2007). In a study conducted by Patrick *et al* (2010) at the Australian Center for International Agricultural Research (ACIAR) the program sponsored by the Indonesian government was investigated. They showed that small-scale farmers are unlikely to sell their animals at the market and therefore lacks the chance of selling them to the best price. Instead the small scale farmers need to sell their animals depending on having a network to minimize costs for transport or sell them when they need the money. The farmers who are most likely to sell their cattle at the market are the ones who have many cattle, live close to the market and have the cattle as main source of income. The price for live Bali cattle are set per kg for individuals >300 kg. In 2007 the cost was RP19.000 /kg ~1.32 EUR/kg. The price of Bali cattle tend to go down in June and July since many families sell their animals to pay the school fees for the next semester and also because the lack of available feedstuff.

Present breeding management

In 1976 a breeding program called P3Bali was introduced by the government but the progress has been slow due to technical issues (Supriyantono, 2011). Also the government, both regional and central, underestimated the population size of Bali cattle. In order to receive the desirable progress, new strategies have to be established (Martojo, 2012). A program called Pengembangan Swasembada Daging Sapi (P2SDS) was run between 2010 and 2014 aiming to increase the productivity of the Indonesian farmers. When this report was written, no data or results were published from the program.

Today many farmers practice free mating, but management of the breeding period is crucial in order to avoid calves being born during the dry season and to lower the stress of the cow (Quigley *et al*, 2009; Dahlanuddin *et al*, 2014). By monitoring the breeding it is possible to lower the calving intervals from today's 16-18 months down to 12 months (Quigley *et al*, 2009). Management of the breeding period also has profound influence on the reproductive traits as well as the profitability for the farmer. By weaning the calf at 5-6 months of age and avoid to get calves being born in the period July-October allows the cow to return to oestrus. By allowing the

cow to dry up during the dry season this would allow her to use the nutrients to recover in body condition and cope with the heat stress (Panjaitan *et al*, 2008). By having the cow in a higher body condition score (BCS) around 3-3.5 on a 5 graded scale, the anoeastrus period is reduced (Graham, 1982; Markusfeld *et al*, 1997) and the calves are born more viable compared with offspring from cows with a lower score (Ezanno *et al*, 2005).

In a study performed on Bali, NTB, NTT and South Sulawesi the average AFC was three years (Talib *et al* 2003a). Usage of planned matings and avoidance of calves being born during dry season resulted in increased pregnancy rate with 80 %, increased weaning rate with 83 %, decreased empty days with 70 days and a 2-4 % lowered calf mortality with (Panjaitan *et al*, 2008). The dry season in Indonesia ranges from 2-8 months from east to west (Martojo, 2012) and therefore this type of system might not be applicable in all parts of Indonesia. One study conducted by Dahlanuddin *et al* (2014) showed that monitoring weaning and supplementary feeding increased the conception rate and body condition of the Bali cattle cows and also the profit for the farmer. All the farmers who participated in that study were positive to continue with the new routines. Lisson *et al* (2010) conducted a long term on-farm field study teaching planned mating and feeding management. The study resulted in that 97 % of the farmers experienced that their cattle was in better condition due to new management routines, and were willing to continue with the program after the study ended.

Genetic status of Bali cattle

Like all breeds, the Bali cattle have been undergoing both natural and artificial selection (Barker, 2001). The many islands in Indonesia create a larger number of subpopulations that are bred in different directions, for instance line-breeding to get individuals that are resistant to the endemic decease Jembrana (Martojo, 2012). Clinical Jembrana has only been reported in purebred Bali cattle and was thought to be unique for Bali cattle but has been shown to be affecting both pure bred *Bos Taurus* and crossbred *Bos javanicus x Bos indicus* .The crossbred and *Bos Taurus* were viraemic for 3-6 months whilst *Bos javanicus* remained viraemic for two years (Soeharsono *et al*, 1995). Line breeding or inbreeding is defined as the probability that two alleles at a locus are identical by decent (IBD) .When individuals that are related to each other are mated the frequency of alleles that are IBD are increasing as well as the overall degree of homozygosity and resulting in a lowered effective population size. Within a closed population no new genetic material can enter and therefore inbreeding is inescapable but should be monitored and kept as low as possible (Falconer and Mackay, 1996). In the previous study (Lindell, 2013) many farmers stated that they did not consider inbreeding and also that their knowledge about breeding was scarce. There was also a negative selection on the breeding material. The best bulls and cows were sold since they were the ones that brought in the best pay and the smaller animals were kept on the farm and used for breeding (Lindell, 2013). The number of cattle used in breeding and the distribution of individuals of each sex are crucial for the effective population size (Ne) (Nunney,1993).

The import of frozen artificial insemination (AI) doses from exotic breeds (*Bos taurus, Bos indicus* and hybrids with *Bos indicus*) started in the 1970´s. The crossbred animals turned out to have a much higher demand for nutrient supply and the lack of fodder made them harder to keep in the small scale farms (Martojo, 2012). According to Patrick *et al* (2010), Bali cattle are only allowed to be bred in pure lines at Bali, and therefore no crossbreeding is allowed. Furthermore, they state that Bali cattle originating from Bali and sold to regions outside of Bali, are only allowed to be sold directly to an abattoir and not for fattening at feedlots or for breeding purposes.

In order to investigate the genetic status of the breed it is important to collect DNA from many individuals and also to link the genetic information to the phenotypic measures (Philipsson *et al,* 2010). The status and the purity of the Bali cattle are major concerns for the Indonesian department of agriculture. Crossbreeding, use of natural mating with crossbreds and the ability to use AI doses from other breeds are threats to the purity of the Bali cattle (Martojo, 2012).

Effects of inbreeding

In 1965 Brinks *et al* (1965) showed the results from a 25-year long-term study where the mean inbreeding coefficient was estimated to 16.1%,and this had resulted in detrimental effects on; birth weight, weaning weight, 12 months-,18 months- and adult weights.

One study showed that breeding half-sibs, meaning an inbreeding coefficient of 12.5 %, of the breed Irish Holstein-Friesian, resulted in a decreased milk yield, lowered milk fat % and protein %. It also increased the somatic cell count (SCC), a 2 % higher risk of dystocia and 1% higher risk of stillbirth. Also the calving interval increased by 8,8 days (Mc Parland *et al,* 2007).

Data from 852,443 Holsteins showed that inbreeding had significant influence on stature, chest width, body depth, size and appearance of the udder. The study also showed that inbred individuals had a shorter expected life length. Every 1 % increase in inbreeding increased AFC with 0.45d and calving interval with 0.53d (Rokouei *et al,* 2010). Adamec *et al* (2006) showed that every 1% increase in inbreeding increased the risk of stillbirth, dystocia or calving difficulties with 0.30-0.42% for heifers and 0.20- 0.25 % for cows. The lower number was when giving birth to a female and the higher risk when giving birth to a male.

Miglior *et al (*2008) showed that inbreeding depression had significant effect on the phenotype of inbred animals. For every 1 % increased inbreeding the pelvic width was decreased by 0.074 cm and the stature decreased by 0.079 cm. They also showed that the age at culling decreased with 30 days and that calving difficulties increased with 0.4 %.

Calf mortality, dystocia and stillbirths

Dystocia, or calving difficulties, is a big economic issue in beef cattle and often results in high calf mortality (e.g. Rice and Wiltbank, 1970). The reported calf mortality causes big losses for

the farmers and is also bad from an ethical point of view. The calf mortality for the Bali cattle differs a lot between regions in Indonesia. One study reported 8 % for South Sulawesi, Bali 8.5 %, NTB 15 % and 48 % for NTT (Talib *et al,* 2002). Panjaitan *et al* (2008) showed that calf mortality among Bali cattle can be decreased by 2-4% by monitoring of weaning and dry off period.

Birth weights is the main factor affecting calving difficulties but are often also related to the cows pelvic area (Rice and Wiltbank, 1970; Bellows *et al,* 1971a; Bellows *et al,* 1971b; Laster, 1974, Morrison *et al,* 1985). The pelvic area is composed by measures of the pelvic width (PW) and the pelvic height (PH). These measures are highly heritable and therefore it is possible to select for them (Morrison *et al,* 1985). Hereford cows had an increased risk for calving difficulties when mated with Charolais, Simmental, Limousin, or South Devon bulls compared to if they were mated with a Hereford male (Laster *et al,* 1973).

Measurements of PH are used in the Nordic breeding evaluation (NAV) since it has been shown to give a good estimation of the overall body size and have a moderate heritability of 0.34. By selecting for pelvic area it is possible to lower the amount of calving difficulties in beef cattle (Johnson *et al,* 1987). It is possible to select for a more favorable pelvic area without getting a heavier cow (Morrison *et al,* 1985).

In some studies (Rice and Wiltbank, 1970; Bellows *et al,* 1971a; Bellows *et al,* 1971b; Laster, 1974) measurements of pelvic area refers to measurements conducted inside the pelvis.

How to plan a breeding strategy

Many breeding programs that have been established in developing countries have failed, often due to lack of long term strategies or mis interpreted and un-subjective goals (Philipsson *et al,* 2011).
The failures are often due to:

- Too complex and demanding in terms of technology, infrastructure and logistics.
- No plan for cross-breeds and how to maintain the pure lines whilst they are improved.
- Neglecting socio-economic values of the animals that affect the way the breeding is performed.
- Not appropriate and applicable in a low-input system.
- No plan for genetic improvements that can be done in the near future or in a long term perspective.
- Scarce information of breed standards and the possibility to select in small populations and the fact that the economic values are graded much higher than the phenotypic (Philipsson *et al,* 2011).

And the key to successful breeding strategies lay within:

- Cooperation with farmers that get profit from the applied program, aiming for the same goals and also support from investors (Ojango *et al,* 2010).

Before starting up a new program it is important to evaluate the impact of the animals involved from as many different viewpoints as possible- such as: household benefits, environmental benefits and food supply. It is also of great importance to identify the production systems that are used and which farmers that will be using the program. Challenges and possible ways how to overcome them need to be pointed out to reach the breeding goals- for instance infrastructure and socio-economic boundaries. By doing this, subjective measures before starting up the breeding plan can be achieved (Marshall, 2014, Barker, 2001).

It is very important to apply all breeding programs in a long term perspective and look upon them as investments for the future (Philipsson *et al,* 2011). It is also very important to involve the small-scale farmers early in the process and in that way intercept desired traits and to have knowledge what is possible to interpret (Ahuya *et al*, 2004; Ahuya *et al,* 2005; van der Westhuizen and Scholtz, 2005; Peacock, 2008; Peacock *et al*, 2011) and also include local stakeholders for future work (FAO, 2010). It should also be taken into consideration that farmers in developing countries are more prone to use a low-risk low output system than a high risk high output system. A parallel can be drawn to the usage of a known old low-producing genotype compared to a new high producing with a potential risk of for instance getting a disease (Marshall *et al*, 2009).

Materials and methods

This project was conducted as a minor field study and as a part of research collaboration between the Swedish University of Agricultural Sciences (SLU), Institut Pertanian Bogor (IPB) and the Indonesian Institute of Sciences Bogor (LIPI) where the genetic status of Banteng and Bali cattle will be explored. The project also fulfilled the criteria for a Master´s thesis in agricultural sciences at the SLU.

The collaborating Indonesian colleagues from LIPI were crucial in order to arrange and perform the study and field work and also to contact and get permissions from the authorities in Indonesia. Farmers were contacted in advance so that the number of cattle on each location could be maximized and that many cattle could be gathered on each location in order to rationalize the time consumption.

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

No harm analysis

Prior to the project a no harm analysis was conducted where possible risks were investigated. The project was determined not to risk harming the informants. The questionnaire was put up in consultation with the Indonesian colleague and was considered not to include any details with potential to harm the informants. By participating in the study the farmers earned some extra money and the information from the project revealed important information about the management of the Bali cattle and the breed itself.

Phenotypic measurements

The phenotyping was performed as an extended follow up study to a previous study conducted by Lindell (2013). Each individual cattle received a catalogue ID, continuing the numbering from the previous study where 107 Bali cattle were measured and therefore **starting at nr 108**. The continuous numbering was done in order to be able to compile the data and to create a larger number of recordings of phenotypes. 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 in track of which animal that had been sampled and to be able to connect phenotypic measurements to the ID.

