STRATEGIES TO IMPROVE BALI CATTLE IN EASTERN INDONESIA

ACIAR PROCEEDINGS No. 110

STRATEGIES TO IMPROVE BALI CATTLE IN EASTERN INDONESIA

ACIAR

110

ACIAR
The Australian Centre for International Agricultural Research

www.aciar.gov.au

Strategies to Improve Bali Cattle in Eastern Indonesia

Proceedings of a Workshop 4–7 Februrary 2002, Bali, Indonesia

Editors: K. Entwistle and D.R. Lindsay

Australian Centre for International Agricultural Research
Canberra, 2003

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has a special research competence.

Where trade names are used this constitutes neither endorsement of nor discrimination against any product by the Centre.

ACIAR PROCEEDINGS

This series of publications includes the full proceedings of research workshops or symposia organised or supported by ACIAR. Numbers in this series are distributed internationally to selected individuals and scientific institutions.

Entwistle, K. & Lindsay, D.R. 2003.
Strategies to Improve Bali Cattle in Eastern Indonesia.
Proceedings of workshop 4–7 February 2002, Bali, Indonesia.
ACIAR Proceedings No. 110, 100 pp.

ISBN 1 86320 366 4 Printed
1 86320 367 2 Electronic

Editorial management: P.W. Lynch
Production editor: Robert Byrnes
Typesetting and layout: Sun Photoset Pty Ltd, Brisbane, Australia
Printed by: Watson Ferguson & Co., Brisbane, Australia

Contents

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Foreword

The demand for beef in Indonesia continues to grow in response to increases in population and income. Satisfying this demand has been achieved by government-sponsored expansion of the beef sector in some regions, importation of ‘boxed’ beef and live cattle, and increases in the off-take rate from established cattle populations. Such off-take from the Bali cattle herd in the Eastern Islands has led to speculation of a decline in numbers and loss of genetic merit of this important breed.

Against this background ACIAR and CRIAS supported a project to provide a sound basis for government initiatives that support the Bali cattle herd and the farmers who own and manage these cattle. The project considered the status of past and current breeding strategies and herd improvement programs, whether some of the concerns about the herd size and quality are warranted, what breeding strategies would be best suited to the Eastern Islands, and what traits would be given highest priority in a breeding program. The project culminated in a workshop that brought together Indonesian and Australian expertise on Bali cattle production and herd improvement.

These proceedings report input to that workshop and recommended strategies for the future development of the Bali cattle herd in eastern Indonesia.

The issues discussed and conclusions drawn include:

- The two surveys of the Bali cattle herd size in eastern Indonesia taken 25 years apart do not provide a good platform for speculation on herd dynamics.
- Artificial insemination programs have had a negative impact on herd fertility in many situations.
- There are no data to support the speculation that the genetic potential for growth of Bali cattle has declined.
- Large pyramid breeding programs have had little or no impact on the general Bali cattle herd and were not recommended in future.
- Growth rate was considered to be the highest priority for selection, but there are concerns about possible effects on the mature size of females.
- Controlled mating programs at the village level and the establishment of national/regional recording schemes are prerequisites for an appropriate herd improvement program in eastern Indonesia.

W.H. Winter
Research Program Manager
ACIAR

Introduction and Opening Address

Dr Djoko Budianto, Director General of AARD[1]; Distinguished guests and participants in the workshop

Due to the increasing demand for beef in recent years, beef cattle are considered a strategic commodity in developing the livestock sub-sector. Unfortunately, national production of beef has never met the demand. Therefore, an effort with the goals of increasing production and productivity of beef cattle through the optimal use of local resources is strongly needed.

Improved cattle production could be achieved by maintaining and increasing the population as well as improving cattle performance, primarily through nutrition, reproduction, health and genetic aspects.

Bali cattle have dominated the cattle population outside of Java, primarily in Eastern Indonesia. The majority of cattle are maintained extensively and traditionally, but farmers do not give enough primary attention to feed supply, either quantitatively or qualitatively. Therefore, the performance of Bali cattle is considered to be decreasing. However, Bali cattle are fertile, and give birth each year constantly over a long time.

Due to high demand and provincial regulation of the trade and of livestock distribution, heavy Bali cattle have moved off the farm very quickly. This has tended to cause a negative selection. At the same time, the availability and regular use of the same bulls may cause inbreeding.

The effort to increase productivity of Bali cattle in some areas made use of crossbreeding with exotic breeds. However, this effort was apparently not followed by management improvements. Moreover, it may have negative impacts due to genotype–environmental interactions. Beef cattle that have superior genetic composition but do not get enough feed may not survive. On the other hand, Bali cattle with small body size have resistance to high environmental stress. The Bali cattle crosses using AI and raised extensively appear to have been very unsuccessful, due to difficulties in the application of AI technology.

Based on market information in Jakarta, Bali cattle from Bali command a higher price per kilogram live body weight than other local or imported breeds. This indicates that Bali cattle have good genetic potential and benefit from consumer preferences because of higher carcass percentage and meat quality in line with market needs. However they need to be maintained under good feed management systems.

Therefore, there is a need to define real problems, determine facts, and try to find appropriate solutions. In reality, genetic and management problems need to be restructured, but which one is more important in terms of priority? Improvement must be sought by using appropriate innovative technology that can readily be applied and that is socially acceptable, economically feasible and environmentally friendly.

Breeding strategies to produce feeder cattle must be developed in order to reduce inbreeding and negative selection. AI activities need to be assessed and re-evaluated in terms of both the crossing program and the technology. Therefore, the breeding program must be directed to making use of the genetic potential of Bali cattle, primarily its adaptation and its fertility as well as its ability to produce good carcass quality.

Raising beef cattle for breeding purposes to produce feeder cattle may not be profitable in partial budget analysis. However, if the raising of animals could be integrated with other agricultural production systems, it might have good synergism. It is also hoped that the Crop–Livestock System (CLS) can ease management problems, primarily by improving the supply of good quality feed. Raising of cattle by a group of farmers such as in West Nusa Tenggara

[1] Agency for Agricultural Research and Development, JI. Ragunan 29, Pasar Minggu, Jakarta

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

was considered the starting point for increasing CLS rice-based cattle production.

It is hoped that this workshop will produce recommendations and solutions to the problems of developing the Bali Cattle Program. The solutions may be locally specific, but some strategic solutions offered could be announced as a national policy. Therefore, the topics discussed could be involved equally with technical, economic and social aspects.

CRIAS[1] is genuinely concerned to acquire accurate information about Bali cattle production and its constraints nationally. Research and development plans of Bali cattle should anticipate activities for many years ahead. The experience and mistakes of the past should become an asset serving to redirect future strategy. There is a need for cooperation between national and international institutions to come up with solutions for these complex problems.

In the future, we hope that ACIAR or other international donor agencies may help stimulate the development of beef cattle industries in Indonesia, primarily in using the genetic potential of Bali cattle in the Eastern Islands. Feedlot industries, which developed in Indonesia several years ago, need a constant supply of feeder cattle of good quality and quantity. This is the chance to develop Bali cattle in order to increase national production by raising productivity and efficiency.

Thank you for your kind attention, and I look forward to receiving conclusions and recommendations from this workshop.

Dr Kusuma Diwyanto
Central Research Institute for
Animal Sciences (CRIAS)

[1] Central Research Institute for Animal Sciences

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Survey of Population and Production Dynamics of Bali Cattle and Existing Breeding Programs in Indonesia

C. Talib[1], K. Entwistle[2], A. Siregar[1], S. Budiarti-Turner[3] and D. Lindsay[4]

Abstract

The paper provides information on the current status of Bali cattle in Indonesia gleaned from national and regional statistical records, and amalgamates them with research and subjective information from government and university officers and farming groups in the regions in which Bali cattle are run.

There are about 2.95 million Bali cattle in Indonesia or about 26% of the total cattle population, around 80% of them to be found in the Eastern Islands and South Sumatra. Numbers have declined in three of the last four years; this is believed to be a long-term trend, but the information and numbers vary widely from region to region. The annual calving rate is 52–67%, which is moderate, but calf mortality varies from 8 to 48%, which is very high. It is concluded that there are opportunities for reversing the decline in numbers of Bali cattle through encouraging husbandry practices that improve survival, reducing the slaughter of pregnant animals and improving the genetic base towards animals that grow and survive better than at present.

Introduction

BALI cattle (*Bos sondaicus*; *Bos javanicus*; *bos/Bibos banteng*) are one of the important beef cattle breeds contributing to the development of livestock industries in Indonesia, and are the most predominant genotype within the Eastern Islands and some provinces in western Indonesia. This well-adapted genotype forms the basis for many smallholder enterprises in the region, but in recent times there have been considerable pressures placed on the Bali cattle population because of high demands for slaughter animals: large numbers of productive females have been slaughtered, no effective selection has been applied in the basic population and there has been a probable decline in the genetic resources of the genotype because the best bulls and heifers are exported from the population, while high calf mortalities occur in some areas.

[1] Central Research Institute for Animal Science, Bogor
[2] Australian Centre for International Agricultural Research, c/o University of New England, Armidale
[3] Director General for Livestock Services, Jakarta
[4] Australian Centre for International Agricultural Research, c/o University of Western Australia, Perth

In contrast to many other more extensive tropical cattle production systems which rely on the production and adaptational traits of *Bos indicus* and their crossbreds, the Bali cattle industry is characterised by a smallholder farming system with a heavy dependence on the availability of natural feed resources and on the survival traits of the genotype, which is extremely important in the frequently harsh and low-input/low-output management system typical of the region.

Productivity of Bali cattle in Indonesia, Malaysia and Australia has been reviewed by a number of authors (Devendra et al. 1973; Kirby 1979; McCool 1992; Wirdahayati 1994; Talib 2002), and these details will not be discussed here other than in the context of the projects to be described. However work by Wirdahayati (1994) indicates that the genotype can be more productive than a *Bos indicus* genotype, the Ongole, under conditions of poor nutrition and low levels of management; and Talib (2001) showed that under good nutrition and management calf mortalities can be reduced.

Bali cattle have been widely distributed throughout the Eastern Islands of Indonesia outside Bali, to form three major foci in South Sulawesi and East and West Nusa Tenggara, and numbers there

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

now exceed those in Bali (Siregar et al. 1985). The distributed areas could be divided into two management type groups: those under pasture management and those under a cut and carry system. Outside of Indonesia, the breed is distributed in other areas of South East Asia and in northern Australia.

Demand for meat in Indonesia is growing at 6–8% per annum, with demand greatest in the densely populated and more urbanised areas of Java. Records over the past decade indicate that the size of the Bali cattle herd is declining in most areas of the Eastern Islands as export demand exceeds replacement rates. There is also a widespread view among many animal scientists that the genetic merit of the genotype may be declining as a consequence of regular and sustained disposal of larger bulls (genetic erosion). The average weight of these exported bulls is decreasing (Talib et al. 2001) and this, combined with an increasing number of exported females and fattened bulls (it is important to remember that exported bulls and females are usually the largest and best animals in the basic population), is putting increasing pressure on the development of Bali cattle. Thus both the size and quality of the genetic pool may be decreasing.

In some areas the shortage of mature bulls also appears to be an impediment to herd improvement (Wirdahayati and Bamualim 1990; Siregar et al. 2001), and while AI is promoted widely and used extensively in some areas (Talib et al. 2000) success levels appear variable, depending upon local husbandry practices and environmental conditions.

Bali Cattle

Bali cattle (variously named *Bos sondaicus*, *Bos javanicus*, *Bos/Bibos banteng*) belong to the family *Bovidae*, the most common being the domestic animals *Bos taurus*, *Bos indicus* and Bubaline groups. In some countries other breeds of bovids are also used by local farmers, including *Bos bison* in the United States and *Bos grunniens* in Tibet. The diploid chromosome number of bovids varies between 30 and 60 but the fundamental number varies only from 58 to 62. *Bos taurus* has the same diploid number (60) as *Bos indicus* and *Bos sondaicus*, and they can therefore hybridise with each other. Karyotype studies show that the Y male-sex chromosome of *Bos sondaicus* is apparently identical to that of *Bos taurus*, but not to that of *Bos indicus* (Kirby 1979). Kikkawa et al. (1995) state that *Bos taurus* and *Bos indicus* had a common ancestor more than three million years ago (*Bos primigenius* — Aurochs), and that both groups diverged more than one million years ago prior to domestication. These authors used restriction fragment length polymorphisms (RFLPs) of mitochondrial DNA (mtDNA), and the sequences of mitochondrial genes for cytochrome b confirmed that *Bos sondaicus* (Bali cattle) had a different ancestor from that of European and Zebu cattle.

Bali cattle are well adapted to the tropics and are indigenous to South East Asia. Their morphological characteristics differ markedly from those of *Bos taurus* and *Bos indicus* (Kikkawa et al. 1995). Their hair colour is very distinctive, usually reddish-brown, except for a clearly defined white area on the hindquarters that extends along the belly, and also white socks reaching from the hooves to just above the hocks. There is a well-defined narrow band of black hair running along the back from behind the shoulder to the tail. In bulls, but not in females, the red hair over the whole of the body begins to darken at 12–18 months of age and by maturity is almost black, the band of black hair on the back still being visible. In castrated bulls, black hair on the whole body changes to red again within a few months of castration. These are humpless cattle, the body being relatively large framed and well muscled, with good hindquarters.