Phenotype measurements were recorded for each individual according to guidelines from the Food and Agricultural Organization (FAO) (FAO, 2012) and according to measurements used in the NAV. 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 this report the pelvic height (PH) refers to a measure taken from the ground to pelvis and pelvic width, (PW) refers to phenotypic measurements of pelvis between the pin bones on the outside of the animal. For descriptions of all measurements, see Appendix 1 and for illustrations of the measurements, see Appendix 2. PH was not included in the comparisons that were performed with data from the phenotypic measurements from the previous study by Lindell (2013)

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 was also stated. Some variables were recorded separately for males and females, these were: presence of horns, horn shape, horn orientation, horn attachment, ear shape, ear orientation, hair type and hair length. For the cows the age at first calving (AFC), current gestation status and number of calves born were noted. By looking at the age of the heifers and their pregnancy status their earliest AFC was estimated. Giving that a heifer aged two years and not pregnant, received an earliest AFC of two years and nine months.

The measurements were performed with folding-rulers and a measuring-tape. A calibrated European weight measuring-tape for cattle was used to record weight. This made it possible to obtain estimated weights, and an ability to compare between individuals and also with the previous study (Lindell, 2013) since the same method was used in that study for estimation of BW.

In order to compare the weights between individuals measured in previous study (Lindell, 2013) and eliminate the risk that the weight measurer could be causing errors in the result, all the recorded weights were converted from the measurements of the CG into weight using the same measuring tape.

All measurements are described in Appendix 1, and illustrated in Appendix 2.

Animals were sampled at four different locations – Bogor on Java, Kampar on Sumatra, Paremas on Lombok and Pleihari on Kalimantan. The locations can be seen in Figure 2. The number of animals >2 years of age sampled at each location is shown in Table 1. None of the farmers participated in the previous study, hence there was no risk of duplication in the dataset of interview answers or phenotypical measurements of their cattle.

Table 1 Locations and number of phenotyped individuals at each location

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

Figure 2 Map of locations in the study. Modified from hdwallpapers-3d.com

DNA-sampling

Tail hairs were collected from each individual in order to extract DNA from the hair bulbs. About 30-40 hairs were plucked from each individual and marked with the individual's catalogue-ID to enable identification and to be able to match the DNA extracted from the hairs to the phenotypic measures and the photographs. This was done as part of another ongoing research project in collaboration with SLU, LIPI and IPB.

Affinity was noted when possible. In cases where there was a risk that the animal already had been measured in the previous study by Lindell (2013) the location, name of the farmer, photographs and phenotypic numbers was compared to avoid any duplication of individuals in the dataset.

Interviews

Interview questions were composed using a standardized questionnaire and guidelines from Bell (1999) and translated into Bahasa Indonesia. The questionnaire considered desired traits, the farmers 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. The questionnaire can be found in appendix 3. A total of 68 farmers were interviewed on four different locations; Bogor on Java, Kampar on Sumatra, Pleihari on Kalimantan and Paremas on Lombok. For all locations see Figure 2. Not all the results from the interviews were

discussed in this report but focus was on questions concerning breeding, management and market. The compiled answers from the interviews can be found in Appendix 6.

Additional interviews regarding price of the animals, and observation of phenotypes were conducted on the cattle market in Beringkit, Bali. The market in Beringkit is the only big farmers market on Bali and every Sunday and Wednesday approximately 800 cattle are sold there. The results from the visit on the market can be seen in

Information to the farmers

Information about breeding was gathered in a manual. The manual was first written in English and then translated into Bahasa Indonesia. The manual was handed over to the farmers together with simple tools for monitoring of small scale breeding programs at an on-farm-level. This tool was a registration form with the intention to introduce the farmer to possible ways to keep information about relationships between individuals. This tool would make it easy to over-look affinities within the herd and thereby give good abilities to minimize levels of inbreeding. It was also possible to note certain traits that may be possible to influence by breeding e.g. growth rate, fertility, calving performance and stillbirths. The registration form are found in Appendix 4 and the information to the farmers, Appendix 5

Statistical analysis

Statistical analyses 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 (H_1) stated that there was a difference (α =0.05). A p-value <0.05 indicated a significant difference.

Males were tested depending on *location* ; Java and Lombok and *origin;* NTB and Bali.

Females *located* at Sumatra, Kalimantan and Lombok were tested against each other. The females were also tested depending on the *origin* Sumatra, NTB and Lombok.

Additional ANOVA tests were performed in order to compare the recordings from the previous study by Lindell (2013). The female cattle were compared with regards to location; Sumatra, Kalimantan and Lombok. The male cattle were compared for origin Bali and for the location Lombok. Also the whole datasets was compared in order to find differences in the recordings.

Comparisons were made between white spotted animals and standard colored ones. ANOVA was performed for white spotted animals in this study combined with data from previous study by Lindell (2013). White spotted males and females were compared to standard males and females and white spotted females were compared to standard females (Lindell, 2013).

Correlations

The correlations were estimated using Pearsons correlation coefficient r and the significance level of the correlation were estimated. Correlations $r > 0.7$ was considered as a strong correlation and $r > 0.4$ a moderate correlation.

Correlations of the phenotypic measurements were conducted with regard to origin, sex and location. Correlations were also estimated for all males and all females and for the white spotted animals compared with standard colored ones.

Moreover correlations were estimated for the dataset combined with the data from previous study by Lindell (2013).

Results

Visit to farmers market, Beringkit, Bali

Observations of phenotypes were performed during three hours, both in the stalls and outside at the market place were the animals where shown moving whilst the buyers bid on them. One white spotted cow with the same pattern that was described in a previous study by Lindell (2013) was seen and also documented with photographs. Two cows had one horn that grew downwards, inwards towards the eyes and two bulls had abnormally long horns, these animals are also documented on photographs. An overview of the body condition of the animals looked very good as a whole. Four calves had been dehorned by burning of the horn buds. Many attempts were made to interview farmers and people at the market, but language barriers made it difficult. The approximate price per kg live animal was 17000 IDR~ 10.70 SEK. Young animals at about six months -one year of age cost about 1 000 000 IDR ~ 630 SEK and a mature well grown black bull about 15 000 000 IDR~9500 SEK . Even if prices were claimed to be set per kg live weight and four handling-boxes equipped with scales were seen at the market place, the scales were not used during the market day. One person said that the rice-producing farmers tended to buy more machines for their cropping instead of using Bali cattle for draught. One farmer said that many of the animals were sold to Java.

Interviews

A total of 68 farmers were interviewed on the four locations. For the questionnaire, see Appendix 3. Detailed answers from the interviews, see Appendix 6.

None of the farmers used planned mating but mated their cows throughout the year regardless of season. The farmer that owned the feedlot on Java stated that it was hard to get in hold of purebred Bali Cattle and also that he preferred to use crossbreds with Limousin. The majority of the farmers preferred to use AI and crossbreeding. Limousin and Simmental were preferred breeds due to their large size.

When the farmers were asked to grade their knowledge about breeding on a scale from 1-5 where 1 was little and 5 was much, the average grade was 2.33. All gradings can be seen in Figure 3.

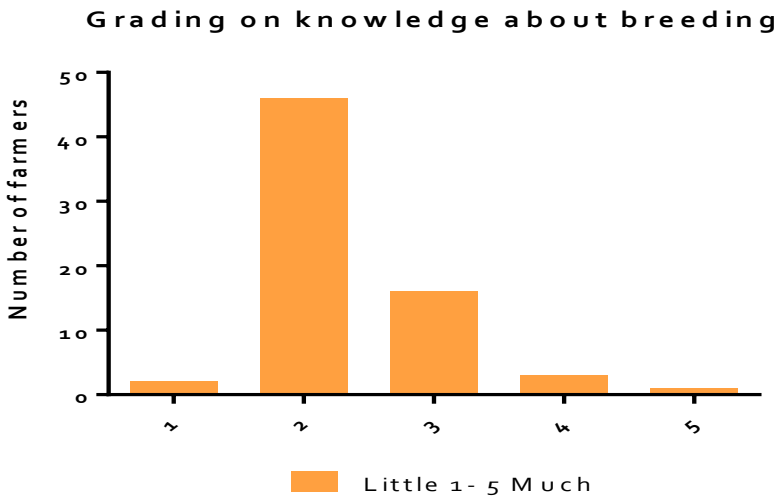

Figure 3 The result of the farmers grading their knowledge about breeding

All of the farmers on Kalimantan had a breeding strategy and all of them answered that the goal with the strategy was to get bigger animals.

The average cost for one AI dose on Java, Lombok and Kalimantan was 25000 IDR ~16 SEK whilst the average cost on Sumatra was 45000 IDR ~29 SEK. One of the farmers on Lombok stated that he took advice from the inseminator regarding breeding.
The most desirable trait to improve was the size and growth of the animals. The posture and conformation was also mentioned as important.

The majority of the farmers stated that the purpose for slaughter was to get money for school fees or weddings. One of 68 farmers reported that the animals were slaughtered to get meat for own consumption.

The most common health problems were fever, diarrhea and infections. On Sumatra 13.3 % of the farmers stated that they had problems with Jembrana disease.

Phenotypic measures

A total of 93 animals >2 years of age were phenotyped, 8 males and 85 females.

The previous study by Lindell (2013) included 42 males and 50 females >2 years of age, resulting in a combined dataset of 50 males and 135 females.

One cross bred male (Bali cattle x Kupang cattle) was phenotyped on the feed lot at Java. The phenotype looked very much like the pure bred Bali cattle except from longer horns pointing upwards and darker skin with brownish colored coat. Hair samples were collected from this individual but the phenotypical measurements were not included in the statistical analysis.

The CG measurement of cow ID nr 166 was excluded from the analysis since it was an obvious error in the recordings. Since BW was estimated from CG, the BW was also excluded from the analyses.

For all mean values, see Table 2. For descriptive statistics of the male cattle from each location see, Table 3. For descriptive statistics of the female cattle from each location, see Table 4 and Table 5. For illustrations of the phenotypic recordings of the males, see Appendix 8, Figure 8. For illustrations of the phenotypical recordings of females, see Appendix 8, Figure 8.

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

	All males N=8				All females N=85			
	Mean	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*
Age (years)	2.00	2	0	0	5.55	2/17	2.79	7.8
BL (cm)	123.25	104/149	13.97	195.07	110.66	95/130	7.09	50.3
HW (cm)	120.38	110/129	6.7	44.84	110.42	100/125	4.6	21.15
CG (cm)	165.75	133/181	16.02	256.5	150.32	130/166	8.13	66.09
BW (kg)	389.13	205/492	99.96	9992.7	285.00	192/381	41.9	1755.61
PH (cm)	119.13	112/131	6.73	45.27	111.27	101/128	4.67	21.82
PW (cm)	33.00	18/40	7.62	58	23.96	10/36	7.8	60.8
HL (cm)	23.75	19/28	2.96	8.79	21.26	8/35	8.76	76.67

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

Table 3 Descriptive statistics of phenotypic measurements of male cattle located on Java, Kalimantan and Lombok

	Bali (Located on Java), N=5				Kalimantan, N=1				Lombok, N=2			
	Mean	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*
Age (years)	2	2	0	0	2	2	0	0	2	2	0	0
BL (cm)	128.80	115/149	13.54	183.20	104	104	0	0	119.00	113/125	8.49	72.00
HW (cm)	123.80	117/129	5.17	26.70	110	110	0	0	117.00	114/120	4.24	18.00
CG (cm)	174.00	158/181	9.30	86.50	133	133	0	0	161.50	161/162	0.71	0.50
BW (kg)	429.00	320/480	64.59	4172.00	205	205	0	0	347.50	344/351	4.95	24.50
PH (cm)	121.40	112/131	7.06	49.80	113	113	0	0	116.50	112/121	6.36	40.50
PW (cm)	35.60	26/40	5.86	34.30	18	18	0	0	34.00	32/36	2.83	8.00
HL (cm)	22.60	19/27	2.97	8.80	28	28	0	0	24.50	24/25	0.71	0.50

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

Table 4 Descriptive statistics of phenotypic measurements for female cattle located on Kalimantan, Lombok and females origin from NTB

	Females located on Kalimantan N=40				Females located on Lombok, NTB N=28				Combined origin NTB N=68			
	Mean	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*
Age (years)	6.65	3/17	2.71	7.33	5.14	2.5/8	1.37	1.87	6.02	2.5/17	2.36	5.55
BL (cm)	106.9	95/120	6.1	37.2	114.57	107/130	4.46	19.88	110.1	95/130	6.64	44.09
HW (cm)	109.9	102/122	4.48	20.04	111.96	103/118	3,58	12.85	110.76	102/122	4.23	17.85
CG (cm)	149	131/166	8.62	74.3	153.79	144/165	4.93	24.32	150.9	131/166	7.66	58.68
BW (kg)	282.4	196/381	45.59	2078.45	305	255/373	26.42	697.93	291.3	196/381	40.4	1632.14
PH (cm)	110.62	102/120	4.54	20.61	112.18	105/118	3.33	11.12	111.27	102/120	4.13	17.02
PW (cm)	16.62	10/24	3.69	13.61	30.46	13/36	4.3	18.48	21.96	9/36	8.41	70.8
HL (cm)	29.56	26/35	2.11	4.46	14.25	9/30	4.71	22.19	23.16	9/35	8.34	69.56

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

Table 5 Descriptive statistics of female cattle from Sumatra

	Sumatra N= 17			
	Mean	*Min/Max*	*sd*	*var*
Age (years)	3.03	2/6	1.47	2.17
BL (cm)	112.65	100/126	8.71	75.99
HW (cm)	108.76	100/125	5.66	32.06
CG (cm)	144.59	130/159	8.21	67.38
BW (kg)	259.41	192/332	39.67	1573.51
PH (cm)	110.94	101/128	6.49	42.18
PW (cm)	29.71	24/36	3.46	12.00
HL (cm)	13.12	8/27	4.77	22.73

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

Estimating weights with the formula ***Lwt = 2.34G+1.86L-307.6*** , where G is chest girth and L is body length, from Soares and Dryden (2011) the result showed to match better for the smaller individuals where the difference was < 10 kg but for animals with bigger CG and BL there was a bigger span of differences. When comparing the entire dataset of males the average difference was 79.6 kg and for the females 36.4 kg where the weight measurer showed a higher weight compared to the weight calculated from the formula.

Recordings of other traits

White spotted animals were seen on Sumatra, Kalimantan, Lombok and on the farmer´s market on Bali, see Figure 4a and 4b. Many of the females on Kalimantan had abnormally looking horns pointing in different directions and with differing attachments, see Figure 5a-5f.

The farmers were asked about the current gestation status of the females. On Sumatra one individual was checked vaginally. In the interviews the true average AFC were stated to be 2.5 years but when phenotyping the animals many of the females were older than 2.5 years and had not given birth and some of them were still not pregnant. Estimated earliest AFC was calculated to 2.9 years. When counting on the productivity of the females regardless of the AFC but including the current gestation status the average number of produced calves per cow and year was 0.58. According to the farmers reports, 67.4 % of the phenotyped females were pregnant. Although only one female was pregnancy checked during the phenotyping.

Figure 4a and 4b white spotted female on farmers market Beringkit, Bali and a white spotted female located on Kalimantan

Figure 5a-5f Examples of abnormal horns on females from Kalimantan

ANOVA

Since only one male were sampled on Kalimantan, no ANOVA comparisons were made between location Kalimantan and Java and Kalimantan and Lombok. For all results from the ANOVA see Appendix 7.

The ANOVA-test comparing phenotypic measurements for males originating from Bali and males originating from NTB showed that the ones from Bali were bigger in all measurements except from HL. Significant results were found for BW where males from Bali on average weighed 142.6 kg more than the ones from NTB.

Comparing females on Sumatra with the females located on Lombok showed significant 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 narrower PW and also got significantly shorter HL.

Comparisons between the females located on Lombok and Kalimantan showed significant differences in HL where the average difference was 15.38 cm shorter on Lombok. Significant differences were also found for PW and BW where the females on Lombok were heavier and having wider hips.

When comparing females from Sumatra with all females originating from NTB, significant differences were found for the BW where females from Sumatra on average weighed 33.6 kg less. Females on Kalimantan had significantly longer HL, narrower PW and lower BW compared to the ones originating from NTB.

The performed ANOVA comparing white spotted females with the standard colored females showed that the white spotted was smaller in all measurements and significant differed in BW where the white spotted cattle on average weighed 48.0 kg less compared to the individuals with standard color . The other phenotypical measurements did not differ significantly.

For all results from the ANOVA see Appendix 7.

Correlations

For males, strong significant correlations were found between HW and BL, CG and BL, CG and HW, BW and BL, BW and HW, BW and CG, PH and BL, PH and HW, PW and BL, PW and HW, PW and CG, PW and BW as well as PW and PH, Table 6. Correlations are above the diagonal and p-values are below the diagonal. For abbreviations of all measurements, see Table 2 and Table 3.

Table 6 Correlations between phenotypic measurements, males, N=8

	BL	HW	CG	BW	PH	PW	HL
BL	**1**	0.834	0.797	0.809	0.725	0.846	-0.022
HW	0.010	**1**	0.847	0.851	0.792	0.818	-0.146
CG	0.018	0.008	**1**	0.991	0.655	0.993	-0.471
BW	0.015	0.007	2E-06	**1**	0.686	0.914	-0.439
PH	0.042	0.019	0.078	0.060	**1**	0.764	-0.199
PW	0.008	0.013	0.001	0.002	0.027	**1**	-0.329
HL	0.958	0.731	0.239	0.277	0.637	0.426	**1**

Correlation	>0.7 strong	>0.4 Moderate	p-value <0.05 = significant

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PH=Pelvic height, PW=Pelvic width, HL=Horn length

For females, strong positive significant correlations were found for BW and CG and for PH and HW. Strong negative significant correlations were found for HL and PW. Moderate positive significant correlations were found for BL and HW, CG and BL, CG and HW, BW and BL, BW and CG, PH and BL, PH and CG, PH and CG, PH and BW and PW and BL. Moderate negative correlations were found for HL and BL, Table 7. Correlations are above the diagonal and p-

values are below the diagonal. For abbreviations of all measurement, see Table 2, Table 4 and Table 5.

Table 7 Correlations between phenotypic measurements, females, N=85

	BL	HW	CG	BW	PH	PW	HL
BL	**1**	0.488	0.475	0.470	0.525	0.490	-0.416
HW	2.2E-06	**1**	0.670	0.672	0.766	0.132	0.046
CG	4.9E-06	3.2E-12	**1**	0.997	0.528	0.154	0.067
BW	6.6E-06	2.7E-12	0,0E+00	**1**	0.532	0.145	0.082
PH	2.6E-07	1.3E-17	2.5E-07	1.9E-07	**1**	0.115	0.003
PW	1.9E-06	0.229	0.162	0.188	0.293	**1**	-0.803
HL	7.4E-05	0.676	0.542	0.461	0.977	2.55E-20	**1**

Correlation	>0.7 strong	>0.4 Moderate	p-value <0.05 = significant

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PH=Pelvic height, PW=Pelvic width, HL=Horn length

Analyses of the white spotted animals

Comparisons between the white spotted cattle with the standard colored individuals, showed that the white or spotted animals were smaller in all the phenotypic measurements and significantly differed in BW. For all ANOVA results, see Appendix 7.

Since only females were white/spotted in this study, additional comparisons were made with standard colored females to avoid differences depending on gender. For descriptive statistics of all white spotted and standard colored females, see Table 8.

Table 8 Descriptive statistics of phenotypic recordings of white spotted and standard colored cattle

	White spotted N=5				*Standard colored females N=80*			
	Mean	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*
Age (years)	4.30	2/8	2.95	8.70	5.59	2/17	2.80	7.85
BL (cm)	107.40	100/114	4.98	24.80	110.86	95/130	7.13	50.87
HW (cm)	105.00	103/106	1.22	1.50	110.60	98/125	4.71	22.19
CG (cm)	140.60	132/150	6.39	40.80	150.32	130/166	8.13	66.09
BW (kg)	240.20	201/285	29.85	891.20	285.00	192/381	41.9	1755.61
PH (cm)	105.60	101/108	3.05	9.30	111.49	101/128	4.66	21.70
PW (cm)	21.00	11/29	8.37	70.00	24.14	10/36	7.73	59.77
HL (cm)	19.00	10/32	9.85	97.00	21.25	8/35	8.79	77.21

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

Combining datasets with previous study

The previous dataset consisted of data from 42 males and 50 females >2 years of age. For descriptive statistics for the compiled dataset, see Table 9. For all results from the ANOVA, see Appendix 7.

When comparing data from the different locations from present study with the study by Lindell (2013) no significant differences were found in the datasets of phenotypical measurements of females. Significant difference were found for the bulls originating from NTB, where the bulls in the present study weighed 114.7 kg less compared to previous study. Significant differences were also found for BW for the males from Bali, where the males in the present study on average weighed 48.7 kg less than in previous study (Lindell, 2013). No females originating from Bali were phenotyped in any of the two studies and no males were phenotyped on Sumatra in the present study, thus no comparisons could be made with these categories of cattle.

Table 9 Descriptive statistics of males and females. Dataset combined with previous study by Lindell (2013)

	All males present + previous study N = 50				All Females present + previous study N = 135			
	Mean	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*
Age (years)	2.36	2/4	0.49	7.33	5.25	2/17	2.54	7.33
BL (cm)	114.3	97/149	11.6	37.2	112.5	95/135	7.36	37.2
HW (cm)	118.9	103/138	8.75	20.04	111.2	100/131	5.06	20.04
CG (cm)	163	133/204	17.28	74.3	150.1	130/174	9.09	74.3
BW (kg)	374.5	185/685	115.8	2078.45	287	185/441	49.46	2078.45
PW (cm)	24.38	18/40	5.66	13.61	22.94	9/36	6.69	13.61
HL (cm)	23.68	5/30	3.78	4.46	19.08	8/35	7.88	4.46

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

Correlations

The combined dataset of males showed strong significant positive correlations for HW and BW, CG and HW, BW and HW and for BW and CG. Moderate significant positive correlations were found for CG and BL, BW and BL, PW and BL as well as for PW and CG , Table 10. Correlations are above the diagonal and p-values are below the diagonal. For abbreviations of the combined dataset of measurement, see Table 9.

Table 10 Correlations between phenotypic measurements males, N=50 Combined dataset with Lindell (2013)

	BL	HW	CG	BW	PW	HL
BL	**1**	0.751	0.694	0.629	0.594	0.295
HW	3.3E-10	**1**	0.926	0.881	0.347	0.270
CG	2.3E-08	5.5E-22	**1**	0.926	0.415	0.208
BW	1.0E-06	3.0E-17	5.5E-22	**1**	0.343	0.289
PW	5.4E-06	0.013	0.003	0.015	**1**	0.149
HL	0.037	0.058	0.147	0.042	0.302	**1**

Correlation	>0.7 strong	>0.4 Moderate	p-value <0.05 = significant

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PW=Pelvic width, HL=Horn length

For females strong significant positive correlations were found for BW and CG. Moderate significant positive correlations were found for HW and BL, CG and BL, CG and HW, BW and BL and for BW and HW. Moderate and significant negative correlation was found for HL and

PW, Table 11. Correlations are above the diagonal and p-values are below the diagonal. For abbreviations of compiled dataset of measurements, see Table 9.

Table 11 Correlations between phenotypic measurements, females, N=135 combined dataset with Lindell (2013)

	BL	HW	CG	BW	PW	HL
BL	**1**	0.584	0.429	0.433	0.382	-0.350
HW	1E-13	**1**	0.534	0.559	0.144	0.011
CG	2.2E-07	3.1E-11	**1**	0.973	0.147	0.059
BW	1.8E-07	2.2E-12	0	**1**	0.146	0.066
PW	5.3E-06	0.097	0.091	0.094	**1**	-0.600
HL	3.1E-05	0.900	0.497	0.450	1.9E-14	**1**

Correlation	>0.7 strong	>0.4 Moderate	p-value <0.05 = significant

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PW=Pelvic width, HL=Horn length

Analyses of the white spotted animals, compiled dataset

When combining the datasets for white spotted and the standard-colored cattle with measurements from the previous study (Lindell, 2013), it was shown that the white spotted cattle were smaller in all phenotypic recordings compared to the standard-colored individuals and significantly differed in BW. On average the white spotted animals weighed 51,4kg less compared to the standard colored cattle. For descriptive statistics of the compiled dataset see, Table 12. For all results from ANOVA, see Appendix 7. For illustration of the phenotypic records of white spotted females and standard colored females, see Appendix 8, Figure 9.

In the previous study three of the white spotted animals were males. Comparisons with all standard animals, both males and females, showed that the white spotted ones were smaller in all measurement and significantly lighter in BW. To control if the result was caused by gender, since the majority of the white spotted cattle were females, an additional ANOVA was performed with white spotted females compared to standard females. The result showed that the white spotted individuals were smaller in all measurements and significantly lighter in BW. For descriptive statistics of the compiled dataset see, Table 12. For all results from ANOVA, see Appendix 7.