Pulungan and Ma'sum (1978) have shown that male F1-generation crossbreds between *Bos sondaicus* and *Bos taurus* are infertile. Kirby (1979) reported that all F1 ¼ Bali and ¾ Bali bulls resulting from crossbreeding with Brahman/Shorthorn cattle were infertile, although some semen was present in ¼ Bali bulls. All the crossbred females were fertile.

Objectives

The objectives of the project from which this report arises are to develop appropriate options for the genetic improvement of the Bali cattle herd in the Eastern Islands of Indonesia. This project is one of the research activities of the Australian Centre for International Agricultural Research (ACIAR) in Indonesia in collaboration with scientists from the Central Research Institution for Animal Science, Bogor, and the Director General for Livestock Services, Jakarta.

Materials and Methods

Data collection was conducted from June 2001, when the Indonesian and Australian team visited East Nusa Tenggara (NTT), West Nusa Tenggara (NTB), Bali and South Sulawesi in the Eastern Islands and Lampung in South Sumatra to gather information on population dynamics and production data of Bali cattle under several different management regimes.

There are areas in the Eastern Islands that have some Bali cattle breeding herds in the Bali cattle breeding institutes. NTT and NTB have Bali cattle breeding offices (Lily and Sarading), while Lampung, South Sulawesi and Bali have special projects for Bali cattle breeding called P3Bali. In fact only one institute, P3Bali in Bali, has any real selection activity; in this paper the evaluation of existing breeding programs will be focused on that institute.

National population data are from statistical information on Indonesian livestock published by the National Statistic Institute and the Directorate General of Livestock Services. Regional population data come from animal services offices in every region, as a result of calculating the total population of Bali cattle in the region between 1998 and 2001. Productivity data collection for the project began in May 2001 and has involved an exhaustive review of published information on the genotype, which was followed by a detailed survey at project and provincial level undertaken by the team from late June 2001. The team met with a wide range of research and extension groups at provincial and national levels, with staff at universities in NTT, NTB, Bali and South Sulawesi, and with farmers at a number of localities.

Results

Population dynamics of Bali cattle

The Indonesian beef cattle population was 11m and 11.2m head in 2000 and 2001 respectively. The percentage of Bali cattle in this total decreased slightly from 26.9% to 26.5% in 2001 (Ditjenak 2001). Dynamics of Bali cattle population are summarised in Table 1.

Reasons for the population decline in Bali cattle are many and varied, and have been discussed in a number of previous reports. However, data for 2000 on slaughter rates, numbers exported, mortality rates, and calculated calving numbers, summarised in Table 2, provides partial explanations for this shift in population size.

Between 1998 and 2000 Bali cattle numbers declined by 3.2%, but this decline slowed to –1.5% in 2001. There were wide variations in population declines between provinces: the greatest were in NTT and Lampung (between –22 and –25%), and these were significant declines (around 9%) in NTB and South Sulawesi.

Table 1. Population dynamics of Bali cattle, 1998–2001.

Location	1998	1999	2000	2001*	Change (%)
NTT	633 704	633 451	442 940	472 626	–25.4
NTB	429 847	374 970	376 526	392 090	–8.8
Bali	524 615	526 013	529 064	533 042	1.6
S. Sulawesi	823 245	749 392	718 139	751 277	–8.7
Lampung	331 502	278 360	254 823	256 312	–22.6
Sub-total	2 742 913	2 562 181	2 332 330	2 405 347	–12.3
% of total	91.03	78.64	79.96	81.11	10.1
Total Indonesia	3 013 174	3 257 993	2 916 944	2 965 610	–1.5

* Preliminary figure to May

Table 2. Bali cattle: information by province for 2000 on bulls, cows, slaughter, export and mortality, together with estimated calving of the herd. (Numbers in parentheses are percentages of total Indonesian cattle population.)

Province	Bulls	Cows	Slaughterings and export	Mortalities	Calving numbers (estimated)*
NTT	11 077	224 025	78 283	71 567	149 089
NTB	39 050	153 197	72 550	11 878	79 183
Bali	71 940	184 572	66 475	10 347	122 322
South Sulawesi	39 789	337 051	99 459	16 294	203 680
Lampung	19 554	165 084	178 836	5 163	73 740
Total	253 342 (10.9)	1 032 079 (44.3)	495 603 (21.3)	115 294 (4.9)	628 014 (26.9)

* Calving rate of population extrapolated from research data and from female Bali cattle population statistics. Data are estimates only and should be viewed with some caution.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

It seems that local governments have applied some strategies to slow the continuing population decline that occurred from 1998 to 2000, resulting in some improvement in 2001. If the progress in that year continues it will be good for future Bali cattle development, but if not, in the next decade the low herd size will be of even greater concern. Such a situation would seriously affect Indonesian beef production capacity, the economic wellbeing of many Indonesian smallholders (679 990 households rely on Bali cattle as an income source), and constrain opportunities for improvement of this genotype. It is predicted that if the Indonesian economic crisis is overcome and beef consumption increases by 1 kg/cap./year, an additional one million head of cattle will be needed. Therefore local government should create appropriate and applicable strategies to increase the number and the quality of Bali cattle.

Some local governments have recognised the significance of the declining Bali cattle population and created strategies to stem the decline. For example, the NTT government decided to ban export of the best bulls and heifers and now permits disposal of only lower quality and culled animals. It will also buy productive females from slaughter houses and redistribute them to smallholders under a contract system. Management and nutrition of Bali cattle are also being improved through increasing the role of extension workers.

Combined slaughter and export rates ranged from 13% to 64% of the total population in 2000, the higher figure being from Lampung. So far the project team has not been able to analyse in any detail the reasons for this high figure. However, the close proximity of the province to high-density populations in western Javan, where demand for beef is increasing and where major meat processing plants are located, may be an explanation.

On the basis of the data in Table 2 it can be calculated that, at least for 2000, some 21% of the total Bali cattle population was either slaughtered or exported (for grow-out, for breeding or for slaughter). Mortalities accounted for further overall declines in numbers of almost 5%. Mortality rates were especially high in NTT (16%); in other provinces they ranged from 2% to 3%.

The combination of slaughterings, exports and mortalities accounted for a total population off-take of almost 26%. Some of this off-take probably represents the export of breeding animals. Nevertheless the overall rate is extremely high compared with standards in developed country cattle industries. Such rates are unlikely to be sustainable in the short to medium term without serious damage to the national economy, to the Indonesian cattle industry and to the wellbeing of individual smallholders.

Some caution is needed in interpreting the estimated calving numbers and the ratio between number of bulls and cows, as shown in Table 2. These are extrapolated data from research results on reproductive performance, calculated from small numbers of animals, and then calculated for each province from estimated cow numbers. Hence they probably have a large error variance, and their use for comparative purposes needs to be approached cautiously. Another point that has to be highlighted is that even though the cow:bull ratio is good, almost all the best bulls are housed as fattening cattle for export and never used for breeding. The bulls for breeding are therefore young bulls of small size, which in the long term will influence the productivity of the herds.

When slaughterings were dissected by gender the ratio of cow to bull slaughter rates ranged from 3:1 to 20:1, with an average of about 4:1. Depending on the proportion of productive (reproductively active/pregnant) cows being sent to slaughter, the effects of such a ratio on future population dynamics may vary.

In fact only limited data are available on the proportion of productive cows slaughtered. These slaughterings represent potential losses in terms of offspring for replacement or later slaughter. For NTT, NTB, Bali and South Sulawesi, the data indicate that such animals represent 30%, 15%, 69% and 35% respectively of all cow slaughterings. For all these provinces the mean figure is 34% — i.e. one-third of all cows slaughtered were reproductively active. If these data are extrapolated to the entire Bali cattle population in Indonesia, of which approximately 44% are cows, the potential for increasing herd reproductive performance and changing herd dynamic patterns by limiting the slaughter of pregnant females becomes apparent.

In summary, the population dynamics data presented here confirm a significant and serious decline in Bali cattle numbers. Should these trends be allowed to continue a number of adverse impacts, discussed above, will occur. These will have unfortunate national consequences. A range of options. both genetic and non-genetic, need to be developed to counter these adverse trends and to enable smallholders to continue to use and benefit from this well-adapted and valuable genotype.

Current productive performance

One of the key tasks of the current ACIAR–CRIAS project is the collation of available data on productive performance of Bali cattle in those provinces where they are the most important/dominant genotype. These data are essential as a prerequisite to the development of future strategies to improve the productivity of the Bali cattle herd.

Summarised data on weight traits in Bali cattle by province are presented in Table 3.

Some of the apparent variations between provinces in the data probably reflect the impact of variable environmental and management conditions, particularly nutrition, on performance levels. Mature cow weights are lower in NTT and South Sulawesi than in either Bali or NTB. When compared with other published estimates for weight traits (Table 4), the current data set is at about the mid-point of the range for mature cow weights of Bali cattle in Indonesia.

Data on reproductive performance traits and milk production in Bali cattle are summarised in Table 5. Again the estimates derived here are not dissimilar from those summarised by Wirdahayati (1994). The data highlight the fact that given the harsh conditions and generally poor nutritional regimes under which Bali cattle are run, reproductive performance is moderate (calving rates 50–67%). Previous studies in NTT and NTB (Wirdahayati 1994, Talib 2001) identified calving rates ranging from 63% to 78%.

In line with earlier reports, milk production was extremely low, and is no doubt a factor contributing to low calf growth rates and high calf mortalities. Calf mortality rates were a feature of the survey data and ranged from 8% to 48%, levels similar to those found in Timor (20–47%) by Wirdahayati and Bamualim (1990) and Talib (2001).

Current management and breeding strategies

While the vast majority of Bali cattle are naturally mated, AI has been used extensively in some areas, especially in 'cut and carry' systems, and offers the only short-term solution to the implementation of breeding strategies for genetic improvement. For

Table 3. Production performance of Bali cattle.

Province	Production traits (kg)				
	Birth weight	Weaning weight	Yearling weight	Puberty weight	Mature cow weight
NTT	11.9 ± 1.8	79.2 ± 18.2	100.3 ± 12.4	179.8 ± 14.8	221.5 ± 45.6
NTB	12.7 ± 0.7	83.9 ± 25.9	129.7 ± 15.1	182.6 ± 48.0	241.9 ± 28.5
Bali	16.8 ± 1.6	82.9 ± 8.2	127.5 ± 5.7	170.4 ± 17.4	303.3 ± 4.9
South Sulawesi	12.3 ± 0.9	64.4 ± 12.5	99.2 ± 10.4	225.2 ± 23.9	211.0 ± 18.4

Table 4. Published estimates for mature cow and bull weights for Bali cattle.

Location	Mature weights (kg)		Reference
	Cows	Bulls	
Malaysia	264	—	Devendra et al. 1973
Sulawesi, NTT, NTB	224–234	335–363	Astawa 1989
Bali	264	395	Pane 1990
NTT, Bali, Sulsel, Australia	180–306	—	Talib 2001
South Sulawesi	110–230	—	Siregar et al. 2001
NTT, NTB, Bali, Sulawesi	221–303	—	Current study
Australia	248	315	McCosker Eggington & Doyle 1984

Table 5. Reproductive performance and milk production data in Bali cattle.

Province	Age at puberty (years)	Calving age (months)	ICI* (months)	Calving rate (%)	Calf mortality (%)	Milk production (kg/6 months)
NTT	2.5	41	15.4 ± 2.0	66.6	48	164.7
NTB	2.0	36	16	51.7	15	(no data)
Bali	2.0	32	14	66.3	8.5	274.5
South Sulawesi	2.5	36	15.7 ± 1.8	60.4	8.0	164

* Inter-calving interval

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Bali cattle, because the only selection work appears to have been at P3Bali, production and distribution of frozen semen from proven bulls is very restricted, both in numbers of doses and area of distribution, which has prevented the spread of specific Bali cattle diseases that exist in Bali and may be contaminants in semen. Therefore the location of any future breeding institute should take into consideration disease issues as well. It would be advantageous if some provinces that have high Bali cattle populations could create a breeding institution or local station. These could then undertake performance testing to identify the best bulls and heifers that could be used for breeding purposes in breeding herds which have similar treatments, especially nutritional status. Together with this, standardising the performance records of Bali cattle and dividing the standard into some classes is important so that every breeding institute can know how good the cattle are.

Although there have been some Bali cattle breeding activities in Indonesia in the form of breeding institutes and projects such as Lili (NTT), Sarading (NTB), P3Bali, Bone (South Sulawesi) and in Pulukan (Bali) and Lampung, only P3Bali in Bali has applied selection programs to produce proven bulls. Even though this institute has existed since the 1970s, the effectiveness of selection and the use of proven bulls should be re-evaluated. Evaluation of the data from breeding centres and from the basic population suggests that breeding has not effectively improved the genetic quality of the herd in the 20 years from 1980 to 2000 because individual breeding values have not changed in that period (Talib et al., these proceedings).