Table 12 Descriptive statistics of white spotted and standard colored cattle. Dataset combined with previous study by Lindell (2013)

	White spotted N=10				*Standard colored N=175*			
	Mean	*Min/Max*	*sd*	*var*	*Mean*	*Min/Max*	*sd*	*var*
Age (years)	3.95	2/8	2.61	6.80	4.50	2/17	2.53	6.42
BL (cm)	108.00	100/121	6.36	40.44	113.27	95/149	8.76	76.76
HW (cm)	107.40	103/114	3.84	14.71	113.65	100/138	7.14	50.91
CG (cm)	144.80	132/152	6.61	43.73	154.38	130/204	13.72	188.24
BW (kg)	260.10	201/295	31.40	986.10	315.67	185/685	88.04	7750.49
PW (cm)	21.40	11/29	5.72	32.71	23.37	9/40	6.57	43.13
HL (cm)	19.30	10/32	7.47	55.79	20.38	5/35	7.30	53.32

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

Discussion

Visit to farmers market Beringkit

According to ACIAR and to interviewed farmers on the market the price of the cattle was set per kg live weight. Despite that, none of the animals were weighed during the market day, instead the price mostly depended on posture and phenotype. The price on the other hand agreed with the ones mentioned in the report by ACIAR even though the report was published in 2010. This could mean that the price haven't been changed in 5 years time, or that the price was roughly estimated. The animals on the market were over all in good body condition, better than the average for the animals that was phenotyped in this study . This confirmed that the best animals are sold and also aligns well with the answers in the interviews that the biggest animals that brought in the best pay were sold. This was contradicting with the farmers wish to breed for bigger animals, since the biggest animals often were sold and not included in the breeding.

Phenotypes

The animals that were sampled on Kalimantan were stated by the farmers to origin from NTB. Since Lombok is a part of NTB comparisons were made both for the origin of the animal and also for the location where the animal was sampled. Only one male were sampled on Kalimantan, and therefore no statistical analysis were made for the location since such comparison would be very unreliable. Also the comparisons with the males located on Lombok were very scares since only two males were measured there. BW was estimated with a calibrated weigh measurer and when comparing the recorded weights with the weights calculated with the formula from Soares and Dryden (2011), the weights differed. In order to receive more accurate results for BW it would have been beneficial to use a calibrated scale. Although, the method provided the ability to compare measures between the cattle.

Descriptive statistics

For the females the mean values for BL (110.66 cm) and HW (110.42 cm) were only differing with 0.22 cm and the measurement of PH was 111.27 cm. This showed that the females tended to be very square-like in their body stature. This was also true for the males although the males got the average BL of 123.25 cm, HW 120.38 cm and PH 119.13cm. The males was slightly more rectangular compared to the female cattle, since they were 2.87 cm longer in BL compared to HW.

The HL for males compared to females was not differing as expected. The average for males was 23.75 cm and for females 21.26 cm. Literature describing the differences in HL between genders states that the differences in horn length are considerable, which wasn't the case in this study.

When combining the dataset with phenotypical measurements from the previous study the descriptive statistics for the females showed the same angularity in conformation, within the same order of magnitude as mentioned earlier. BL 112.5 cm and HW 111.2 cm resulting in a difference of 1.3 cm. For the males the BL was 4.6 cm shorter compared to HW. The mean values were overall very equal when comparing with the numbers from present study and the compiled statistics. BL was the record that differed the most for male cattle. The mean value in present study was 123.25 cm and in the compiled dataset 114.3 cm- a difference of 8.95 cm. The mean value also differed for BW where the BW in the compiled statistics was 14.63 kg less and also the PW was 8.62 cm narrower. For descriptive statistics, see Table 2-5.

When comparing statistics from present study with the compiled data from previous study the measures did not differ more than two units for age, BL, HW, CG, BW and PW. The measure that differed most was HL which differed 2.18 cm between the mean values. These results show the uniformity of the phenotypical measuring in both of the studies. The bigger dataset in the compiled data makes it more reliable compared to the studies separate from each other. The fact that the numbers in the present study was very close to the numbers in the compiled dataset could be seen as a proof of that the dataset are representative. For descriptive statistics of the compiled dataset, see Table 9.

Correlations

The fact that a calibrated weight measuring-tape was used both to measure the CG and also estimate the weight, resulted in that the BW and the CG was strongly significantly correlated for both females and males respectively. This was also the explanation to why the p-values for the correlation between BW and CG were close to 0 for the males and 0 for the females. The weight measuring-tape was not graded for every centimeter which resulted in that an animal with a CG that was in the middle of two marked weights on the weight measurer got the average of the two surrounding values. This is why the p-value for the bulls did not result in the same a p-value as the females.

For the males the phenotypic measures for CG/BW and PH were not significantly correlated. All of the other phenotypic measures for correlations between BL, HG, CG, BW and PH were strongly positive significantly correlated. This was expected since a bigger measurement in one of these measures was expected to give a bigger measurement for the other. This was true for all the measurements but the HL, which was negatively correlated to all measures but not significantly.

The phenotypic measure that varied the most among all individuals that was measured, was the HL which differed largely between the individuals both within and between each location and origin. The results from the estimation of correlations for the males showed that the HL got shorter when all the other phenotypical measurements were bigger. The correlations for HL were not significant but negative moderate correlations were found to CG and BW where a bigger measure resulted in shorter HL. If this correlation would have been significant, it might have been explained with that the horns only grow to a certain length and that the animal still can grow more muscles and get bigger in the other phenotypical measurements. This would result in that larger measures of the body results in shorter HL in relation. For the females the HL was strong significant negative correlated with PW where a bigger PW resulted in shorter horns. HL was moderately significant negatively correlated with the BL where a longer BL gave shorter HL. This was probably a correlation that happened by coincidence. The fact that the HL differed much between the individuals within location and origin made the estimations of correlations of HL uncertain.

For the females significant strong positive correlations were found for BW and CG as well as for PH and HW. This was expected since the animals that are higher in HW also would be expected to be higher in PH. BL was significantly positively moderately correlated with all measures except for HL which was significant negative moderately correlated. Positive significant moderate correlations were also found for CG and HW, BW and HW, PH and CG and for PH and BW.

The fact that strong correlations were found for more measurement parameters for the males might be due to the fact that less males were measured and that most of them were sampled at the same location which would reduce the effect of differing management. All the males in this study were 2 years old, making it a uniform dataset. A bigger number of females were phenotyped and this created a bigger variation in the dataset. That is also one possible explanation to why the results for the males are more uniform and have stronger correlations compared to the females.

ANOVA analysis showed significant differences in BW for males from Bali compared to the ones originating from Lombok where the ones from Bali were significantly heavier. The dataset of males were very small and also the males originating from Bali were kept in a feed lot which probably was the explanation to why they were heavier.

Abnormal animals

White spotted animals were sighted on Bali, Lombok, Sumatra and Kalimantan, in the previous study only on Kalimantan and Lombok. According to information given in the present and the previous study, the white color or spotted color pattern appeared on inbred animals. Since all the white spotted individuals in this study were females they were compared to standard colored females to avoid differences depending on gender. For descriptive statistics, see Table 8 and Table 12.

Since the farmers stated that the animals located on Kalimantan originated from Lombok additional test were performed for both origin and location. Testing in ANOVA, showed that the white spotted animals were smaller in all measurements and significantly differed in BW, 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 propose 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. Further gathering of data from the white spotted and white individuals is needed to draw reliable conclusions.

Comparisons of phenotypic recordings compiled datasets

Comparisons of the datasets showed that the weights of the bulls from NTB were differing significantly. This was probably due to that most of the bulls originating from NTB in previous study were measured in a feedlot. This could explain the heavier weight, since they most likely were fattened and in better body condition compared to the bulls phenotyped in the villages. Bulls originating from Bali were also differing significantly in BW between the studies, where the male cattle were heavier in previous study. In the previous study the males from Bali was recorded in a slaughter house, which probably was the reason for the significant difference in weight.

The previous study was performed during the hot season and the present study was conducted during the end of rain season. If more bulls had been phenotyped in the villages they would have been expected to be heavier compared to in the previous study, since the access to feedstuff would have been better due to the season.

No significant differences were found when comparing the females. This indicated that the recordings of phenotype had been carried out in an equivalent way in the two studies.

The animals were very easily stressed and not always willing to cooperate whilst being measured. This made it hard to get accurate measurements. The limited time available to measure each animal made it impossible to make multiple measurements of each parameter. By using an average of several recordings, errors might be smaller leading to a more accurate result. The fact that the phenotyping had been tested during the previous study made it possible to adjust it on beforehand and add and delete measurements.

It is likely that errors occurred in the data collection for the phenotype measurements such as human errors, and animals that did not cooperate and stood still making it hard to take exact measurements. For instance the CG of cow with ID 166 was measured to 202 cm which is not likely since she was rather thin and in the same size as the other cows that on average measured 150 cm in CG. Her CG measurement was excluded from the analysis and also the weight was removed since it was estimated from the CG.

When comparing the bulls, most of them were located on feedlots. These individuals are not representing the standard phenotype and this might have led to errors in the comparisons.
In the previous study some of the bulls were measured in the slaughter house. Since the bulls often are slaughtered when they are fattened and in best body condition they are not representing the standard conformation. In order to estimate reliable values for the cattle, data from feedlots and slaughterhouses needs to be excluded or only compared with animals with the same presumptions.

Interviews

Programs that have been established in an effort to increase the knowledge about breeding, and to promote Bali cattle, have not been successful and were not followed up. When this report was written, no data from the P2SDS program was available and the last up-date on the programs web page was made in October 2009.

None of the interviewed farmers used planned breeding but mated their cattle throughout the year. Many studies have shown that both animals and production results could benefit from planning mating according to dry and wet season. This lowers the stress for the cows both during gestation and lactation, and would also give the best opportunities for the calf.

Management practice of the breeding could benefit from a field study with on farm studies in for example villages were the new methods are applied and studied for a longer time on sight. Dahlanuddin *et al* (2014) showed that 97 % of the farmers in their management-study were willing and likely to proceed with the new routines after the study was conducted in a successful way. There is a big need of knowledge, and by applying the knowledge in field, and doing that by showing the positive effects and how to do it in practice, is one possible way. This method also makes it possible to gain a lot of local knowledge from the farmers in the field, and have better chances of not neglecting or wasting important traits and features. This approach decrease the risk of that the breeding program fail according to Philipsson *et al* (2011) and also aligns well with the statements from Ojango *et al* (2010) on how to establish a successful breeding program.

According to Patrick *et al* (2010) it is prohibited to cross bred Bali cattle and to sell them from Bali for other purposes than for slaughter. No other literature regarding this prohibition could be found during the literature study in this project. However, crossbred cattle were frequently seen during the field study and the interviews revealed that a majority of the farmers preferred crossbreeding.

Regarding the genetic diversity, many of the farmers preferred to use AI and depending on the selection of AI bulls and how frequently the same bull are used for the AI-doses will have impact on the genetic variation in the population. In the cases where natural mating was used it was very few bulls available, thus the possibility for selection was very limited. Regardless of which method that is used, the number of males used in breeding is very important for the effective population size.

If the pregnancy checks used to be performed vaginally without gloves it would mean a serious risk of bacteria entering the uterus and increase the risk of abortions. If this was the standard procedure, informing the farmers about hygiene routines could improve the health of the female cattle and also decrease the risk of abortions.

The knowledge about breeding was low. When the farmers were asked to grade their knowledge on the scale 1-5 the average was 2.3 and 14 % of the farmers were not aware of inbreeding . According to Lindell (2013) the number of farmers who did not consider inbreeding was large. On the other hand the farmers stated that they knew which animals that were related, which, if it is managed properly, is one way of taking inbreeding into account. The same pattern was seen in this study. Some of the farmers answered that they didn't consider inbreeding but also stated that they did not mate related animals. No trends could be found between the grading of the farmer and the number of owned animals.

In the interviews the true average AFC were stated to be 2.5 years but when estimating the earliest possible AFC it was estimated to be 2.9 years. This age is calculated without taking parameters such as heat expression and conception into account but was used to make a rough estimation. If these parameters would be considered, the true AFC would be even higher,

especially since many of the farmers stated that it was hard to get the heifers pregnant. One of the farmers on Lombok stated that he took advice and learned about breeding from the inseminator. Since the popularity of AI was high, one possible way to increase the information reaching out to the farmers could be to educate the inseminators.

The most desired trait to improve, and the trait that was most frequently mentioned as important was the size of the animals. The farmers wanted to have bigger animals and this might increase the risk of calving difficulties and may also create a risk of breeding for animals that no longer are adapted to the demanding conditions. Taylor and Murray (1988) stated that smaller individuals tended to cope better with heat-stress. The size was stated as the reason for the usage of crossbreeding- to get bigger animals with better growth. The heavier beef cattle have much higher energy requirements compared to the Bali cattle and are not suited for the given conditions. This might result in animals that get malnourished, risk of getting sick and resulting in a big loss of income for the farmer and an animal welfare problem. If the crossbred animals should be given the best conditions to produce under Indonesian conditions maybe they could be used in high in-put systems with high quality fodder or in systems where they are allowed to graze freely, foraging. The cross breeding might possibly result in a higher frequency of calving difficulties. When mating Bali cattle females with sires of larger breeds such as Simmental or Limousin, the risk is likely to increase. Laster *et al* (1973) showed that Hereford females mated with larger sires got an increased risk of calving difficulties. Since the Bali cattle females are smaller compared to the Herefords makes the theory of increased calving difficulties even more thinkable.