AI has been applied in beef and dairy cattle development in Indonesia since the 1970s. It was planned at first to improve both dairy and beef cattle but AI is working well in only dairy cattle. In beef cattle almost all of the AI is directed at the production of commercial stocks and only a small amount is being used for purebred animals, including Bali cattle. The semen for AI in Bali cattle is produced at the AI Centre at Singosari, East Java and distributed throughout the Eastern Islands, but the genetic source of bulls used for producing it is unknown. This is an area that needs to be examined.

Data for 2001 indicate that 1 356 521 doses of frozen semen from nine breeds of cattle were produced and distributed, at Singorasi, including some 50 239 doses of Bali semen. About 30% of the beef cattle population and 30% of inseminators (857) are located in the Eastern Islands. The capability of one inseminator is only one cow per day inseminated and almost exclusively for cows in cut and carry systems. Assuming that all Bali semen produced is inseminated, along with predicted calving rates from AI of around 30%, about 15 000 calves would be produced yearly. If these calculations are correct, a specific evaluation is needed to examine the impact of subsequent slaughter of inseminated cows on genetic improvement, the environment and the welfare of the farmers.

Conclusions

1. Bali cattle are the predominant beef cattle in the Eastern Islands of Indonesia.
2. The declining population should be improved by applying strategies to reduce calf mortalities, decrease the slaughter of productive cows, and prepare and retain appropriate bulls in the herds.
3. No significant improvement in production and reproduction traits is likely in a randomly mated population such as exists at the moment.
4. The activities of breeding institutes and projects need to be reviewed to re-evaluate their location and operations for producing better Bali cattle in the future.
5. AI should use semen from proven bulls not only to produce commercial stock but to contribute to genetic improvement programs.

References

Devendra, C., Lee Kok Choo, T. and Phatmasingham, M. 1973. The productivity of Bali cattle in Malaysia. Malaysian Agricultural Journal, 49, 183.

Ditjenak. 2001. Indonesian Statistical Book on Livestock 2001. Directorat General of Livestock Services, Jakarta.

Kikkawa, Y., Amano, T. and Suzuki, H. 1995. Analysis of genetic diversity of domestic cattle in East and Southeast Asia in term of variations in restriction sites and sequences of mitochondrial DNA. Biotechnical Genetics, 33, 51.

Kirby, G.M.W. 1979. Bali cattle in Australia. World Review of Animal Production, 31, 24.

McCool, C. 1992. Buffalo and Bali cattle — exploiting their reproductive behaviour and physiology. Tropical Animal Health Production, 24, 165.

McCosker, T.J., Eggington, A.R. and Doyle, F.W. 1984. Observations on post-weaning performance of Braham cross animals in the Darwin district of the Northern Territory. Proc. Australian Society of Animal Production, 15, 452–455.

Pane, I. 1990. Improving the genetic quality of Bali cattle (Upaya Peningkatan Mutu Genetic Sapi Bali di P3Bali). Proceedings of Bali Cattle Meeting, 20–23 September 1990, Denpasar, A42.

Pulungan, H. and Ma’sum, K. 1978. Performance of Bali cattle and their crossbreed with Hereford and Shorthorn. Proceedings Seminar Ruminansia. Directorat of Animal Services and Bogor Agriculture University and Proyek Pengembangan Peternakan (P4). Bogor, 132.

Siregar, A.R., Talib, C., Diwyanto, K., Sitepu, P., Kusnadi, U., Prasetyo, H. and Sitorus, P. 1985. Performance of Bali cattle at East Nusa Tenggara (Performance sapi Bali di Nusa Tenggara Timur). Dirjennak and Balitnak. Jakarta.

Siregar, A.R., Talib, C., Sariubang, M., Purba, ?? and Priadi, I. 2001. Increasing survival and growth rates of Bali calves through breeding system. Proceedings of Ruminant Meeting, University of Diponegoro, 192.

Talib, C. 2002. Productivity and reproductivity of Bali cattle. PhD thesis, University of New England, Australia.

Talib, C., Siregar, A.R., Kuswandi and Haryanto, B. 2001. The influence of feed improvement and CIDR application on dynamic of ovarium activity in postpartum period of Bali cows. Proceedings Hasil Penelitian Rekayasa Teknologi Peternakan/ARM-II, CRIAS, Puslitbangnal, 231.

Wirdahayati, R.B. 1994. Reproductivity of Bali cattle in Nusa Tenggara Islands — Indonesia. PhD thesis, University of Queensland, Australia.

Wirdahayati, R.B. and Bamualim, A. 1990. Production, performance and population structure of Bali cattle in Timor, East Nusa Tenggara (Penampilan produksi dan struktur populasi ternak sapi Bali di Pulau Timor, Nusa Tenggara Timur). Proceedings of Bali Cattle Meeting, 20–23 September 1990, Denpasar, C1.

Feeding Strategies to Improve the Production Performance and Meat Quality of Bali Cattle (*Bos sondaicus*)

I. Made Mastika[1]

Abstract

A range of high quality rations was fed to Bali cattle in two experiments to test the hypothesis that perceived degeneration of genetic capacity of these animals may be due to poor nutritional management. On a diet supplemented with 4 kg of high quality concentrate, animals gained up to 850 g per day compared with control animals that grew at 526 g/day on a traditional rice-bran supplement. Their feed conversion was also significantly better (6.42 vs. 9.59). In addition, in a taste panel test, the meat from the faster-growing animals achieved preference scores as high as those for imported meat and much higher than those for poorer fed, slower-growing animals. It was concluded that Bali cattle can grow well and produce good quality meat if their nutrition is managed adequately.

Introduction

WITHIN Indonesia, Bali cattle (*Bos sondaicus*) have been reported to be superior to other breeds in fertility and conception rate (Oka and Darmadja 1996) and adaption to harsh environments, and to be highly efficient in utilising low quality feed (Darmadja 1980; Darmadja and Oka 1980; Martojo 1995). However, until recently a lot of national attention has been paid to the perceived weaknesses of Bali cattle, such as slow growth rate and small body size (Sonjaya and Idris 1996), high calf mortality due to low milk production (Wirdahayati and Bamualin 1990), and poor quality or tough meat (Arka 1996). Some scientists have also proposed that this breed should be replaced or crossed with exotic breeds with faster growth rates and a higher target body size.

These workers concluded that the weaknesses of Bali cattle were genetically based. However, these opinions and suggestions come mostly from the eastern parts of Indonesia where feeding conditions, management and farmers' skills are very different from those on Bali, the original home of Bali cattle. In this island, the problems cited are not apparent and, in fact, every year a contest carried out by the Department of Animal Husbandry shows that the heaviest Bali bulls are between 800 and 850 kg. These contradictions suggest that the supposed weaknesses of Bali cattle are in fact not due to genetic factors but related to environmental, nutritional and management factors. There has undoubtedly been a decrease in the mature size of Bali cattle in other areas of Indonesia, perhaps due to negative selection for growth and size, but while this may have a genetic component it is primarily a management issue.

To support these arguments two experiments were carried out, firstly to study the performance of Bali cattle when fed good quality feed, and secondly to examine the effects of combinations of feeding strategies such as the application of non-protein nitrogen (NPN), starbio, or legume and other leaves considered to contain anti-protozoal agents or to improve the ruminant ecosystem. Meat quality was also assessed in these experiments.

Materials and Methods

Young Bali cattle steers with an average body weight of 122 kg (experiment 1) and 150 kg (experiment 2) were used for the studies.

Two experiments were carried out in a feed-lot system to study the growth, feed conversion efficiency, performance and meat quality of Bali cattle fed high quality rations. Both experiments were run at Br. Siyut, Tulikup village of Gianyar Regency, Bali, the first for 112 days and the second for 120 days.

The first experiment used a complete randomised block design in which 25 young Bali cattle steers were divided into 5 groups, then fed:

[1] Department of Animal Nutrition, Faculty of Animal Husbandry, Udayana University, Denpasar, Bali, Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

- a control diet consisting of 70% elephant grass (*Pennisetum purpureum*) + 30% *Gliricidia* (treatment A); or
- 50% elephant grass + 30% *Gliricidia* + 20% *Hibiscus* leaves (Treatment B);
- 70% elephant grass + 15% *Gliricidia* + 15% urea molasses blocks (UMB) (treatment C); or
- 50% elephant grass + 20% *Gliricidia* + 15% *Hibiscus* leaves + 15% UMB (treatment D); or
- 40% elephant grass + 60% concentrate 20.74% Crude Protein (CP) and 77.3% Total Digestible Nutrients (TDN) (treatment E).

The second experiment, involving 12 Bali cattle steers, was a complete randomised factorial design consisting of two main and two sub-treatments. Each treatment consisted of three replicates with one steer each. The animals were randomly assigned and fed:

- elephant grass and 4 kg rice bran (13% CP and 75% TDN) (treatment RD); or
- similar to treatment RD, but with the rice bran supplemented by 0.5% starbio (treatment RDS); or
- elephant grass and 4 kg concentrate (18.34% CP and 72.5% TDN) (treatment RK); or
- similar to treatment RK but with the concentrate supplemented by 0.5% starbio (treatment RKS).

Feed and water were provided ad libitum. During both experiments, feed consumption was recorded daily and body weight was measured every second week. At the end of the experiment, the animals were slaughtered and measurements of carcass weight and of carcass components were carried out at the abattoir, where meat samples were taken. Subsequently, organoleptic tests of meat cuts were undertaken at the Bali Beach Hotel, Bali, for samples from the first experiment, and at the Bali Intercontinental Resort, Jimbaran, Bali for samples from the second experiment.

Results and Discussion

Results are summarised in Tables 1 and 2 for experiments 1 and 2 respectively.

In the first experiment, cattle fed 40% grass + 60% concentrate (treatment E) had significantly higher ($P<0.05$) body weight and body weight gains and feed conversion efficiencies that those on the four other diets. Overall, cattle fed the control diet had the smallest body weight gain and lowest feed conversion efficiency of any group. The total organoleptic acceptance score for samples from animals fed

Table 1. Experiment 1: Performance of Bali cattle fed concentrate on feedlotting system (112 days).

Treatment	Initial body weight (kg)	Final body weight (kg)	Weight gain (kg)	Daily weight gain (g)	Total feed consumption (kg dry matter)	Food conversion ratio	Meat quality score
A	122.1 ± 9.2	159.08^a ± 14.8	36.98	320^b	375.20	10.60^a	5.90^a
B	122.1 ± 8.9	165.83^a ± 12.3	43.73	390^b	456.96	11.01^a	7.05^b
C	122.1 ± 18.8	172.67^a ± 25.1	50.47	440^b	435.68	9.27^a	6.15^a
D	122.1 ± 7.39	172.3^a ± 2.7	50.23	450^b	502.88	10.14^a	7.80^c
E	122.1 ± 2.66	208.0^b ± 9.2	86.07	760^a	406.56	5.08^b	7.20^{bc}
Imported beef							7.20^{bc}

Values in the same column with different superscripts are significantly different ($P<0.05$). Treatment A: 70% grass + 30% *Gliricidia*; treatment B: 50% grass + 30% *Gliricidia* + 20% *Hibiscus*; treatment C: 70% + 15% *Gliricidia* + 15% UMB; treatment D: 50% grass + 20% *Gliricidia* + 15% *Hibiscus* + 15% UMB; Treatment E: 40% grass + 60% concentrate (20.74% CP, 77.3% TDN).

Table 2. Experiment 2: Performance of Bali cattle fed high quality concentrate of rice bran, with or without starbio supplement.

Treatment	Initial body weight (kg)	Final body weight (kg)	Weight gain (kg)	Daily weight gain (g)	Total feed consumption (kg DM)	FCR	Meat quality score
RD	152.7	215.81^a	63.13^a	526.08^a	605.99^a	9.59^a	5.87^a
RDS	151.3	218.71^a	67.66^a	563.83^a	587.37^a	8.68^a	6.16^b
RK	155.8	258.0^b	102.2^b	851.67^b	655.83^b	6.42^b	6.58^c
RKS	156.5	249.7^b	93.16^b	776.33^b	656.23^b	7.04^b	6.71^{bc}
Imported beef							7.39^c

Values in the same column with different superscripts are significantly different ($P<0.05$). Treatment RD: grass + 4 kg rice bran; treatment RDS: grass + 4 kg rice bran + 0.5% starbio; treatment RK: grass + 4 kg concentrate (18.34% CP, 72.5% TDN); treatment RKS: grass + 4 kg concentrate + 0.5% starbio.

treatment E was the same as that for imported meat and significantly higher (P<0.05) than for samples from animals on the control diet or on treatment C.

Results from the second experiment confirmed those of the first study. Steers fed elephant grass + concentrate, either with or without 0.5% starbio supplementation (treatments RK or RKS), had significantly heavier body weight and body weight gains (P<0.05), consumed significantly (P<0.05) more feed and had significantly better (P<0.05) feed conversion efficiencies than those fed elephant grass + rice bran with or without starbio supplementation (treatments RD or RDS).

Neither supplementation nor starbio significantly affected any of the measured parameters other than eye muscle area index, where starbio supplementation significantly (P<0.05) increased this parameter. Carcass weight, components of the carcass and percentage physical composition of the carcass were not significantly affected by treatments, although steers on treatment RK had a slightly higher carcass percentage and absolute carcass weight.