The fact that the farmers said that it was hard to get in hold of pure bred Bali cattle, the increased use of crossbreeding and the decreased use of Bali cattle as draught animals might be future threats for the breed. The crossbreeding is also a future threat for the purity of the Bali cattle as discussed by Martojo (2012).

The animals were used as capital savings and were sold when need arose. Only one of the interviewed farmers slaughtered animals for own consumption. Close to all farmers, 98.6 %, wanted to know more about breeding and the fact that they were eager to learn more opens future possibilities for further education and collaborations.

The fact that the study was conducted partly as a follow up study made it possible to adjust the interviews prior to the visits. In the previous study open questions were used in the beginning but were switched to multiple-choice questionnaires due to limitations for translation and ability to sum up the results in a quantitative way. Language difficulties and translations might have affected the results in the interviews. According to the Indonesian colleagues the questions had been translated correctly. In future interviews it would be beneficial to note where the farmers had bought their animals. In this study the origin was noted but not the actual place of purchase.

One weakness showed up during the statistical analysis. Since the studies main focus laid upon breeding, some of the questions regarding everyday management were left out from the previous study. It would have been desirable to be able to connect answers about feeding to the phenotypic measurements. This would have provided more parameters that could have been compared with the previous study and possible explanations of phenotypical differences.

When composing the information to the farmers, it was hard to know in advance which information that was applicable and wanted by the farmers. The language barrier made it hard to formulate tools that were understandable and useful. The Indonesian colleagues translated and handed out the information to the farmers who wanted to take part of the information.

Future perspectives

Today taurine cattle contributes to the world´s majority of both milk and meat produced. But in the future some of the properties of Bali cattle could possibly be introduced into domesticated *Bos taurus* breeds by genetic introgression. The changing climate bring about many different and possibly, yet unknown demands. Discovering traits and conserving important features of today's livestock will provide better opportunities to handle difficulties in the future. The future might bring new opportunities for the farmers. The number of smart phones increase and opens up for the use of applications for farmers getting in touch with each other and can give new ways to sell, mate and trade animals.

The different management and the demanding and differing conditions, makes it challenging to distinguish breeding values for the animals, and how to select correctly in future breeding programs. One crucial point is to start up the record keeping for the cattle. Further studies in field and integrated work together with the farmers might be possible ways to approach the task.

Conclusion

The knowledge about breeding was scarce among the farmers and few records were kept for the cattle. The farmers were positive and willing to learn more about breeding and genetics. It is important to educate the farmers and to communicate the importance of record keeping, in order to develop future breeding programs. Educating the farmers could also be beneficial in order to diminish the rate of inbreeding and possibly slow down the rate of the decrease in genetic variation. The fact that the biggest animals are sold and the poorer ones are kept and used in breeding, contradicts with the fact that the farmers wants to breed for bigger animals. Furthermore the genetic factor underlying the white spotted animals is still unknown and needs to be studied further; however their smaller size could be an indication of inbreeding. The popularity of breeding with the focus on size of the animal, combined with the increased popularity of the use of crossbreeding with larger exotic beef breeds, might be a risk for increased number of calving difficulties. This could also pose a threat for the purebred Bali cattle, resulting in an increase in the number of animals that cannot cope with the heat stress and

result in decreased animal welfare as well as economic losses for the farmers. The dataset aligned well with that from the previous study by Lindell (2013), indicating that despite a rather small number of measurements, the recordings have been performed in a comparable way and may provide a realistic estimate for the population as a whole, on the locations included in the two studies. Still, more animals need to be sampled at each location to be able to find significant differences depending on location and the genetic background responsible for the different traits needs to be investigated further.

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Appendix 1. Description of phenotypic measurements

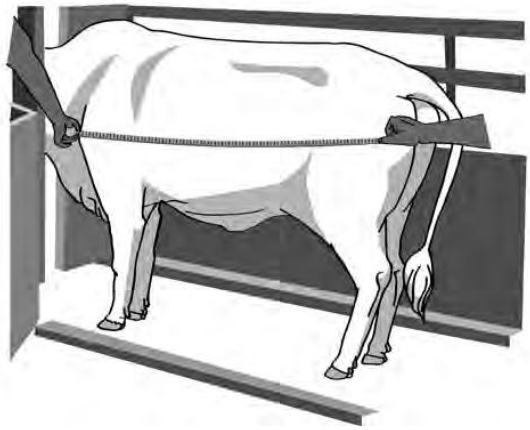
Table 13 Description of phenotypic measurements

Measurements	How to perform the measurement
Body Length (cm, caliper)	Measure from point of the shoulders to the point of the buttocks (pin bone). Both points have a protruding bone that can be located for correct measurement (FAO, 2012; Gilbert *et al* , 2013).
Height at withers (cm, two calipers)	Measure from the ground to the highest point of the withers (Soares *et al*, 2011; FAO, 2012).
Ear length (cm, 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).
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

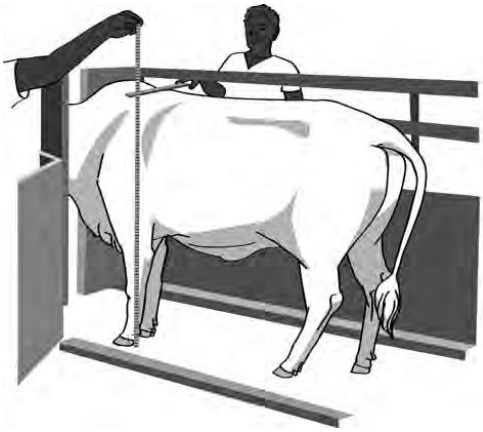
Dewlap size (visual measurement)	Absent/small/medium/large: The dewlap can be related to physical condition (Soares *et al,* 2011). The size of the dewlap can also be related to heat resistance. Graded as: 1(absent) = non-existing or very small, 2(small) = loose skin situated near the brisket, 3(medium) = 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 (vision measurement)	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 too a bad back) or soar feet (Svensk Mjölk, 2000).
Pelvic width	Measure from inside of one hip bone to inside of the other (FAO, 2012)
Pelvic height (cm, two calipers)	Measure from ground to top of pelvis (Svensk mjölk, 2008; McPeake, 2006)

Appendix 2. Illustrations of phenotypic measurements

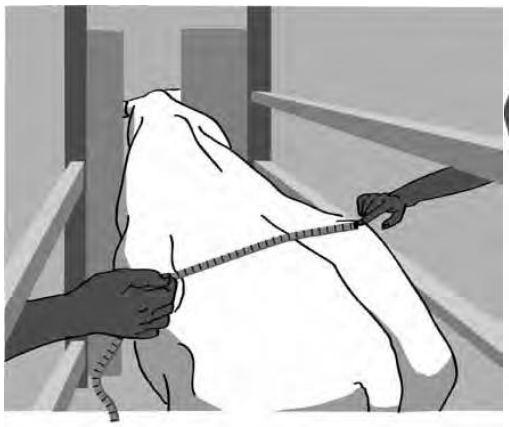
Body Length, BL



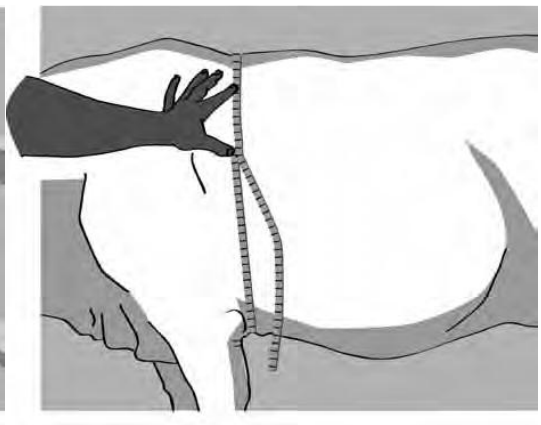
Height at whiters, HW



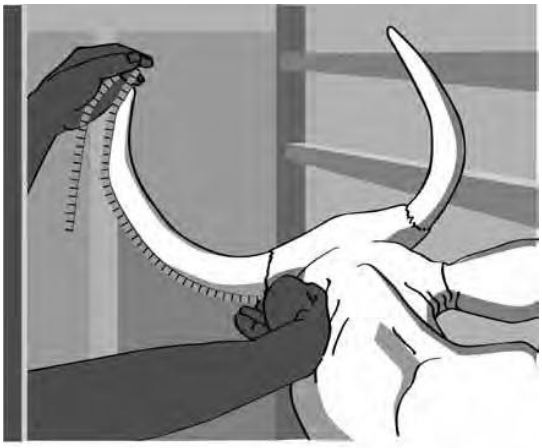
Pelvic width, PW



Chest girth, CG



Horn Length, HL



Pelvic Height, PH

Appendix 3. Interview Questions

Table 14 Interview Questions

Nr	Question	Options:
1	How many males and females are there in the herd and at what age are they?	Males: Ages: Females: Ages:
2	How many calves are born on your farm each year?	Nr of calves:
3	Do you have a breeding strategy? (a goal or a plan e.g. get bigger animals, more calves or a plan for avoidance of inbreeding etc.)	a) yes b) no
	If Yes: What is the main goal with your strategy?	a) bigger animals b) better fertility (shorter calving intervals, easy to get pregnant etc.) c) avoid inbreeding d) breed for health e)….
	If No: Why don't you have any strategy?	a) I don't need one b) I don't know how to put up one c) I don't care about breeding strategies d)…..
4	What records are kept for the animals? Please tick the ones you use.	a) ID b) pedigree c) date of birth d) date of mating e)date of calving f)records from measurements' e.g. weights and heights g) other parameters h) no records
5	What is the expected life-length for your animals?	Males: Females:
6	During which months does mating occur?	a) dry season b) wet season c) anytime d) ….

7	Do you get enough calves for being self-sufficient on animals for recruitment?	a) keep all, get enough for recruitment b) keep all, but not enough for recruitment (need to buy some new animals) c) sell some, keep some (enough for recruitment) d) sell some, keep some for recruitment but still buy some new animals e)...
8	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 (Approx. price:) e)…
9	What traits do you wish could be better?	a) reproductive traits (maternal abilities, high calving rate, etc.) b) temperament (e.g. calmer, more easy to handle) c) health traits (don't get sick) d) growth traits (grow bigger, grow faster, etc.) e)…
10	Do you use cross-breeding?	a) yes b) no
	If **yes:** which breed/breeds are used?	
11	How do you know what animals that are related?	a) from memory b) pedigrees c) by looking at their performance d) keeping records of animals e)....
12	How do you avoid inbreeding?	a) don't mate related animals b) not aware of the term inbreeding c)don't take inbreeding into consideration
13	What mating practice is used?	a) artificial insemination (AI) b) natural mating c) both d)…
14	If you use AI; Where do you buy semen and approximate cost?	From: …… Cost: ……..