In this second experiment the total organoleptic acceptance score (colour, texture, flavour and taste) in meat samples from steers fed elephant grass + concentrate, either with or without starbio supplementation (treatments RK and RKS), was significantly higher (P<0.05) than in those fed elephant grass + rice bran with or without starbio (treatments RD or RDS). Starbio supplementation tended to improve meat quality scores but only minimally, and overall, total organoleptic scores for all treatments were marginally below those for imported meat.

Thus in these two experiments optimal performance and feed conversion efficiency of Bali steers were achieved with good quality concentrate-supplemented diets. The probiotic starbio had no effect on the parameters measured.

Thus the assumption that the growth rate of Bali cattle is low due to genetic factors is not completely true and is in need of further investigation. Evidence from this experiment is that feed quality is perhaps the most important factor in improving Bali cattle performance; management factors may also be involved. It is interesting to note that the meat quality scores of Bali cattle fed concentrate were similar to those of imported meat. Improvement in feed quality could thus also improve meat quality of Bali cattle. Another interesting point to note is that the supplementation of *Hibiscus* leaves significantly improved meat quality. However the mechanism for this is not yet understood. Is some unknown substance responsible? This is an area for further study.

The author has already emphasised (Mastika 1996, 1997) that the main problem of animal production in Indonesia in general, and in the eastern parts in particular, is insufficiency of both quality and quantity of available feed for the whole year. Also, the feeding systems for Bali cattle practised by farmers are influenced by socio-cultural factors as well as by the local environment. All these factors therefore are likely to have a profound effect on the performance of Bali cattle.

Growth, feed conversion efficiency and meat quality of Bali cattle could be enhanced by improving both feed quality and management. Growth rate examples taken from a variety of studies on feeding and management of Bali cattle are shown in Table 3.

Table 3. Summary of experiments into the growth and performance of Bali cattle.

Author	Experimental detail	Weight gain (g/head/day)
Moran (1976)	Bali cattle — feedlot: concentrate ad libitum	660
Musofie et al. (1982)	Bali cattle — feedlot: sugar cane tops + 0.45% *Leucaena* leaf DM	298
Aryawan (1989)	Bali cattle — feedlot: grass + 3 kg rice bran + 15 g starbio	543
Bamualin (1995)	Young Bali cattle — feedlot: 50% King grass + 37.5% *Sesbania* + 12.5% *putak*	510
Rika (1995)	Grazing — legume — Negara, Bali — male Bali cattle (175–200 kg): *Caliandra* pasture under coconut	108
Nitis (1996)	Bali cattle — feedlot: — very intensive (0.25 ha)	169.8
	— less intensive (0.5 ha)	151.6
Parwati et al. (1999)	Bali cattle (220–240 kg): grass + 2 kg rice bran	414
	grass + 2 kg rice bran + 5 cc bio plus	491
	grass + 2 kg rice bran + 20 g starbio	517
Mastika et al. (1996)	Bali cattle (steers) 120 kg — feedlot: 40% elephant grass + 60% concentrate (20.7% CP, 77% TDN)	760
Mastika et al. (2000)	Bali cattle (steers) 150 kg — feedlot: Elephant grass + 4 kg rice bran	526
Mastika (2001)	Elephant grass + 4 kg concentrate	851

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

References

Arka, I.B. 1996. Meat Quality and Marketing of Bali cattle. Proceedings of seminar on Bali cattle, a special species for dry tropics, held by Indonesia Australia Eastern University Project (IAEUP), 21 September 1996, Udayana University Lodge, Bukit Jimbaran, Bali.

Darmadja, D. and Oka, I.G.L. 1980. Bali cattle and its colour variation. Proceedings of 6th congress of Federation of Animal Veterinary Associations, 16–19 October 1980, Denpasar, Bali.

Darmadja, D. 1980. Setengah Abad Peternakan Sapi Bali Tradisional dalam Ekosistem Pertanian di Bali. Disertasi Doktor Universitas Padjajaran.

Leng, R.A. 1990. Factors affecting the utlization of 'poor quality' forage by ruminants particularly under tropical conditions. Nutrition Research Reviews, 3, 277–303.

Martojo, H. 1995. Penyebaran Sapi Bali pada Masa Lampau. Ruminansia, 4, IX.

Mastika, I.M. 1996. Constraints and nutrition system for Bali cattle in the tropics. Proceedings of seminar on Bali cattle, a special species for the dry tropics, held by Indonesia Australia Eastern University Project (IAEUP), 21 September 1996, Udayana University Lodge, Bukit Jimbaran, Bali.

Mastika, I.M., Mariani, N.P. and Suryani, N.N. 1996. Observation on feedlotting of Bali cattle. Proceedings of seminar on Bali cattle, a special species for the dry tropics, held by Indonesia Australia Eastern University Project (IAEUP), 21 September 1996, Udayana University Lodge, Bukit Jimbaran, Bali.

Mastika, I.M. 1997. Livestock production system in eastern part of Indonesia. Proceedings of seminar and workshop on livestock production systems in Eastern part of Indonesia, 15 December 1997, Faculty of Animal Husbandry, University of Udayana; organised by Indonesia Australia Eastern University Project (IAEUP).

Mastika, I.M., Oka, I.G.L. and Bhinawa, I.G.N. 2000. Peningkatan Mutu Daging Sapi Bali melalui Paket Teknologi Pakan Konsentrat. Laporan Hasil Penelitian kerjasama antara Fak. Peternakan UNUD, dengan Pemerintah Daerah Propinsi Bali. 1–39.

Mastika, I.M. 2001. Prospek Peternakan Sapi Bali Dalam Mendukung Pendapatan Asli Daerah. Makalah disampaikan pada. Seminar Nasional Peternakan Universitas Udayana Denpasar, Bali 5 s/d 8 Mei 2001, di Kampus UNUD J1. PB Sudirman, Denpasar.

Oka, I.G.L. and Darmadja, D. 1996. History and development of Bali cattle. Proceedings seminar on Bali cattle, a special species for the dry tropics, held by Indonesia Australia Eastern University Project (IAEUP), 21 September 1996, Udayana University Lodge, Bukit Jimbaran, Bali.

Sonjaya, H. and Idris, T. 1996. Kecenderungan perkembangan populasi sapi potong di Sulawesi Selatan. Forum Komunikasi Pimpinan Perguruan Tinggi Peternakan se Indonesia. 9–10 Agustus 1996, UNHAS Ujung Pandang.

Wirdahayati, R.B. and Bamualin, A. 1990. Penampilan produksi dan struktur populasi sapi Bali di Pulau Timor, Nusa Tenggara Timur. Proc. Seminar Nasional Sapi Bali. Fak. Peternakan UNUD.

Performance of Bali Cattle Heifers and Calves prior to Weaning in a Feedlot System

L. Oka[1]

Abstract

A study was carried out on the performance of 20 Bali cattle heifers and their first calves kept in a feedlot system and fed either elephant grass only (group A), or a mixture of 40% elephant grass and 60% concentrate with 20.7% Crude Protein (CP) and 77.3% Total Digestible Nutrients (TDN) (group B). Live weights to calving, quantity and quality of milk, calf birth weight and preweaning liveweight gain were significantly enhanced by concentrate supplementation. However, services per conception and gestation length were not significantly different between the two feeding regimes. In the short term, improvements in management — particularly feeding a higher quality ration — are needed to overcome the problems of performance degradation of Bali cattle which have been reported recently.

Introduction

UNTIL now farmers in Bali have kept their cattle in a traditional system, where animals are housed in a simple shed and fed with cut and carry roughages. As the human population in Bali is increasing, more and more green area is now being used for housing or other specific purposes. The development of tourism in Bali is also significantly reducing areas available for production of feed resources for cattle. Therefore, alternative animal management and feed supplementation strategies are needed for Bali cattle, in addition to genetic improvement strategies, in order to improve overall performance of these cattle, which has been reported to be decreasing (Sonjaya and Idris 1996; Lay 1997).

The effects of concentrate supplementation on growth and meat quality of male Bali cattle have been reported by Mastika et al. (1996). In that study there were significant improvements in daily weight gain and meat quality in a concentrate-supplemented group.

This paper reports the effects of concentrate supplementation on performance of Bali heifers and their calves prior to weaning.

[1] Department of Animal Production, Udayana University, Denpasar, Bali, Indonesia

Materials and Methods

Twenty Bali cattle heifers were kept in a feedlot system at the Faculty of Animal Science farm, Udayana University, Bukit Campus, Denpasar, Bali. The animals were divided into two groups of ten with an average live weight of 170.6 kg (group A) and 176.2 kg (group B). Animals in group A were fed elephant grass only (the control diet), while those in group B were fed a ration composed of 40% elephant grass and 60% concentrate supplement. The supplement consisted of a mixture of 36% corn, 19% rice bran, 23% coconut meal, 16.5% soybean meal, 5% fish meal and 0.5% salt, containing 20.7% crude protein and 77.3% TDN. The animals were fed an ad libitum diet twice daily and feed refusals were measured daily to calculate daily feed consumption (FC).

Data collected on performance of heifers included live weight at mating, services per conception, gestation length, total weight gain during pregnancy, liveweight at calving, milk production and composition and FC, while for calves birth weight and preweaning growth rate to 18 weeks of age were determined.

Data for each characteristic were analysed using the Student t-test (Sokal and Rohlf 1969) to compare the two feeding regimes.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Results and Discussion

Table 1 shows the effects of concentrate supplementation on characteristics of heifers and their calves prior to weaning. Liveweight gain of heifers during pregnancy was significantly improved by concentrate supplementation. The average daily gain during pregnancy for the concentrate supplemented group (B) was 0.424 g, compared with only 0.150 g for the control group (A). Foetal growth and development in supplemented heifers were faster than in those on the control diet, with calf birth weights increased by an average of 5 kg. However, reproductive traits such as services per conception and gestation length were not improved by concentrate supplementation. The use of natural mating with the same bull, and the biological characteristics of Bali cattle, might be the main factors determining these two characteristics. These data indicate that feeding and management play an important role in improving performance of Bali heifers as well as the genetic potential of this breed.

Concentrate supplementation increased live weight of heifers at calving, and improved milk production and milk composition significantly. Schmidt (1971) found that milk yield and its persistency were closely related to energy intake during early lactation. In this study, the higher energy intake was from concentrate supplementation, and higher protein and energy contents of the ration would have increased milk yield and its components. Consequently this increased the growth of calves during suckling, as shown in higher preweaning weight gains and very enhanced live weight of calves at 18 weeks.

Wirdahayati and Bamualim (1990) also reported that feed supplementation increased milk production of Bali cattle by around 28% over a six month lactation. The higher concentration of milk components of Bali heifers in this study, compared to that of other breeds, might be one of the factors which could support enhanced survival of their calves up to weaning, although milk production in Bali cattle is lower than in other cattle breeds.

Conclusions

The use of concentrate supplements improved performance of Bali heifers and their calves prior to weaning, although services per conception and gestation length were not significantly affected. Therefore, in the short term, nutritional manipulation will play an important role in improving performance of Bali cattle. However, in the long term the genetic potential of this breed must be considered, since indicators of genetic degradation have been recently identified in some areas.

Table 1. Performance of Bali heifers and their calves prior to weaning.

Characteristics	Control group A		Control group B	
Heifers:				
Initial live weight (kg)	170.58^a	(10.58)	176.20^a	(11.04)
Live weight at mating (kg)	194.50^a	(12.13)	232.00^b	(20.00)
Services per conception	1.80^a	(0.79)	2.00^a	(0.67)
Gestation length (days)	288.11^a	(27.41)	275.56^a	(13.56)
Live weight at calving (kg)	225.70^a	(53.79)	331.90^b	(40.25)
Total FC during pregnancy (kg DM)	1658.20^a	(15.34)	1686.60^b	(14.90)
Milk production (kg/day)	1.10^a	(0.93)	1.60^b	(0.34)
Milk consumption:				
Total solids (%)	16.55^a	(0.53)	17.59^b	(0.76)
Fat (%)	5.45^a	(0.52)	7.43^b	(0.27)
Protein (%)	4.51^a	(0.48)	4.99^b	(0.38)
Lactose (%)	5.36^a	(0.31)	5.42^a	(0.30)
Ca (%)	0.17^a	(0.03)	0.18^a	(0.02)
P (%)	0.13^a	(0.01)	0.13^a	(0.02)
Energy (kcal/g)	1.22^a	(0.11)	1.92^a	(0.03)
Daily FC during suckling (kg DM)	6.23^a	(0.02)	6.61^a	(0.10)
Calves:				
Average birth weight (kg)	12.01^a	(1.97)	17.00^b	(2.18)
Male birth weight (kg)	13.83^a	(1.89)	18.75^b	(0.65)
Female birth weight (kg)	11.17^a	(1.24)	13.00^b	(1.92)
Average preweaning weight gain (kg/day)	0.31^a	(0.22)	0.42^b	(0.14)
Calf weight at 18 weeks (kg)	52.00^a	(4.80)	72.57^b	(9.80)

Values in parenthesis are standard deviations.
Values within a line having different superscripts differ significantly ($P<0.05$).

Acknowledgments

Financial assistance for this study was provided by the Indonesian Australia Eastern Universities (IAEUP). Thanks are due to Nengah Rita for looking after the animals during the experiment.

References

Lay, W.A. 1997. Potensi pertumbuhan, produksi karkas dan keempukan daging sapi Bali jantan. Seminar IAEUP. “Environmental Pollution and Natural Product & Bali Cattle in Regional Agriculture”, 24–25 February 1997, Bali Padma Hotel, Legian, Bali.

Mastika, I.M., Mariani, N.P. and Suryani, N.N. 1996. Observations on feedlotting of Bali cattle. Proceedings of seminar on Bali cattle, a special species for the dry tropics, held by Indonesia Australia Eastern University Project (IAEUP), 21 September 1996, Udayana University Lodge, Bukit-Jimbaran, Bali.

Schmidt, G.H. 1971. Biology of lactation. W.H. Freeman and Company, San Francisco.

Sokal, R.R. and Rohlf, F.J. 1969. Biometry: the principles and practice of statistics in biological research. W.H. Freeman and Company, San Francisco.

Sonjaya, H. and Idris, T. 1996. Kecendrungan perkembangan populasi sapi potong di Sulawesi Selatan. Forum Komunikasi Pimpinan Perguruan Tinggi Peternakan se Indonesia. 9–10 Agustus 1996. Ujung Pandang.

Wirdahayati, R.B. and Bamualim, A. 1990. Penampilan produksi dan struktur populasi ternak sapi Bali di pulau Timor, Nusa Tenggara Timur. Proc. Seminar Nasional Sapi Bali. 20–22 September 1990. Fakultas Peternakan Universitas Udayana, Denpasar, Bali.

Nutrition and Management Strategies to Improve Bali Cattle Productivity in Nusa Tenggara[1]

A. Bamualim and R.B. Wirdahayati[2]

Abstract

Bali cattle are the predominant breed in Nusa Tenggara, with a population of around 800 000 head. As a tropical semi-arid area, the region has a marked distinction between the wet and dry seasons which influences the availability of feed. The productivity of livestock increases during the wet season and decreases sharply during the dry season. Cattle management practised by farmers in Nusa Tenggara is divided into two categories: (i) semi-intensive, in which farmers have close contact with their animals, and (ii) extensive, in which the animals are mostly left to graze freely with a very small involvement by farmers. Given the wide variation in both management and the seasons, the productive performance of Bali cattle in Nusa Tenggara also varies widely. The calving rate for Bali cattle is higher than for Ongole cattle, but the mean calving rate of Bali cattle in Timor is lower than those recorded in Sumbawa, Lombok and Flores (64 ± 12%, as against 72 ± 22%, 74.4 ± 11% and 78 ± 13%). Most calving occurs during the dry season, and therefore good management and feeding for survival are required for both cows and calves. The inter-calving interval ranges from 12.5 to 19.7 months, averaging about 15 months. Overall, there is a need to intensify livestock production in the area through improved quality and availability of feed and better management systems.

Introduction

MOST parts of the Nusa Tenggara region experience a long dry season. The annual rainfall is less than 1500 mm, most of it occurring from December to March. The pronounced dry season from May to November and the general lack of water in the area limit intensive agriculture systems. Nevertheless, the economy of the provinces of East Nusa Tenggara (NTT) and West Nusa Tenggara (NTB) depends heavily on agriculture. About 40% of regional gross domestic product is produced by the agricultural sector and about 75% of the labour force is employed in agriculture.

Livestock are a major component of farmers' incomes and contribute some 8–12% of the region's income. Nusa Tenggara is important for livestock production and has been one of the major areas exporting to the other islands in Indonesia and to the Jakarta market. Bali cattle (*Bos sondaicus*) are the predominant breed in the islands of Nusa Tenggara, accounting for 90% of the estimated 800 000 head in the region. The major production advantages claimed for Bali cattle are their outstanding ability to thrive and achieve high conception rates under adverse nutritional and climatic conditions (Wirdahayati and Bamualim 1990). However, there are some major problems that impair efforts to maximise Bali cattle production in the area.

To improve cattle productivity in Nusa Tenggara, it is necessary to relate Bali cattle performance to the environmental limitations and management systems, and this, in turn, will help to determine the level of improvement that is possible for the region. This paper elaborates some aspects of the problems and potential of Bali cattle productivity in Nusa Tenggara, including the effect of nutrition and management on reproduction.

Livestock in Nusa Tenggara

In NTT, it was estimated in the 1993 census that 46% of the 551 430 farming families raised livestock.

[1] Presented at workshop on strategies to improve Bali cattle in Eastern Indonesia, Denpasar, 4–7 February 2002

[2] Balai Pengkajian Teknologi Pertanian (BPTP) — NTT, Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

A survey of eight villages in west Timor showed that 59% of farmers own on average 2.4 head of cattle and a few chickens, pigs and goats per family (Tjaong-Soka et al. 1991), indicating that livestock are an important part of farmers' livelihoods in NTT.

In one of his reports, Holmes (1987) describes the livestock industry in Nusa Tenggara as having the following characteristics:

- Livestock are the primary source of cash income but are of secondary importance to subsistence food cropping for most farmers.
- Cash investment and capacity for investment in livestock are low.
- Major problems exist in availability of vaccines for highly contagious diseases.
- The significance of parasitism and nutritional deficiencies is unknown.
- Post-natal mortalities are high, with potential for improvement via vaccination, protection and nutrition.
- Animals exist at different points on a continuum of management intensity ranging from unrestricted grazing (scavenging) to total confinement with control over feeding and mating.

As with many other regions in the tropics, cattle production in the Nusa Tenggara region depends on unimproved native grasslands. The carrying capacity of NTT and NTB in terms of availability of grazing land and the value of 'animal units' present is indicated in Table 1. The most obvious implications of the carrying capacity related to the nutritional limitations in Nusa Tenggara are the low condition and growth rate of young animals, increasing mortality rates, and, as a consequence, reduced reproductive rates.

A marked seasonal pattern affects the production of native pasture, in both qualitative and quantitative terms. This pattern raises seasonal issues such as: (i) the availability of sufficient quantities of protein to maintain liveweight gain during the wet season (December to May); (ii) phosphorus deficiencies — practically all year, but particularly during the dry season; and (iii) energy deficiencies, except at the start of the rainy season.

Despite the nutritional constraints during the dry seasons, the cattle population has increased to a level that may cause environmental degradation. This is most evident in areas where permanent water is available. Recent field observations indicate that stocking rates in such areas are relatively high, with serious consequences for livestock productivity, control of soil erosion, and long-term sustainability of the pastures (Schottler 1990), while the area of grazing land continues to fall because of its use for other purposes. Consequently, in parts of the region high mortality of calves (ranging from 20% to 47%) has been reported (Banks 1986; Wirdahayati and Bamaulim 1990).

Table 1. Total unimproved native grazing areas and estimated ruminant population (animal units) in East and West Nusa Tenggara.*

Location	Total area (ha)	Native grazing area (ha)*	Animal units (AUs)**	Ha/AU
West Nusa Tenggara				
Lombok	461 875	108 660	269 695	0.4
Sumbawa	1 525 500	500 080	289 360	1.7
Total	1 987 375	608 720	559 055	1.1
East Nusa Tenggara				
Sumba	1 085 440	770 600	145 960	5.3
Flores	1 909 499	406 170	129 630	3.1
West Timor	1 699 080	705 040	537 110	1.3
Total	4 694 000	1 875 680	812 700	1.3

Bali Cattle Productivity in Nusa Tenggara

Reproductive status of Bali cattle

A baseline survey of the productivity of Bali cattle grazing native pasture in Nusa Tenggara outlined the existing field conditions and the effects of seasons on cattle reproductivity (Wirdahayati and Bamualim 1990; Wirdahayati 1994). These studies confirm that Bali cattle possess some extremely useful characteristics, such as high fertility (calving rates ranging from 75% to 90%) and high percentage carcass yield (average dressing percentages of 51% (Masudana 1990) and 52.6% (Kirby 1979)).

An intensive monitoring survey of Bali and Ongole cattle on a few major islands in Nusa Tenggara (Lombok, Sumbawa, Flores and Timor and Sumba) was carried out through the Cattle Health and Productivity Survey (CHAPS) of the Eastern Islands Veterinary Project (EIVSP) for the three year period 1990–1993 (Wirdahayati 1994). This study, which monitored 13 locations with 13 selected herds, has provided important data on the productivity performance of Bali cattle in Nusa Tenggara. Its main findings were:

- The mean calving rate for Bali cattle was higher than for Ongole cattle (67.2% vs. 41%).
- The mean calving rate of Bali cattle in Timor (64 ± 12%) was lower than those recorded in Sumbawa (72 ± 22%), Lombok (74.4 ± 11%) and Flores (78 ± 13%).
- Calving rates vary between sites due to the differences in the environment — particularly the availability of feed resources — and differences in management between sites and between individual farmers.

- Calving in Bali cattle was concentrated in April–June (41%) and July–September (40%) with only 19% in October–March. In other words, the heaviest calf drops were during the dry season, which would have been detrimental to calf survival.
- As a result, management changes are required. Survival feeding for both dams and calves should be considered a top priority unless calving can be shifted to a more favourable season.
- Cows in higher body condition achieved a higher conception rate than cows in low body condition. Bali cows achieved a high conception rate at a body condition score of 3 (on a scale of 1 to 5), with mean body weights of 223 kg.
- Bali calf mortality rates were Sumbawa 7–31%, Timor 3–30%, Lombok 2–14% and Flores 2%.
- The inter-calving interval (ICI) ranged from 12.5 to 19.7 months, with an overall mean of 15 months.

Strategic feeding to increase reproductive performance of cows

Strategic feeding by supplementing late pregnant Bali cows through to the first three months of lactating in Nusa Tenggara had improved post-partum body weight gain (Table 2) and calf productivity (Table 3).

Based on data in Table 2, the overall mean of supplemented and non-supplemented cows for weight at calving was 215 vs. 197 kg; for weight at 3 months of lactation 215 vs. 190 kg; for time to conception after calving 115 vs. 157 days; and for ICI 419 vs. 457 days. From Table 3 it can be calculated that the overall mean of supplemented and non-supplemented cows for milk intake of their calves was 2.1 vs. 1.6 kg/day; for weight gain at 0–3 months 0.27 vs. 0.20 kg/head/day; for weight gain at 3–6 months 0.21 vs. 0.09 kg/head/day; and for calf survival 91% vs. 82%.

It is evident that Bali cows may conceive in any condition, even the worst but, as calving in Bali cows is concentrated in the dry seasons, they face severe problems in rearing their calves. It is therefore imperative to provide adequate food for lactating Bali cows, and this should be promoted in Nusa Tenggara. Evidence from Tables 1–3 indicates clearly that feed supplements given to lactating cows would improve their reproductive performance and the growth of their calves.

Nutrition status and feeding trials to improve cattle productivity

The results of baseline surveys and monitoring of cattle performance and constraints on productivity in

Table 2. Use of strategic feeding during three months post-partum to improve reproductive activity in Bali cows, carried out in a few trials in West Timor.

Parameter	Supplemented			Non-supplemented		
	A	B	C	A	B	C
Weight 3 months before calving (kg)	171	—	—	176	—	—
Weight at calving (kg)	218	190	239	200	192	199
Weight at 3 month lactation (kg)	193	194	255	172	182	209
Conception after calving (days)	76	154	—	114	201	—
Inter-calving interval (ICI) (days)	357	481	—	404	510	—
Age at first calving (months)	33	—	—	—	—	—

A: Wirdahayati (1994), feed supplement given 3 months before calving; B: Wirdahayati et al. (2000); C: Belli and Saleh (2000), during rainy season.

Table 3. The effect of supplementary feeding of lactating cows on calf production.

Parameter	Supplemented			Non-supplemented		
	A	B	C	A	B	C
Calf birth weight (kg)	13.6	11.7	14.9	12.1	12.2	12.6
Milk intake (kg/day)	1.30	2.80	2.21	0.98	2.20	1.50
Calf weight gain 0–3 months (kg/day)	0.33	0.19	0.30	—	0.15	0.24
Calf weight gain 3–6 months (kg/day)	—	0.15	0.27	—	0.09	—
Calf survival (%)	100	73	100	80	67	100

A: Wirdahayati (1994); B: Wirdahayati et al. (2000); C: Belli and Saleh (2000), during rainy season.

Nusa Tenggara have been used to direct some strategic research aimed at overcoming problems and thereby enhancing beef cattle productivity in the region. One of the studies conducted by CHAPS was to evaluate the status of feeds and feeding of cattle in Nusa Tenggara.

The CHAPS study indicated that native grass production was reduced from 2 t DM/ha in the wet season to less than 500 kg DM/ha in the dry season (Table 4: Bamualim et al. 1994a). As a result, carrying capacity was reduced significantly: from around 3 head/ha during wet season to just 0.3 head/ha in the dry season.

During the dry season (6–8 months/year), animals can lose as much as 20% of their live weight due to low pasture intake (Bamualim 1991). Animal production data from grazing trials at Binel (Timor) show that two year old cattle grew at 0.25 kg/day for five months of the wet season after compensatory gains of 0.51 kg/day for the first month, which compares with estimated weight losses for the six months of the dry season of 0.17 kg/day (Piggin 1986). Wirdahayati and Bamualim (1990) reported that during the dry season calves less than one year old lost weight at 0.15–0.22 kg/head/day and young steers 0.34–0.35 kg/head/day. Late in the dry season mature bulls and cows might experience even more severe weight loss (0.42–0.52 kg/head/day).