15	If you use bulls; Where do you get bulls for mating with your cows?	a) using own bull b) from neighbor c) ...
16	If you use neighbor's bull; How much do you pay?	a) cost: b) do not pay in money
17	If mating with a neighbor's bull what information do you base your selection on?	a) pedigree b) reputation c) own experience of the bull d) that the bull is located close to my herd e) ….
18	How do you select bull-calves for future breeding?	a) keep the best b) keep biggest c) keep nicest d) don't keep own bulls for breeding
19	What are the most important/preferred traits in the bull?	a) good temperament b) high growth c) appearance d) good health e) give offspring with good performance (e.g. milk yield, meat quality etc.) f)....
20	What are the most important/preferable characteristics/attributes 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)….
21	What is the target age for first calving?	
22	What is the actual average age for the first calving?	
23	Do you find it difficult to get your cows pregnant?	a) sometimes b) some individuals hard to get pregnant. c) no difficulties
24	Approximately how long is the average lactation length?	
25	Approximately, how much milk can you get from one cow each day?	
26	What do you use the milk for? (please mark the alternatives that match)	a) feeding of calves b) for own consumption c) sell d) ...
27	Do you separate cows and calves? If so, at what age?	a) yes, at the age of : b) don't remove calf from cow

28	How do you select heifers for breeding?	a) select on performance (e.g. milk yield, meat, health, fertility) b) select nicest ones c) no selection, use all my heifers
29	How often do you experience abortions, stillbirth or defect calves?	a) often b) sometimes c) never
30	How many abortions, stillbirths and defect calves have you experienced on your own cows?	Stillbirth: Abortion: Defect calves:
31	Does the rate of abortions differ a lot between individuals?	a) yes b) no
32	How common is it for a cow to get an abortion during her life? (e.g. 1 abortion per cow and lifetime)	
33	What is the most common health problem with your cattle?	a) jembrana b) diarrhea c) fever (also worms and eye problems) d) parasites e)…
34	What is the main reason when you sell/slaughter your animal?	a) sell for slaughter b) sell for breeding c) slaughter for own use d) sell due to loss of function (e.g. doesn't get pregnant, get sick, weakness, doesn't fulfill purpose) e) to rejuvenate the stock f)...
35	If selling animals, where do you sell them?	a) local market b) sell to other island c)….
36	When you sell animals, which ones do you sell?	a) the ones that I get paid most for b) the ones I can't keep (e.g. have to little feed, space, paddocks etc.) c) random d) don't sell animals
37	At what age do you normally sell/slaughter you animals?	
38	How have you gained knowledge about breeding?	a) learned from relatives/friends b) learned from doing c) own studies d) studies on school e)...
39	Please rate your knowledge about breeding between 1-5.	Little 1 2 3 4 5 Much

40	Would you like to know more about breeding?	a) yes b) no
41	If you would like to know more about breeding, what would that be?	a) genetics b) how to breed for certain traits c) how to put up pedigrees and registers d) .....
42	What is your opinion about taking part in this study?	a) fun b) good to exchange knowledge between countries c) hope it will be beneficial for the breed and for me as a farmer d) not good e)...
43	Would you like to take part in a follow up study?	a) yes b) no

Thank you for participating!

Appendix 4. Registration form

REGISTRATION FORM

GENERAL INFORMATION		
ID/ Name :	Weight at birth (Can also be described as small, average or big):	Date of birth:
Sex: Male ◯ Female ◯	Temperament:	Date sold/slaughtered:

PEDIGREE			
Father ID/Name:		Mother ID/Name:	
Paternal grandsire i.e. Fathers father:	Paternal grandmother i.e. Fathers mother:	Maternal grandsire i.e. Mothers father:	Maternal grandmother i.e. Mothers mother:

APPEARANCE		
Color:	Markings:	Horns:
Other info (e.g. unusual color, special conformation etc.):		Size (small, average, big):

HEALTH		
Date for incidence	Type of problem	Treatment:

FEMALE

Age at first heat: Age at first calving:

Date for mating	ID/name of bull or AI-dose :	Known relatives for bull/AI-dose.	Notable characteristics for bull	Date when calf was born	ID/name of calf	Calving performance (Easy, Difficult, Stillborn etc.)	Date when cow is drying off (stops milking)

Milking performance (Much, average, little) :	Growth (Slow, medium, fast):	Meat yield:	Other:

MALE

Date for covering	ID/name of cow	Date for covering	ID/name of cow	Date for covering	ID/name of cow	Date for covering	ID/name of cow	Date for covering	ID/name of cow

Mating performance: Also note how many times he has to mate to get the cow pregnant.	Growth (Slow, medium, fast):	Meat yield:	Other:

Appendix 5. Information to the farmers

How can I breed on my farm?

Breeding doesn't have to be complicated. Just by taking some parameters into consideration it is possible to influence your future animals, preserve the Bali cattle breed and get the best possible animals.

What's in it for me?

Breeding is so much more than just mating your cow to get a calf. By putting up a breeding plan it is possible to improve your animals in preferred ways. For instance one could increase the production or health of the animal which, in the long run, would result in better economy for you as a farmer.

Pedigrees

By keeping pedigrees it is possible to keep in track of which animals that are related to one and other. When you fill in the pedigree in the registering form you can either fill in the ID or the name of the known relatives to the animal. If you don't know name or ID you can fill in for instance whose bull you used, the age of him and the characteristics that you know of. That makes it possible to know that if you used a 5 year old dark brown bull from neighbor A, you could avoid mating that offspring with the same bull.

Inbreeding

In order to breed for a sound breed with good production and health it is important to avoid inbreeding. Increased inbreeding results in lower milk production, smaller animals and higher incidence of dystocia and stillborn calves. Also it results in that genes are lost and the genetic pool of the Bali cattle breed decreases.

Why recordings?

In order to breed for a certain trait it is necessary to start up with recordings of the trait. A trait is a certain characteristic. For instance if you wish for better calving performance one need to start keep records for that trait. With these records one could see the changes in the performance in the trait over time. This makes it possible to look back and evaluate if the breeding have been successful. It is also important to keep in track of other traits since breeding for one trait might affect other traits that you don't have taken into consideration from the beginning.

How to fill in the registration form

It is important to fill in the *pedigree* in order to avoid inbreeding and also to know characteristics of the parents of the animal. If you don't know the full pedigree you might, as mentioned earlier, put in the things that you know. For instance, name of the farmer who owns the bull and some characteristics of it, for instance color.

Appearance is a description of the animal. This can be used for identification, and also predictions for breeding purposes. Like predictions of what characteristics that might be passed on to future offspring.

Dates for mating and covering, mentioned in the columns for each sex, can be filled in with dates when the animals are put together.

Since the *size* of the animal is important in many different ways, for instance too big calves create difficult calving's and a bigger animal needs more feed. The size is referred to as small, medium or big. If you see that one certain combination of cow and bull gives a certain offspring, perhaps it is possible to create another combination in the next mating in order to receive a more desirable calf. If records are kept it is possible to combine individuals that compensate for each other. Perhaps the cow tends to get big calves, combined with a bull that uses to give small calves it might give a more medium-sized calf.

How can I get results and what results can I expect?

It is of great importance to have a big variety in genetic material and a big number of heterozygote individuals. A heterozygote has two different alleles for instance A and a, whilst a homozygote only have a double set of one of the types for instance a and a.

Having a lot of heterozygotes enables combinations of different animals with different genetic make up and the outcome could result in an individual with a more desirable genotype. If the parents have very similar genotypes, for example- are inbred, they have a much lower possibility of creating new mixtures of genes in the calf. Take the example mentioned below:

Here one can see the different results when crossing individuals with different genotypes. Each set, for instance Aa, corresponds to one of parents genotypes. The four boxes are the distribution of genotypes in the offspring.

Aa x Aa

	A	**a**
A	**AA**	**Aa**
a	**Aa**	**aa**

50% Heterozygotes
50% Homozygotes

Aa x aa

	a	**a**
A	**Aa**	**Aa**
a	**aa**	**aa**

50% Heterozygotes
50% Homozygotes

aa x aa

	a	**a**
a	**aa**	**aa**
a	**aa**	**aa**

100% Homozygotes

AA x AA

	A	**A**
A	**AA**	**AA**
A	**AA**	**AA**

100% Homozygotes

The same goes for inbreeding, if one continue to breed on one line and let the inbreeding increase, genes will be lost and the ability for the animals to adapt to a changing environment decrease as the homozygosis increase.

Some traits is easy to affect by breeding and can be seen in a few generations whilst others are long term traits that will be influenced over time and maybe not visual to the eye in the close future.

All progress begins with a first step. Good luck with your breeding!

Appendix 6. Results from interviews

Gunung Sindur Bogor, Java

The feedlot housed 72 animals in total, 5 of them where pure bred Bali cattle originating from Bali, 25 where Bali cattle crossed with breeds like Kupang, Limousin and Simmental. The other animals were exotic breeds, both pure bred and crosses. The owner wanted to focus on beef cattle and preferred pure Limousin or crosses with Limousin. He mentioned that it was hard to get in hold of pure bred Bali cattle. His tactic for buying animals was to buy 3-5 extra animals before the Islamic Eid al-Adha. When buying new animals he was looking for muscle deposition and wanted them to have a good feed conversion rate and grow fast and get big. If some traits could be influenced by breeding he wished to improve growth traits.
He produced calves and kept to an age of 7-8 months before they were sold. Older animals were bought at varying age and then fattened for approximately 1-1.5 years until they were sold or slaughtered at an average age of 3 years. He sold them on the local market when the price was good.

He mainly bought animals for fattening but breeding was performed occasionally and could in those cases be occurring throughout the year. He had gained his knowledge about breeding from relatives and friends and by practicing breeding. He rated his knowledge to 3 on a 1-5 scale where 1 is little and 5 is much. He would like to know more about breeding and especially genetics and more about AI.
He used Limousin for crossbreeding to get bigger calves. He did not know if any of the animals were related since he bought them for fattening and no records were kept but he knew the origin and type of the animals. He did not consider inbreeding and used natural mating with his own bulls. He selected the biggest bulls for breeding (height and weight) when they were about 1-2 years old. The size was also the most important trait and he was especially looking at the length of the body and measure of the chest to get an estimation of the carcass. Females were selected for being big and having a good stature with a long and wide body. The average AFC was 2.5 years and he thought that some of the individuals was hard to get pregnant. The cows were lactating for around 3 months and gave 1-2 liters per day and the milk was suckled by the calves. Calves were separated from cows at the age of 3 months.
Abortions, stillbirths and defect calves were often occurring on heifers but he had not experienced any problems with that for the cows.
The most common health problems were diarrhea and fever.

He thought it was important to exchange knowledge between countries and hoped that his participation would be beneficial for the breed and also for him as a farmer and he would like to take part in future studies.

Kabupaten Kampar, Riau Pakanbaru, Sumatra

15 small scale farmers that housed 1-3 cattle each were interviewed. Each household/farmer produced 1 calf per year and none of them owned a bull. All of the farmers had a breeding strategy where all of them mentioned getting bigger animals as a main goal, but focus was also on health and increasing the stock. 33.3 % of the farmers had an ID on their animals, 66.6 % kept pedigrees for the animals, 93.3 % noted the date of mating and 20 % noted date of calving. None of the farmers kept records for measurement such as weight, height or other parameters.

Average life expectation was 1.5- 3 years, one farmer expected his cows to live for 6 years. All farmers answered that mating was performed throughout the whole year. 53 % of the farmers did not get enough offspring from their cattle for recruitment and therefore needed to buy new animals in order to keep the desired number of animals. When buying or breeding the most desired traits were size and that the animal was looking healthy with shiny fur, nice color and good horns. Only one of the farmers mentioned the price as an important trait. The farmers wished for improvements of growth- , health- and reproductive traits. They also wanted to breed for calmer individuals and one farmer mentioned that he wanted to breed for good hips. 66.6% of the farmers used to cross breed and preferred to use Simmental or Limousin on their Bali cattle females. 46.6 % of the farmers were not aware of the term inbreeding and 13.3 % did not take inbreeding into consideration. Inbreeding was avoided by keeping records of relationship between the animals and by memory. 66.6 % of the farmers used AI, 20 % only used natural mating and 13.3 % used both. The AI doses came from DISNAK, BET Cipelang or BIB Lembang at a cost of 40000-50000 IDR. If the cow was mated naturally, 93.3 % of the farmers used the neighbors bull. When using the neighbors' bull most of the farmers based the selection on reputation of the bull, checked the status of the cows in the bull-owners herd and checked the bulls' health. 53.3 % saved docile and big bull calves for future breeding purposes. Other desired traits for recruitment of both cows and bulls were; health, reproduction and appearance. 40 % of the farmers mentioned that appearance was very important, compared to the alternative "quality of the future offspring" that was mentioned by 33.3 %. All of the farmers aim for an AFC of 1,5-2 years and all stated that the actual AFC was 2 years. 86.6 % had no problems with getting the cows pregnant. The average lactation length was 5-8 months and the daily milk yield was estimated to 1-2 liters. 93.3 % of the farmers used the milk for feeding the calves and 6.7 % of the farmers sold the milk. 80 % of the farmers removed the calf from the cow at an age of 5-8 months. 93.3 % of the farmers never had problems with stillborn, defect of aborted calves. The most common health problem was fever and diarrhea. 13.3 % of the farmers had problems with Jembrana. 93.3 % of the farmers sold their cattle when needed for instance for school fees or weddings. Animals were sold to traders that came to the farms. The farmers sold animals at any age and often choose to sell the ones that brought in the highest pay. All the farmers had gained their knowledge about breeding from relatives or friends and one farmer also studied breeding in school. When the farmers were asked to grade their knowledge about breeding on a scale from 1-5, where 1 was little and 5 was much, 40 % answered 2, 53.3 % answered 3 and 6.7 % answered 5. The farmer grading 5 was the person who had studied breeding in school. All of the farmers

wanted to know more about breeding and breeding for certain traits. They especially mentioned that they wanted to know more about breeding for big animals and 20 % of the farmers wanted to know how to establish records for their animals. The farmer who studied breeding in school wanted to know more about genetics.