Table 4. Average native grass production at different locations and different seasons in Nusa Tenggara (kg DM/ha/3 months: Bamualim et al. 1994a).

Survey locations	March	June	September	December
Timor	1915	1665	450	375
Sumba	1805	1240	565	925
Flores	1415	1065	600	870
Sumbawa	1135	1925	905	315
Lombok	1035	2910	2000	470

Some farmers and researchers have used local feed resources to improve body condition and body weight gain of Bali cattle (Bamualim et al. 1993a, 1993b; Nulik and Bamualim 1998). Improving body condition in Bali cows through strategic feeding during the critical time strongly affects their reproductive performance after calving, the body weight and growth of their calves, and their ICI. A few local feedstuffs such as putak (the pith of the palm tree, which is native to the Nusa Tenggara region and is rich in carbohydrate), native forages, green leaves and legumes are good value as cattle feed. Supplementary feeding trials have been undertaken in west Timor and have shown that it is possible to improve post-partum body weight, milk yield during the six month lactation and calf growth, and to reduce calf mortality (see Tables 2 and 3).

Although native grasses are a dominant feed for cattle whether they are grazing or being fed in the pen, the productivity of Bali cows depends mostly on the continuous provision of good quality forages. Productivity of Bali cows in Flores and Sumbawa was improved by the provision of around 20% tree legumes, given consistently to the cattle all year round (Bamualim et al. 1994b).

Bali Cattle Management Systems in Nusa Tenggara

Management systems

There is some evidence that the performance of Bali cattle in Nusa Tenggara varies widely, not only seasonally but between sites and management systems within sites. These differences in productive performance reflect differences in management and in environmental conditions. A three year survey studied the cattle husbandry practices of owners of Bali cattle in Nusa Tenggara (Wirdahayati and Bamualim 1994). The study was to determine the level of management required to improve cattle productivity at different environments in Nusa Tenggara. The results showed that farmers managed their cattle in four ways: (i) animals were individually housed and hand fed; (ii) animals were tied to a tree during the day and stabled at night; (iii) animals grazed during the day and were stabled at night; and (iv) animals grazed freely day and night. This translates into two main categories: (i) semi-intensive, in which farmers have close contact with their animals; and (ii) extensive, in which the animals are mostly left to graze freely with very little intervention by the farmers. An analysis of types of management used by farmers surveyed in Nusa Tenggara is provided in Table 5.

Table 5. Management systems applied by farmers surveyed in Nusa Tenggara (values in percentages).*

Location/ system	Stabled all day	Tied under tree and stabled at night	Grazing by day and stabled at night	Free grazing	Other
Timor					
Semi-intensive	2.1	85.2	10.0	1.1	1.6
Extensive	—	24.0	52.0	23.0	—
Flores					
Semi-intensive	1.1	71.1	3.9	0.3	23.5
Sumbawa					
Semi-intensive	12.0	22.5	62.3	2.5	5.6
Lombok					
Semi-intensive	14.8	59.7	25.2	0.3	—

* Survey of cattle distributed by Nusa Tenggara Agricultural Support Project (NTASP)

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Table 5 shows that grazing was more common for cattle raised in Timor and Sumbawa islands, whereas cattle in Flores and Lombok islands were mainly tethered during the day and stabled at night.

Improved management in cattle fattening systems

This program is aimed at improving cattle fattening practices of the farmer communities in Timor (Wirdahayati et al. 2001). The general practice in the area was to tether or fully confine the young steers and hand feed for about 1–2 years before the animal was sold to outer islands for slaughtering. If the period of fattening is to be shortened, feeding and management systems need to be improved. It was suggested that the composition of feed offered be 50–60% grasses and 40–50% mixed legumes instead of feeding mostly *Leucaena* spp. (leucaena), as Timorese farmers have done for the past 30 years.

One form of improvement in management was to develop a communal system, consisting of a communal pen composed of several individual pens (confinement). Each steer was confined in its own area by its owner, with feed and water provided at all times. The other improvements introduced were:

- improving the feeding system to 60% grasses and 40% legume leaves;
- adding probiotic material (rumen bacterial starter) and mineral blocks in the expectation that they might increase intake and digestibility;
- collecting animal waste for manure (organic fertiliser), and use of manure for backyard farming/vegetable gardening by women's groups;
- assurance of capital inputs and marketing of the product through partnerships.

The new techniques increased daily weight gain from 0.2 kg/head/day to 0.5–0.8 kg/head/day, and the fair competition among farmers in the group shortened the duration of fattening to as little as four to six months (from one and a half to two years). From 1998 to 2000, the program successfully conducted demonstrations in which around 6–11 groups of farmers keeping 14–246 animals per group involved in each 4–6 month period successfully fattened and sold around 1200 head of cattle worth more than Rp 1.5 billion. Because they sold a number of cattle at any one time the bargaining position of farmers was strengthened and their income increased.

Other benefits of this program were to promote the use of manure for backyard vegetable and horticulture farming by women in the village, providing an extra income and improving the standard of the family diet through the introduction of more vegetables. The approach of this program was to stimulate an integrated agriculture farming system using livestock-based agribusiness in the village.

Early weaning to increase calf productivity and survival

Low survival of Bali cattle calves appears to be due to poor nutrition of the dam after calving. This is also clearly suggested by the CHAPS findings that high calf drops during the dry season were followed by high calf losses during the late dry and early wet season. It confirmed that most calves born at the worst time of the dry seasons were at risk and died within six months. Therefore early weaning might be a strategic way to increase calf survival and reduce mortality.

An early weaning trial to improve Bali calf growth and survival rates was conducted in west Timor by Wirdahayati (2000). Calves were weaned at three months and six months. The results showed that Bali calves can be weaned successfully at these ages by providing good quality forages for the calves plus milk replacer, especially for 3 month old weaners. There were no significant differences between the mean growth rates of male and female calves (243 vs. 274 g/head/day) nor of those weaned at 3 and at 6 months (237 vs. 280 g/head/day), but the control group grew only at 82 g/head/day. Calves weaned at six months reached puberty earlier than those weaned at three months (17 vs. 21 months), but both groups successfully mated at almost the same time (21.8 vs. 22.0 months). The survival rate of the weaned calves was much higher than that of the control group (100% vs. 62%).

Conclusion

Most of the Nusa Tenggara area experiences an annual rainfall of less than 1500 mm, with a pronounced dry season. Livestock are the primary source of income but are secondary to subsistence food cropping for most farmers. Bali cattle is the predominant breed raised in the islands of Nusa Tenggara. It is evident that Bali cows may conceive even when in poor condition, but they face severe problems in rearing their calves.

Although native grasses are a dominant feed for cattle in Nusa Tenggara, the productivity of Bali cows depends mostly on the continuous provision of good quality forage. High productivity of Bali cows recorded in Nusa Tenggara was positively related to the provision of tree legumes all year round.

As well as nutrition, there are some other management strategies that improve the productivity of Bali cattle. These include early weaning for calves born in the dry season, and the development of a system of communal pens for carrying out the fattening.

References

Bamualim, A. 1991. Penampilan produksi ternak sapi dan kerbau sebagai sumber daging di Indonesia. *Prosiding Seminar Nasional Sapi Bali*, 2–3 September 1991. Fakultas Peternakan Universitas Hasanuddin, Ujung Pandang, Indonesia.

Bamualim, A., Arifin, S. and Wirdahayati, R.B. 1993a. Pengaruh pemberian suplemen putak dan biji kapas terhadap pertumbuhan ternak sapi Bali yang digembalakan pada musim kemarau dan musim hujan. Publikasi Wilayah Kering, Vol. 1. no. 1. Proyek Pembangunan Penelitian Pertanian Nusa Tenggara (P3NT/NTASP).

Bamualim, A., Kali Taek, J., Nulik, J. and Wirdahayati, R.B. 1993b. Pengaruh pemberian suplemen daun kedondong hutan (*Lannea grandis*), turi (*Sesbania grandiflora*), putak (*Corypha gebanga*) dan putak campur urea terhadap pertumbuhan ternak sapi Bali di musim kemarau. Publikasi wilayah kering. Vol. 1, no. 1. Proyek Pembangunan Penelitian Pertanian Nusa Tenggara (P3NT/NTASP).

Bamualim, A., Saleh, A., Fernandez, P.Th. and Liem, C. 1994a. Produksi dan kualitas hijauan rumput alam sebagai makanan ternak sapi di Nusa Tenggara. Cattle Health and Productivity Survey, final report seminar, Denpasar, Bali, 15–17 May 1994.

Bamualim, A., Saleh, A. and Patrick, I. 1994b. Komposisi jenis makanan yang diberikan petani pada ternak sapi yang dipelihara dengan sistim semi-intensif di Nusa Tenggara. *Cattle Health and Productivity Survey, Final Report of Seminar*, Denpasar, Bali, 15–17 May 1994.

Banks, D. 1986. Analysis of livestock survey data, 1985. In: NTTLDP Completion Report. II. Livestock. 63–91. ACIL, Melbourne, Australia.

Belli, H.L.L and Saleh, A. 2000. Strategi Pemberian Suplemen Pada Induk Laktasi Sapi Bali Yang Digembalakan Pada Musim Hujan. Laporan Hasil Penelitian Fakultas Peternakan Universitas Nusa Cendana, Februari 2000.

Holmes, J. 1987. Livestock Production. In: Technical Report No 12, Nusa Tenggara Agricultural Support Project. ACIL, Melbourne, Australia.

Kirby, G.W.M. 1979. Bali cattle in Australia. World Anim. Rev. 31, 2–7.

Masudana, I.W. 1990. Perkembangan Sapi Bali Dalam sepuluh Tahun Terakhir (1980–1990). Proceedings Seminar Nasional Sapi Bali: 20–22 September 1990, Denpasar, Bali.

Nulik, J. and Bamualim, A. 1998. Pakan Ruminansia Besar di Nusa Tenggara. Balai Pengkajian Teknologi Pertanian (BPTP) Naibonat bekerjasama dengan Eastern Island Veterinary Services Project (EIVSP)–AIDAB.

Piggin, C.M. 1986. Phase I. Livestock and pasture results. Phase II. Feasibility and design study, NTTLDP Appendices (Vol. II) 113–128. ACIL, Melbourne.

Schottler, J.H. 1990. Suggestions to improve productivity and efficiency in the cattle industry in Nusa Tenggara Timur. Special Report, Livestock Regional Service, Propinsi Nusa Tenggara Timur.

Sherman, A.C., Rika, K. and Lore, J.S. 1976. Livestock production and range management in West Timor, East Indonesia Regional Development Study. Report of Republic of Indonesia and Canadian International Development Agency.

Sutardi, T. 1991. Aspek nutrisi Sapi Bali. Proc. Seminar Nasional Sapi Bali, 2–3 September 1991. Fakultas Peternakan, Universitas Hasanuddin, Ujung Pandang.

Tjaong-Soka, E., Mozes, P.J., Bunga, J.M., Arianto, H. and Schottler, J.H. 1991. Perencanaan Pembangunan Peternakan di Nusa Tenggara Timur. Kerjasama Propinsi NTT dengan AIDAB. Kupang, Juni 1991.

Wirdahayati R.B. 1994. Reproductive characteristics and productivity of Bali and Ongole cattle in Nusa Tenggara, Indonesia. PhD thesis, The University of Queensland, Brisbane, Australia.

Wirdahayati, R.B. 2000. Optimalisasi Pembesaran Anak Sapi melalui Penyapihan Dini untuk Meningkatkan Produktivitas Sapi Bali di Nusa Tenggara Timur. Laporan Tahap Penelitian Kerjasama BPTP Naibonat dengan Kantor Menteri Negara Riset dan Teknologi/Lembaga Ilmu Penegtahuan Indonesia.

Wirdahayati, R.B. and Bamualim, A. 1990. Penampilan produksi dan struktur populasi ternak sapi Bali di pulau Timor, Nusa Tenggara Timur. G.N.R. Haryana, A.A.B. Palguna, I.B. Djagra, K.B.G.N. Saka, I.B. Mantra, M. Mastika and D.K.H. Putra (ed). Seminar Nasional. Sapi Bali, Proceeding Seminar Nasional Sapi Bali, 20–22 September 1990. Fakultas Peternakan, Universitas Udayana, Denpasar, Bali, C1–C5.

Wirdahayati, R.B. and Bamualim, A. 1994. Cattle management systems in Nusa Tenggara, Indonesia. Proceedings of the 7th AAAP Animal Science Congress held in Bali, Indonesia, 11–16 July 1994, Vol. II, 149.

Wirdahayati, R.B., Bamualim, A., Fernandez, P.Th., Liem, C., Winugroho, M. and Teleni, E. 2000. Feeding and management strategies for improved reproductive efficiency in cattle. Cattle Species Comparison at Lili. Final Report ACIAR Project 9312, Kupang.