All of the farmers thought it was fun to participate in the study and were willing to take part in future studies.

Interview Kabuoaten Tanahlaut, South Kalimantan

31 small scale farmers were interviewed on South Kalimantan. They kept 1-7 cattle each, both males and females and produced 1-3 calves per farm and year. 51.6 % of the farmers had a breeding strategy where they prioritized breeding for traits in the following order; health, bigger animals, avoiding inbreeding followed by appearance traits- color and big horns, and fertility. Out of the farmers who did not have a breeding strategy 46.6 % said that they did not know how to set up one, 20 % said that they did not need one and 20 % said that they did not care about breeding strategies. The remaining 13.3% answered that they kept the cattle on free range and that they mated freely and therefore did not need any strategy. 80.6 % of the farmers kept records for their animals. The most commonly kept records was date of birth, date of mating and pedigree. 9.6 % of the farmers had an ID for the animals. No one of the farmers kept records of measurements such as weights, heights and growth.

Bulls had an expected life length of 1.5-3 years and the cows were expected to live for 3-10 years. The farmers were willing to sell the cattle at younger age if the price was good.
All farmers stated that mating occurred throughout the whole year regardless of season. Most farmers did not get enough calves to be self-sufficient on recruitments and therefore needed to buy animals to compliment the number of animals on the farm. 45.1 % of the farmers got enough calves for recruitment and could also sell some.

When buying a new animal the most important features for the farmers were appearance traits, size and weight of the animal. Long body, rounded rear, good nipples, big mouth, big feet and long tail was also mentioned. The price was mentioned as important by 16.1 % of the farmers. When the farmers were asked to mention traits that they wished could be improved for Bali cattle the farmers answered in following order; health, reproduction, growth and temperament. Tail length, appearance and willingness to consume a lot of fed and water was also mentioned.

No one of the farmers used crossbreeding but one farmer stated that he sometimes had to use crossbreeding when that was the only option and no pure bred bull was available. 58 % of the farmers did not know which animals that were related. 32.2 % kept pedigrees for their animals, 25.8 % remembered which ones that were related and 6.4 % looked at the animals performance to know the relationships between individuals.
Inbreeding was avoided by 77.4 % of the farmers who stated that they never bred related animals. 16.1 % of the farmers did not take inbreeding into consideration and 6.5 % of the

farmers were not familiar with the term inbreeding. Natural mating was the most common way to practice mating and 74.2 % of the farmers used entirely natural mating. 9.7 % relied entirely on AI and 16.1 % used both methods. AI doses are bought from a registered nurse at a cost of 50000 IDR per dose.

89.3 % of the farmers that used natural mating used the neighbors bull at an average cost of 30000 IDR. Some farmers paid 25000 IDR for a jump and additional 25000 IDR when the calf was born alive. Selection of the bull was based on reputation and own experience of the bull. Big size and long horns was mentioned as desirable. The most important traits for recruitment of own bulls were a high growth rate, appearance and good health. Most preferred characteristics for recruitment of cows were good reproductive measures such as mother ability, ease of calving and ease to get pregnant. Long tail, rounded head, shiny red fur and willingness to eat were also mentioned.

83.9 % of the farmers had no problems with getting the cows pregnant although difficulties with getting heifers pregnant was mentioned by several farmers. The goal for AFC was 2.5-3 years and the actual AFC was 2.5-4 years. The lactation length was between 3-9 months with an average of 6-7 months. The daily milk yield was estimated to 1-2 liters and the milk was mainly used for feeding of calves but 12.9 % of the farmers used it for their own consumption and 9.7 % of them sold milk. 64.5 % of the farmers separated cow and calf, this usually occurred when the calf reached an age of 6-7 months. 87.1 % of the farmers actively selected heifers for recruitment whilst the other farmers had to use all of their heifers without any opportunity for selection.

16.1 % of the farmers sometimes experienced stillbirths, abortions or defect calves and abortion was the most frequently occurring problem in this group. One farmer had experienced three abortions and one farmer had been actively breeding for 12 years and had experienced one abortion. Two other farmers said it was expected that the cow got problem ones during her lifetime.

The most common health problems were diarrhea, worms and fever. The farmers also mentioned parasites, dry muzzles and limping as occurring problems.
87.1 % of the farmers sold their animals to get money for weddings or school fees and used the cattle as savings. 3.2 % of the farmers slaughtered animals for own consumption of the meat. Traders came to the farm to buy animals. Most of the farmers choose to sell the animals that brought in the best pay whilst 9.6 % sold the ugliest and 9.6% sold animals due to lack of space in paddocks and stalls. The animals did not have to reach a certain age before they got slaughtered but was sold when need arose or when the price was good.

The farmers had gained their knowledge about breeding from friends/relatives or from practicing. When the farmers were asked to grade their knowledge on a scale from 1-5 ,where 1 was little and 5 was much ; 3.2 % graded 1, 77.5 % graded 2, 12.9 % graded 3 and 6.4 % graded 4. All the farmers were interested in getting more information about breeding. The farmers

especially wanted to know more about how to breed for certain traits and mentioned size and health as examples. 32.2 % of the farmers wanted to know more about genetics and 19.4 % of the farmers answered that they wanted to learn how to breed. 6.4% of the farmers wanted to know how to set up records and keep registers for the animals.

All of the participating farmers thought it was fun to take part in the project and hoped it would be beneficial for them and the animals. All of them would like to take part in future studies.

Labuhan Haji, east Lombok, NTB

21 small scale farmers were interweaved on Lombok. Each farmer housed 1-2 cows with calves and 14.3 % of the farmers also housed one bull. On average the farmers produced 1 calf per cow and year.

76.2 % of the farmers had a breeding strategy. For the majority, 93.4 %, the reason was to increase the size of their animals. 37.5 % stated that they had a strategy to breed for health and 12,5 % said that their strategy was to avoid inbreeding. Among the farmers without a breeding plan the two main reasons were either that they did not need one or that they did not know how to implement one.

90.5 % of the farmers kept some records for their animals, most commonly the date of mating and the date of birth was recorded. 9.5 % of the farmers kept records of the performance of the animals, for instance growth and size.

All the farmers mated their animals throughout the whole year, regardless of season. Most of the farmers got enough calves to be self sufficient on recruitment animals. Some farmers sold bull calves and some farmers needed to buy additional animals in order to keep the desired number of animals.

When buying a new animal the appearance was the most important feature for the farmers. A big animal with nice shiny fur and long horns was preferred. Good legs, thick skin, rounded hind and good nipples were also mentioned as desirable. None of the farmers mentioned a good price as important. When the farmers were asked which traits they wished to improve in Bali cattle, growth- and reproductive traits were the most desired ones.

All of the farmers practiced crossbreeding with pure Simmental and Bali/Simmental crosses, some also used PO cattle. 66.6 % of the farmers kept track of which animals that were related using memory while 33.3 % used pedigrees. 85.6 % of the farmers avoided inbreeding by not mating related animals, the rest did not take inbreeding into consideration.

All farmers relied entirely on the use of AI and the doses came from the company BIB Singosari located in Malang, Java, at a cost of 20000 IDR per dose. When they previously used a neighbor's bull for mating they used to pay 25000-50000 IDR. If the farmers would save a bull for breeding purposes they liked it to be big, healthy and have a good appearance, preferably be

black with shiny coat and big horns. 9.6 % of the farmers also mentioned that it was important that the bull was willing to consume a lot of feed. The most important traits for the bull were high growth, good health and that it gave good offspring. One farmer stated that it was important that the mating bull had a pedigree. The most important traits for the cows were reproduction, health, growth and temperament. It was also important that the cow allowed to be suckled by the calf. Other characteristics that were mentioned were wide hips and high milk production.

The goal AFC was 2-3 years while the actual AFC was 2.5- 3.5 years. 90.5 % of the farmers thought it was easy to get the cows pregnant. The average lactation length was 5-6 months. The cows were suckled by the calves and none of the farmers had ever measured the milk and could therefore not estimate the daily milk yield. The calves were separated from the cow at an age of 5-6 moths.

95.2 % of the farmers had never had problems with stillborn, aborted or defect calves. One farmer had experienced abortion once. One farmer stated that the risk of getting abortions was once in 12 years. The most common health problems were fever, diarrhea and parasites.

The animals were often used as savings and sold when needs would arise; for instance for school fees and weddings. 19 % of the farmers said that they sold animals in order to rejuvenate their herd. All of the farmers sold their cattle at the local cattle market. They sold males and crossings and the ones that brought in the best pay.

Most of the farmers had gained their knowledge about breeding from friends/relatives or by practicing breeding. One of the farmers had studied breeding in school and one of the farmers took advice from the inseminator. Two farmers stated that they did not know anything about breeding. When the farmers were asked to grade their knowledge about breeding on a scale from 1- 5, where 1 was little and 5 was a lot, they graded as following ; 76.2 % graded 2, 19 % graded 3 and 4.8 % graded 4. The two farmers who stated that they did not know anything about breeding still graded themselves as 2, and the farmer who studied breeding in school was the one grading 4. All of the farmers wanted to learn more about breeding and especially how to breed for certain traits. The most commonly mentioned traits were; size, growth and weight. 19% of the farmers wanted to know more about genetics, 14.3 % wanted to know how to implement breeding strategies and one farmer wanted to know how to keep records of the animals.

All of the participating farmers thought it was fun and good to exchange knowledge between countries and hoped it would be beneficial for them and the animals. All of them would like to take part in future studies.

Appendix 7. Results from ANOVA

Table 15 Summary of ANOVA comparisons of males

ANOVA Males				
Measurement	**t-value**	**df**	**Mean difference**	**Significance**
BL				
location;				
Java and Lombok	0.49	35	9.80	ns
origin;				
Bali and NTB	0.72	42	14.80	ns
HW				
location;				
Java and Lombok	0.34	35	6.80	
origin;				
Bali and NTB	0.45	42	9.13	ns
CG				
location;				
Java and Lombok	0.63	35	12.50	
origin;				
Bali and NTB	1.08	42	22.00	ns
BW				
location;				
Java and Lombok	4.76	35	95.10	***
origin;				
Bali and NTB	6.32	42	129.00	****
PH				
location;				
Java and Lombok	0.25	35	4.90	
origin;				
Bali and NTB	0.30	42	6.07	ns
PW				
location;				
Java and Lombok	0.08	35	1.60	
origin;				
Bali and NTB	0.34	42	6.93	ns
HL				
location;				
Java and Lombok	0.10	35	-1.90	
origin;				
Bali and NTB	0.15	42	-3.07	ns

df=degrees of freedom. Significance: *= p <0.05, **= p<0.01, ***= p<0.001, ****= p<0.0001
ns= not significant

Table 16 Summary of ANOVA comparisons of all females

ANOVA Females				
Measurement	**t-value**	**df**	**Mean difference**	**Significance**
BL				
location;				
Lombok and Sumatra	0.48	301	1.92	ns
Lombok and Kalimantan	1.99	460	7.50	ns
Kalimantan and Sumatra	1.11	383	-5.57	ns
origin;				
Sumatra and NTB	0.56	579	2.49	ns
Lombok and NTB	1.99	460	7.50	ns
HW				
location;				
Lombok and Sumatra	0.80	301	3.20	ns
Lombok and Kalimantan	0.51	460	1.91	ns
Kalimantan and Sumatra	0.26	383	1.29	ns
origin;				
Sumatra and NTB	0.47	579	-2.07	ns
Lombok and NTB	0.51	460	1.91	ns
CG				
location;				
Lombok and Sumatra	2.30	301	9.20	ns
Lombok and Kalimantan	1.26	460	4.79	ns
Kalimantan and Sumatra	0.88	383	4.41	ns
origin;				
Sumatra and NTB	1.45	579	-6.41	ns
Lombok and NTB	1.26	460	4.79	ns
BW				
location;				
Lombok and Sumatra	11.39	301	45.59	*
Lombok and Kalimantan	5.98	460	22.64	****
Kalimantan and Sumatra	4.56	383	22.95	****
origin;				
Sumatra and NTB	7.33	579	-32.41	****
Lombok and NTB	5.98	460	22.64	****

PH				
location;				
Lombok and Sumatra	0.31	301	1.24	ns
Lombok and Kalimantan	0.37	460	1.40	ns
Kalimantan and Sumatra	0.03	383	-0.17	ns
origin;				
Sumatra and NTB	0.09	579	-0.41	ns
Lombok and NTB	0.37	460	1.40	ns
PW				
location;				
Lombok and Sumatra	0.19	301	0.76	ns
Lombok and Kalimantan	3.58	460	13.49	**
Kalimantan and Sumatra	2.54	383	-12.73	ns
origin;				
Sumatra and NTB	1.63	579	7.18	ns
Lombok and NTB	3.58	460	13.49	**
HL				
location;				
Lombok and Sumatra	0.28	301	1.13	ns
Lombok and Kalimantan	4.08	460	-15.38	***
Kalimantan and Sumatra	3.29	383	16.51	**
origin;				
Sumatra and NTB	2.31	579	-10.18	ns
Lombok and NTB	4.08	460	-15.38	***

df=degrees of freedom. Significance: *= p <0.05, **= p<0.01, ***= p<0.001, ****= p<0.0001
ns= not significant

Tabel 1 Summary of ANOVA results of comparisons of males in the present study and previous study by Lindell (2013)

ANOVA results comparing male cattle				
Measurement	**t-value**	**df**	**Mean difference**	**Significance**
BL				
All males present study and all males in previous	0.62	336	10.63	ns
Males origin NTB, Present and previous study	1.06	108	9.29	ns
Males origin Bali, Present and previous study	0.63	161	9.85	ns
HW				
All males present study and all males in previous	0.10	336	1.71	ns
Males origin NTB, Present and previous study	0.45	108	3.90	ns

Males origin Bali, Present and previous study	0.18	161	-2.85	ns
CG				
All males present study and all males in previous	0.19	336	3.27	ns
Males origin NTB, Present and previous study	0.45	108	3.94	ns
Males origin Bali, Present and previous study	0.30	161	-4.65	ns
BW				
All males present study and all males in previous	2.53	336	43.64	ns
Males origin NTB, Present and previous study	13.09	108	114.70	****
Males origin Bali, Present and previous study	3.11	161	-48.65	*
PW				
All males present study and all males in previous	0.60	336	10.26	ns
Males origin NTB, Present and previous study	0.69	108	6.02	ns
Males origin Bali, Present and previous study	0.78	161	12.25	ns
HL				
All males present study and all males in previous	0.00	336	0.08	ns
Males origin NTB, Present and previous study	0.24	108	2.14	ns
Males origin Bali, Present and previous study	0.12	161	-1.80	ns

df=degrees of freedom. Significance: *= p <0.05, **= p<0.01, ***= p<0.001, ****= p<0.0001
ns= not significant

Table 17 Summary of ANOVA results from comparisons of female cattle- in the present study and the previous study by Lindell (2013)

ANOVA results comparing female cattle , compiled dataset (Lindell, 2013)				
Measurement	**t-value**	**df**	**Mean difference**	**Significance**
BL				
All females in present study and all females in previous	1.31	795	-4.94	ns
Females located on Sumatra, present and previous study	0.26	186	1.46	ns
Females located on Kalimantan, present and previous study	1.32	359	-9.83	ns
Females located on Lombok, present and previous study	0.57	228	-4.51	ns
HW				
All females in present study and all females in previous	0.57	795	-2.16	ns
Females located on Sumatra, present and previous study	0.37	186	-2.05	ns
Females located on Kalimantan, present and previous study	0.31	359	-2.31	ns
Females located on Lombok, present and previous study	0.42	228	-3.37	ns

CG				
All females in present study and all females in previous	0.28	795	-1.06	ns
Females located on Sumatra, present and previous study	0.12	186	-0.66	ns
Females located on Kalimantan, present and previous study	0.56	359	-4.13	ns
Females located on Lombok, present and previous study	0.31	228	2.45	ns
BW				
All females in present study and all females in previous	1.23	795	-4.68	ns
Females located on Sumatra, present and previous study	0.55	186	-3.03	ns
Females located on Kalimantan, present and previous study	2.22	359	-16.48	ns
Females located on Lombok, present and previous study	1.55	228	12.33	ns
PW				
All females in present study and all females in previous	0.63	795	2.39	ns
Females located on Sumatra, present and previous study	1.67	186	9.27	ns
Females located on Kalimantan, present and previous study	0.59	359	-4.45	ns
Females located on Lombok, present and previous study	0.90	228	7.13	ns
HL				
All females in present study and all females in previous	1.55	795	5.88	ns
Females located on Sumatra, present and previous study	0.10	186	0.56	ns
Females located on Kalimantan, present and previous study	1.89	359	14.03	ns
Females located on Lombok, present and previous study	0.57	228	-4.50	ns

df=degrees of freedom. Significance: *= p <0.05, **= p<0.01, ***= p<0.001, ****= p<0.0001
ns= not significant

Table 2 Summary of ANOVA comparisons of standard colored and white spotted individuals, dataset compiled with the previous study by Lindell (2013)

ANOVA standard colored and white spotted, compiled dataset (Lindell, 2013)				
Measurement	**t-value**	**df**	**Mean difference**	**Significance**
BL				
Standard females and white spotted females	0.37	983	2.78	ns
Standard and white spotted	0.54	1277	5.27	ns
HW				
Standard females and white spotted females	0.77	983	5.79	ns
Standard and white spotted	0.64	1277	6.25	ns
CG				
Standard females and white spotted females	0.94	983	7.10	ns
Standard and white spotted	0.92	1277	9.02	ns
BW				
Standard females and white spotted females	4.72	983	35.44	****
Standard and white spotted	5.23	1277	51.41	****
PW				
Standard females and white spotted females	0.32	983	2.38	ns
Standard and white spotted	0.20	1277	1.97	ns
HL				
Standard females and white spotted females	0.20	983	1.51	ns
Standard and white spotted	0.11	1277	1.08	ns

df=degrees of freedom. Significance: *= p <0.05, **= p<0.01, ***= p<0.001, ****= p<0.0001
ns= not significant

Appendix 8. Descriptions of phenotypic recordings

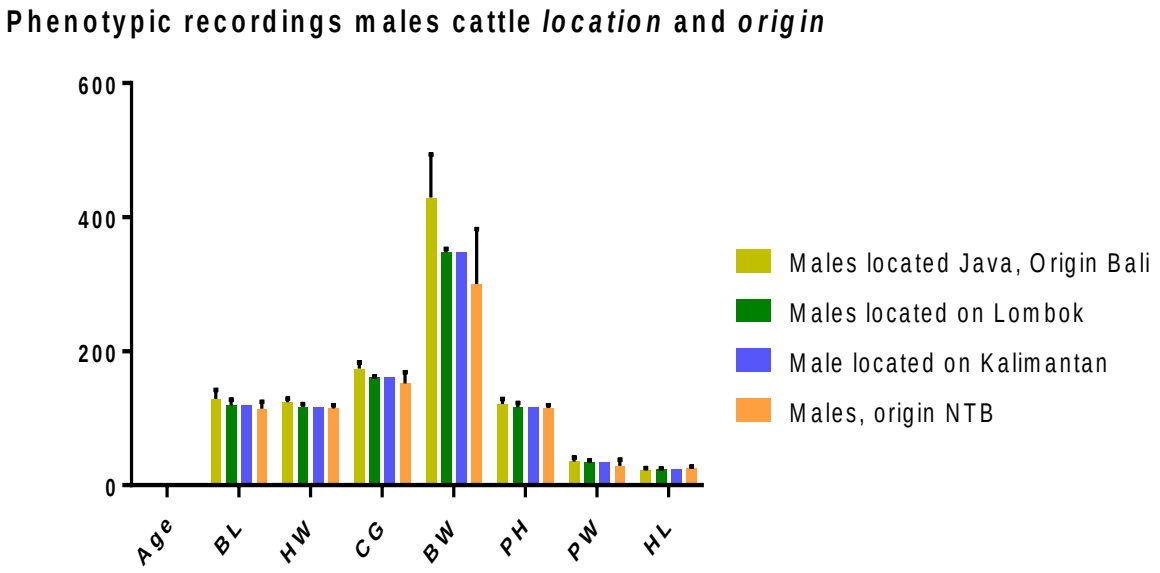


Figure 6 recordings of male cattle origin and location

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PH= Pelvic height, PW=Pelvic width, HL=Horn length

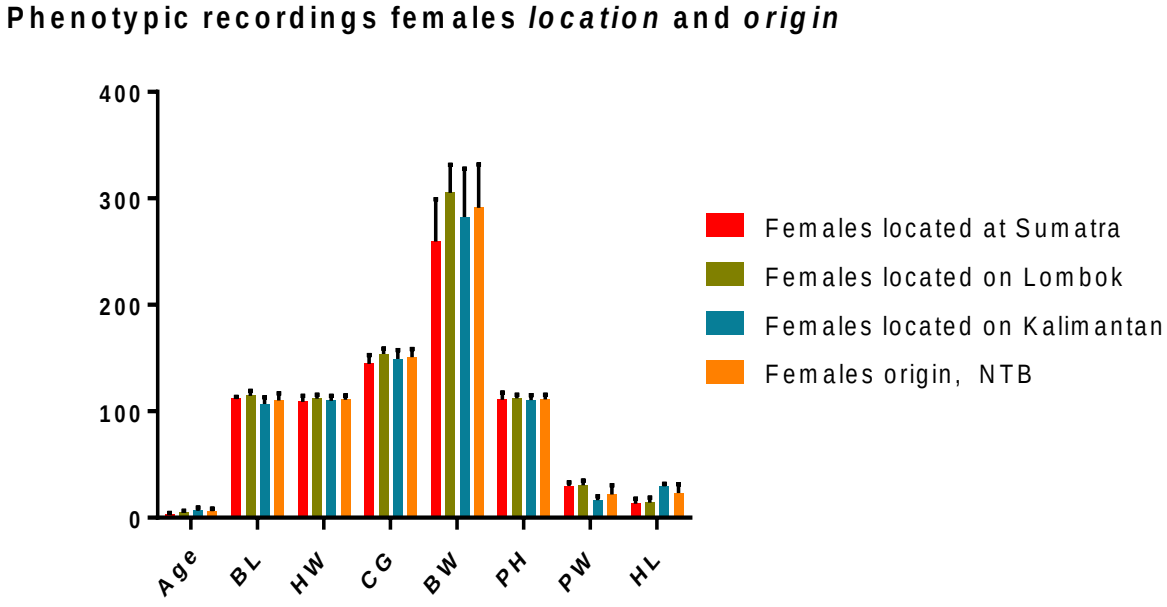


Figure 7 Description of phenotypic recordings of standard colored- and white spotted females compiled dataset with Lindell (2013)

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PH= Pelvic height, PW=Pelvic width, HL=Horn length

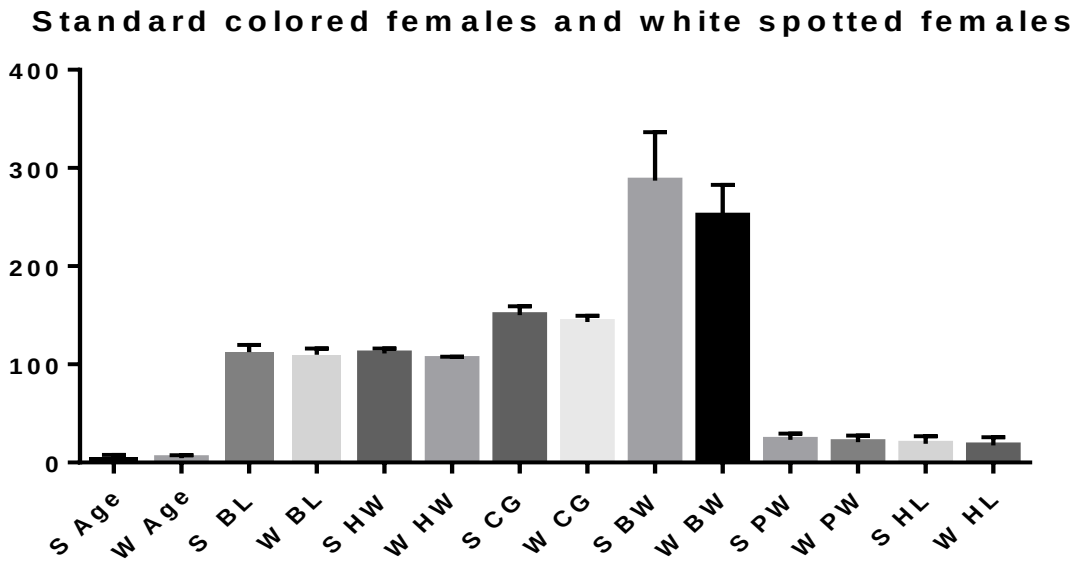


Figure 8 Description of standards colored females compared to white spotted females, compiled dataset with Lindell (2013)

BL=Body length, HW=Height at whiters, CG=Chest girth, BW=Body Weight, PW= Pelvic width, HL=Horn length