Wirdahayati R.B., Ila, A., Kana Hau, D., Lailogo, O.T., Masniah and Bamualim, A. 2001. Dinamika usaha penggemukan sapi Bali di Pulau Timor, Nusa Tenggara Timur. BPTP–NTT internal publication.

Management to Facilitate Genetic Improvement of Bali Cattle in Eastern Indonesia

Geoffry Fordyce[1], Tanda Panjaitan[2], Muzani[2] and Dennis Poppi[3]

Abstract

This paper emphasises the importance of developing a genetic improvement program that is not isolated from the social and physical environment in which it is operating. Growth and reproduction are likely to be the most important genetic traits. The minimum requirements to select for them are clear and permanent identification of animals together with records of pedigrees, weights, diet, husbandry, breeding dates and breeding outcomes. Nutrition needs to be improved and standardised to accelerate breeding by reducing the age of puberty and the post-partum anoestrous interval. Artificial breeding is useful but is not essential and, in many Bali cattle breeding systems, may be less efficient than well-controlled natural mating. The key appears to be to minimise costs and inconvenience, and this means substantial modification of the high-input systems used in many 'Western' countries. Possible strategies for doing this in Indonesia are outlined in the paper.

Introduction

BALI cattle (*Bos sondaicus*) are small (~⅔ Brahman size) and have the combined physical and behavioural traits of other cattle, buffalo, and deer. They have the same number of chromosomes as cattle (n = 60), though F1 male crossbreeds with *Bos indicus* are infertile (Kirby 1979). Herd dynamics of current production systems for Bali cattle in eastern Indonesia indicate that most weaner heifers are required as replacement breeding cows, but that 40% of females from a village group are sold annually. This level of sales is unsustainable and accounts for the decline in stock numbers. Strategic management that increases the annual proportion of cows rearing a calf from 65% to 80%, and which decreases calf mortality from 15% to 10% should enable:

- net turnoff to increase by a third, with annual turnoff of about 50% of females possible;
- farmers to sell annually about 25% of weaner heifers.

The cattle industries of the world have a long history of attempts to improve production efficiency by changing the genotype — the 'magic wand'; but the frequency of success is usually quite low. McCool (1992) suggested that replacing indigenous with exotic breeds in South East Asia might in fact create significant problems, e.g.:

- dystocia because of heterosis increasing calf birth weight;
- low tolerance of diseases, parasites, poor nutrition, and harsh environmental conditions;
- increased work to feed each animal because of higher growth and greater size at maturity.

Genotypes that might be used in crossbreeding or breed replacement are typically 50% larger than Bali cattle. If the feed provided does not increase to match increased requirements, most of the diet will be expended on maintenance and very little on production, with the consequence of very low productivity.

Bali cattle appear suited to the needs of the farmers of eastern Indonesia. Significant opportunities exist to improve them through selection. However, to achieve genetic improvement the industry must have systems that:

- identify and use elite breeding (seed) stock;
- enable dissemination and use of these seed stock by smallholders.

The management requirements to efficiently support this are discussed in this paper.

[1] Department of Primary Industries, PO Box 976, Charters Towers, Queensland 4820, Australia
[2] BPTP, J1 Raya Peninjuan Narmada, PO Box 1017, Mataram, Indonesia
[3] School of Land and Food Sciences, University of Queensland, St Lucia, Queensland 4072, Australia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Identifying Suitable Breeding Stock

For any level of success in genetic improvement, breeding objectives must be established. Initially, the ideal characteristics of the cattle are defined. These may include being of a size that enables them to be fed properly each day, as well as being fertile and of good temperament and having a high growth rate. The relative importance of each of these characteristics (traits) is then determined so that correct emphasis can be placed on them during selection. That importance is determined by its economic impact, whether it is heritable, and if it can be measured. Selected animals (G1) of a seed stock producer may product progeny (G2) within one year. G2 progeny might be raised, sold, and mated to produce their first progeny (G3) at three years of age. G3 animals may then be sold for breeding or slaughter at two years of age. Therefore, the importance of traits needs to be judged in the light of the expected financial, social, and physical environment many years hence. In either an elite breeding program or a commercial smallholder situation, bulls — and to a lesser extent females — are then selected so that when mated, they will produce progeny which have the desired traits in the required balance.

Identifying superior animals requires management that enables fair performance comparisons to be made between individuals. Direct comparison of contemporaries requires rearing on similar diets and husbandry systems in the same environment. This process is significantly enhanced when records are kept to enable objective comparison and correction for management differences. In the initial stages of a genetic improvement program where no records are available, some form of subjective assessment is required to identify those animals most likely to have the best phenotype.

Growth and reproduction are likely to be the most important traits to be used in selecting breeding cattle. To record the data requires unambiguous, secure, individual identification attached to each animal. Basic records required include:

- pedigree and dates of key life events such as birth, weaning, mating;
- weight and/or body condition at critical points such as birth, weaning, seasonal interfaces and sale, using a consistent weighing protocol;
- information on diet and husbandry for different management groups;
- time of puberty if known and reproductive events in each year.

Records can be kept in book systems that enable simple assessment and easy access and analysis for any person involved in the program. Information must also be in a format enabling easy transfer to computer systems for more detailed analyses. Such records are being maintained in a current ACIAR-sponsored demonstration (Project ACIAR.AS2.2000.103) of efficient cattle management in Lombok and Sumbawa.

Mating

Cattle control

The fundamental requirement of genetic improvement is animal control so that each female is mated to a selected bull. Most Indonesian cattle owners will use natural mating, thus requiring ready access to the desired bull through the mating period. Systems can be established to allow mating of oestrous females while denying access by other bulls. The ACIAR demonstration cited above is using a mating pen or area into which oestrous females are introduced during the desired mating season; this is proving very successful and has high farmer acceptance.

Female cyclicity

Mating will occur only when the female is in oestrus. Management based on a good understanding of reproductive performance is required to maximise the chance of mating during the optimal period. Reproductive traits of Bali cattle established from Indonesian, Australian and Malaysian studies have been reviewed by McCool (1992) and Wirdahayati (1994). Key features from these reviews and from unpublished information include:

- Puberty is generally reached by both males and females between 12 and 24 months of age, at weights from 100–150 kg.
- There is no real evidence of a significant photoperiod effect on cyclicity.
- The average length of the oestrus cycle is 21 days, with some evidence that it is shorter when nutrition is poorer.
- Oestrus is primarily a nocturnal event, with an average duration of 18–19 hours.
- Pregnancy occurs after an average of two matings. This may be due partly to the widespread use of artificial breeding, but it does suggest embryonic mortality rates of at least 30%, which is normal for cattle in the tropics (Holroyd et al. 1993).
- Pregnancy rates in cyclic females are high.
- Gestation is between 280 and 290 days.
- Calf birth weight averages about 17 kg, but may be less than 9 kg in poorly nourished cows.
- Calf mortality rates vary between 2% and 40%. Higher levels occur in small calves and if management does not support mothering.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

- Calving to conception intervals typically average around five months, indicating a significant post-partum anoestrus problem.

The above performance parameters indicate substantial opportunity to improve both the chances of cycling during the optimum period, and the ability to successfully raise calves. Nutrition is the primary limiting factor, since dietary quality of cattle in the tropics is very seasonal. Good management capitalises on the ability of cattle to efficiently store energy (muscle and fat) during periods of adequate nutrition to enable survival and continued production through seasonal periods of poor nutrition. Improving nutrition via supplements increases utilisation of available poor quality forages and provides additional nutrients directly.

Improving nutrition of breeding females will:

- advance age at puberty, and may also decrease weight at puberty (Fordyce 1998). Early puberty increases lifetime reproductive efficiency (Fordyce et al. 1994);
- increase calf birth weight. Fordyce et al. (1993) reported a variation in calf weight of 25% due to variations in late-gestation nutrition of *Bos indicus* × *Bos taurus* cattle. Late-gestation supplementation of Bali cattle can substantially increase calf birth weights (a component of 'flushing') (unpublished data);
- increase milk yields, and hence calf growth (Fordyce et al. 1996), This is an objective of 'flushing' of Bali cattle, which includes energy supplementation in the two months post-partum, reputedly resulting in much lower calf mortality rates;
- reduce the post-partum anoestrus interval (PPAI). Fordyce et al. (1997) showed that short-term (50 days) pre-calving energy supplementation (equivalent to the pre-partum component of 'flushing') can significantly reduce the PPAI. Post-partum supplementation to reduce the PPAI tends to be far less effective and more expensive because much of the elevated energy intake is diverted to milk production.

Nutritional management strategies include:

- ensuring that appetite is satisfied in both cut and carry and grazing systems, and that cattle have ready access to plentiful clean water. The small mature size of Bali cattle is a distinct advantage in a cut and carry system;
- through seasonal mating, synchronising lactation with high-nutrition periods. The physiological effects of late pregnancy and lactation typically increase maintenance demands for nutrients by up to 50% (Fahey et al. 2000). Hence, in many tropical regions, restricted mating is used to prevent lactation of cows during periods of poorest nutrition.

  Mating is often timed so that calving begins just before rain is expected. In these systems, mating duration is no longer than seven months, so if all suckling calves are weaned at the end of a seven-month mating, lactation is prevented in all cows for at least two months.

  Mating periods can be reduced to as low as three months if nutrition and management are very good. However, Fordyce (1992) reported that weaning rates might be lowered by as much as 20% where nutrition is not optimal, so a minimum mating period of five months is recommended under such conditions. In practice, when implementing restricted mating systems, a seven month mating period should be used in the first year and thereafter reduced in response to conception patterns and weaning rates.

  Kirby (1979) reported that changing the mating period of Bali cattle to synchronise lactation with periods of high pasture growth did not diminish their fertility. In the ACIAR demonstration we have had very high pregnancy rates early in our defined mating period of five months, though the specific period varies according to climate and draught requirements of cattle;
- weaning practices that aim to minimise lactation during periods of poorest nutrition. Weaning at the appropriate time is an integral component of sustaining high herd reproductive rates by maintaining cows in relatively high body condition (Fordyce 1992), thus ensuring that ovarian function and follicle growth are not compromised. In the ACIAR demonstration, we are observing the effect of weaning and how it can be done in village systems;
- strategic provision of supplements containing key limiting nutrients when high responses are expected — e.g. protein meals or high-protein forages such as leucaena leaf in the dry season to animals with ad libertum access to roughage. More specifically in the ACIAR demonstration, we are 'flushing' cows during the dry season by supplementing those that will calve or have calved within two months. The objectives are to enhance ovarian function, increase birth weight and raise milk yields;
- limiting the effect of stress factors that significantly depress intake or increase energy expenditure. Strategies include control of ecto- and endo-parasites (e.g. fluke) and strategic use of animals for draught or other purposes requiring significant energy expenditure.

Nutritional management strategies that reduce age at puberty and the PPAI will reduce generation interval and accelerate genetic progress. Fertility can be enhanced by selection and is repeatable (Fordyce et al. 1988), so retention of females that exhibit high reproductive performance early in life will elevate lifetime fertility of a female group. If research with other cattle species (Toelle and Robison 1985; Davis 1992) can be extended to Bali cattle, then bulls with larger scrotal size may sire female progeny that reach puberty earlier.

Bull fertility

Fertile matings in *Bos indicus* (presumably similar to the situation in Bali cattle), require 2–10 million normal sperm per ejaculate (Den Daas et al. 1998). Typical Bali bulls produce 2.6×10^9 sperm per day (McCool 1992) and even with only 50% normal sperm produce at least one million such sperm per minute, i.e. a potentially fertile ejaculate every 10 minutes. Therefore if a bull is reproductively sound, which most appear to be (Wirdahayati 1994), mating capacity is limited only by libido and opportunity. As in most production systems where an excess of bulls is used, individual fertile bulls may easily impregnate at least 50 females during a short mating period each year (Fordyce et al. 2002).

The breeding soundness of selected bulls should be assessed prior to mating, particularly where single-sire mating is used. This is the practice within the ACIAR demonstration programs. Holroyd et al. (2002) have outlined the key attributes to secure a high probability of fertile bulls; it is particularly important that they have at least 50% normal sperm in an ejaculate (Fitzpatrick et al. 2002).

Artificial breeding (AB)

AB is used throughout the world's beef industries, mainly to produce genetically superior breeding animals which are then disseminated and mated naturally in commercial production systems. The cost per calf of AB is usually much higher than for natural breeding; for example in northern Australian herds it typically exceeds A$50, vs. A$5–20 when natural mating is used. In cattle production systems where group sizes are small, as in Indonesia, access to bulls may be as difficult as or more difficult than access to AB. This may bring the real cost of service closer for the two systems. However, unless AB provides higher value genetic material than that available through natural service, natural mating will be the most efficient system in most situations. Artificial breeding is used for more than 70% of cows on Lombok and 30% of cows on Sumbawa, apparently to improve the genetics of the herd and to overcome a shortage of bulls.

In a typical northern Australian beef herd, conception rates to natural mating average about 70–75% per cycle, due to embryonic mortality levels of 25–30% (Holroyd et al. 1993). This results in an average of about 1.5 cycles per conception. In contrast, conception rates per cycle using AB are in the vicinity of 50% per cycle, even with the best technology available (Boothby, personal communication) and are much lower when AB systems are not ideal. This results in a minimum of 2 cycles per pregnancy and may therefore contribute to low herd fertility.

Other major limitations to successful artificial breeding (*Project In Calf:* a current national Australian dairy program) that are very relevant in Indonesia include:

- oestrous detection. This is more a problem when the predominance of expression is at night, as is the case for Bali cattle;
- access to semen and AB technicians, particularly where there are problems of communications and access;
- the skills and experience of AB technicians.

In the ACIAR demonstration, we are using only natural mating in commercial village systems, to avoid the inefficiencies of AB and to take full advantage of efficient, natural, controlled mating with bulls that meet breeding objectives. However, it is clearly recognised that AB is a valuable tool for introducing elite genetic material.

Integration of Requirements into Effective Management for Smallholders

Management systems

For smallholders, low-input, low-technology management systems must be used because of limited resources and capital investment. The efficiency of any beef cattle production enterprise is as in Figure 1:

Inputs Rp: Cattle, feedstuffs, infrastructure, veterinary care
Time: Hours

$\Downarrow$

Beef cattle production business		**Benefits**	
	$\Rightarrow$	Profit	(Output–Inputs)/Capital investment
	$\Rightarrow$	Lifestyle	Time/Capital investment

$\Downarrow$

Outputs Rp: Cattle sold

Figure 1. Efficiency of a beef cattle production enterprise.

McCool (1992) recognised that high-input 'Western' systems are inappropriate for many Asian situations, but indicated that relatively low-cost and

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

targeted (strategic) management might substantially improve production efficiency. The efficacy of such systems has been demonstrated by Fordyce (1998), who reported an average weaning rate of 83% for a *Bos indicus* × *Bos taurus* herd using very low but strategic inputs in the dry tropics. In the ACIAR demonstration, we have introduced low-cost modifications to management including seasonal mating, use of selected bulls in natural mating enclosures, dry season weaning, strategic dry season supplements for pre-pubertal heifers and breeding cows, individual animal identification, and data recording. These modifications are designed to ensure that business objectives are met by increasing pregnancy rates in lactating cows, reducing calf mortality, reducing the bull cost per calf, and increasing average postweaning growth rates and survival. This will minimise costs, increase turnoff rates, reduce average turnoff age, and increase net financial returns. To date, villagers using these strategies are very pleased, as they perceive improved financial efficiency with little extra input, and without losing opportunities to use animals for draught.

Stud industry sector

A feature of any animal industry with a record of successful genetic improvement is a nucleus elite animal breeding industry that is operated commercially. In western cattle industries, this is referred to as the stud sector. Such a sector currently does not appear to exist in eastern Indonesia. To successfully establish a stud Bali cattle industry to enhance genetic progress, the industry will need to establish reward for bull ownership through such avenues as service fees, semen sales, and premiums when bulls are sold for breeding.

Individual villages will select bulls to meet their breeding objectives using whatever information they can gather on available stock. However, the existence of a nucleus industry which can produce breeding stock that meet their objectives should dramatically improve genetic progress.

To encourage reward for ownership of bulls and elite females we are introducing, in two of the villages, competitions linked to the ACIAR demonstration. Cattle will be judged on traits such as weight corrected for age, breed character, calf output and temperament, while bulls will be judged on breeding soundness examination results. This activity will:

- encourage good animal management, data recording, and use of Bali cattle;
- underpin future genetic improvement programs. It is likely to show that the genes for large Bali cattle still exist.

Managers

Success in adopting new cattle management and breeding systems in eastern Indonesia will rely on developing the appropriate knowledge, skills and experience in cattle breeding by cattle owners. This must be done by providing technical training in a range of forms to cater for different ages and cultures of producers. In all cases, for successful adoption of the new methods cattle owners will have to:

- see the need and opportunity to change;
- recognise that better management strategies are available;
- be exposed to low risk in adopting new methods;
- be supported by readily available technical and advisory services.

A switch to new methods is a slow and different process, as major changes to traditional thinking are needed. In project ACIAR.AS2.2000.103, we are initiating extension of the demonstrated cattle management strategies. We are using proven methods of achieving change, and these focus on the perceived needs of the cattle owners. At this early stage of the project, however, we do not have any significant progress to report.

Acknowledgments

We are gratefully indebted to Dr Ir. Hasil Sembiring (BPTP) and Dr Bill Winter (ACIAR) instrumental in establishing project ACIAR.AS2.2000.103, which may contribute significantly to more efficient cattle breeding and management practices for Bali cattle in eastern Indonesia. Likewise, we greatly appreciate the ongoing support of Dr Ir. Mashur (BPTP) in the conduct of the project.

References

Davis, G. 1992. In: Bull Fertility. Department of Primary Industries, Queensland, Brisbane. 74.

Den Daas, J.H.G., de Jong, G., Landsbergen, L.M.T.E. and van Wagtendonk-de Leeuw, A.M. 1998. The relationship between the number of spermatozoa inseminated and the reproductive efficiency of individual dairy bulls. Journal of Dairy Science, 81, 1714–1723.

Fahey, G., Boothby, D., Fordyce, G. and Sullivan, M.T. 2000. Female selection in beef cattle. Information Series Q100047, Department of Primary Industries, Queensland, Brisbane.

Fitzpatrick, L.A., Fordyce, G. McGowan, M.R., Holroyd, R.G., Bertram, J.D., Miller, R.G., Jayawardhana, G.A., Doogan, V.J. and de Faveri, J. 2002. Bull selection and use in northern Australia; 2, Semen traits. Animal Reproduction Science, 66, accepted for publication.

Fordyce, G. 1992. Opportunities to increase productivity of north Australian breeder herds. Proceedings of the north west Pastoral Conference, Katherine, Northern Territory, 27–29 October. 19–52.

Fordyce, G. 1998. Heifer and breeder management. In: Blakely, S. ed., The North Australia program 1998: Review of reproduction and genetics projects. Meat and Livestock Australia. 54–63.

Fordyce, G., Saithanoo, S. and Goddard, M.E. 1988. Factors affecting mature size and dry-season weight loss in *Bos indicus* cross cows in north Queensland. Australian Journal of Agricultural Research, 39, 1169–1180.

Fordyce, G., James, T.A., Holroyd, R.G., Beaman, N.J., Mayer, R.J. and O'Rourke, P.K. 1993. The performance of Brahman–shorthorn and Sahiwal-shorthorn beef cattle in the dry tropics of northern Queensland; 3, Birth weights and growth to weaning. Australian Journal of Experimental Agriculture, 33, 119–127.

Fordyce, G., Entwistle, K.W. and Fitzpatrick, L. 1994. Developing cost effective strategies for improved fertility in Bos indicus cross cattle. Final report Project NAP2:DAQ062/UNQ009, Meat Research Corporation, Sydney.

Fordyce, G., Cooper, N.J., Kendall, I.E., O'Leary, B.M. and de Faveri, J. 1996. Creep feeding and prepartum supplementation effects on growth and fertility of Brahman cross cattle in the dry tropics. Australian Journal of Experimental Agriculture, 36, 389–395.

Fordyce, G., Fitzpatrick, L.A., Mullins, T.J., Cooper, N.J., Reid, D.J. and Entwistle, K.W. 1997. Prepartum supplementation effects on growth and fertility in Bos indicus cross cows. Australian Journal of Experimental Agriculture, 37, 141–149.

Fordyce, G., Fitzpatrick, L.A., Cooper, N.J., Doogan, V.J., de Faveri, J. and Holroyd, R.G. 2002. Bull selection and use in northern Australia; 5. Social behaviour and management. Animal Reproduction Science, 66, accepted for publication.

Holroyd, R.G., Entwistle, K.W. and Shepherd, R.K. 1993. Effects on reproduction of oestrus cycle variations, rectal temperatures and liveweights in mated Brahman cross heifers. Theriogenology, 40, 453–464.

Holroyd, R.G., Doogan, V.J., de Faveri, J., Fordyce, G., McGowan, M.R., Bertram, J.D., Vankan, D.M., Fitzpatrick, L.A., Jayawardhana, G.A. and Miller, R.G. 2002. Bull selection and use in northern Australia; 4. Calf output and predictors of fertility in multiple-sire herds. Animal Reproduction Science, **71**, 67–79.

Kirby, G.W.N. 1979. Bali cattle in Australia. World Animal Review, 31, 2–7.

McCool, C. 1992. Buffalo and Bali cattle — exploiting their reproductive behaviour and physiology. Tropical Animal Health and Production, 24, 165–172.

Toelle, V.D. and Robison, O.W. 1985. Estimates of genetic correlations between testicular measurements and female reproductive traits in cattle. Journal of Animal Science, 60, 89–100.

Wirdahayati, R.B. 1994. Reproductive characteristics and productivity of Bali and Ongole cattle in Nusa Tenggara, Indonesia, PhD thesis, The University of Queensland, Brisbane, Australia.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Strategies for Using Improved Forages to Enhance Production in Bali Cattle

B.C. Pengelly and S.N. Lisson[1]

Abstract

There is increasing demand for livestock products in Indonesia, but this can be met only by increasing the quality and quantity of forages for animals. In this paper we consider three options and their potential for improving production of forage. 1. In natural grasslands some improvement of *Imperata* grasslands may be possible with introduced legumes such as *Brachiaria* and *Stylosanthes*. However, under the traditional communal grazing of these regions, improvement will be difficult. 2. Forages as an understorey in estate cropping are likely to provide the greatest opportunity to improve forage production in Indonesia. In addition, they can provide feed when other systems become unproductive because of the dry season or the need to keep livestock away from crop areas. 3. Rotation with other crops in intensive cropping areas, where selected forage crops can be grown in the short period between harvest of the main crop (usually rice) and the end of the wet season. There are many regions where this strategy could be attractive in Indonesia. The emphasis here is to provide high quality forage only in the regular dry season because of its relatively higher value at this time. The best combination of systems to obtain maximum benefit depends on ameliorating a number of factors, but the major ones are the lack of experience of farmers in using these strategies and the fact that farmers have had little input into the development of farming practices in which these strategies might be used.

Introduction

BEEF cattle production is an important component of many smallholder farming systems throughout Indonesia. As well as providing income from sales, cattle also provide draught power and manure for fertiliser. As with most smallholder animal production systems in the developing world, animal production in this farming system is constrained by seasonal quantitative and qualitative feed shortages, genetic potential of the animal, and animal health and management issues. This paper considers options for overcoming some of the seasonal feed shortages by the introduction of sown forages into the farming system.

The feed sources for Bali cattle are extremely variable: grazed forage from grasslands and estate cropping, cut and carry forages from on and off the farm, and crop residues. Without substantial additions to the diet in the form of mineral, protein and energy supplements, both reproduction and animal production are invariably poor. Despite this, dietary supplements including sown forages are not widely used because of farmers' perceptions that they are not needed, the lack of capital or planting material, or the absence of a financial incentive to invest labour and capital in forage production. For many years, this lack of incentive for forage investment resulted in poor adoption of almost all new forage technologies in smallholder systems in Indonesia.

In the past ten years there have been remarkable increases in demand for livestock products across the tropical world and this trend is predicted to become even more pronounced in the future. It has been estimated that milk consumption across the tropics will increase by about 3.2% per annum to the year 2020 (Delgado et al. 1999). Similarly, consumption of beef and pork is expected to double in developing countries between 1993 and 2020. This increased demand is already having, and will continue to have, a major impact on the household, farm and even regional economies throughout the tropics. The mixed crop–livestock farming systems of the tropics

[1] CSIRO Sustainable Ecosystem, Longpocket Laboratories, 120 Meiers Rd, Indooroopilly, Queensland 4068, Australia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

will be most affected by and will benefit most from this phenomenon. These systems already produce more than half the world's meat and most of its milk (Blackburn 1998; CAST 1999), and in the tropics more than 85% of cattle, sheep and goats are held in these mixed systems (Gardiner and Devendra 1995).

Changes in demand for livestock products have already had a profound impact on the beef industry of South Sulawesi. The increased demand for beef in Java has resulted in a rapid decline in the local herd size on the islands of Lombok and Sulawesi. High beef prices have encouraged farmers to market a significant proportion of the breeding herd for slaughter. Consequently, beef cattle numbers in South Sulawesi have declined from 1.23 million in 1991 to only 841 000 in 1997 (FAO 1999).

The rapid increase in demand for livestock products is providing opportunities for farmers to derive or increase income from livestock production and to improve the economic sustainability of their farming enterprise. In order to harness these opportunities, however, farmers need to tackle the major constraints to livestock production enterprises, especially in the areas of animal feed, health and management. Improved planted forages have the capacity to provide quality feeds for livestock; this paper looks at some of the possibilities farmers might use to meet the increasing demand for such forages.

Improved Forages into Smallholder Crop–livestock Farming Systems

Fujisaka (1994) listed four situations within Asian upland farming where the use of improved forages has potential:

- in naturally occurring grasslands;
- in regions where shifting cultivation is being practised;
- as an understorey in plantations or estate crops;
- in rotation with other crops in intensive cropping areas.

Naturally occurring grasslands are important in some regions such as Kalimantan, and improved forage species such as *Stylosanthes guianensis*, *Brachiaria decumbens* and *B. humidicola* are being used there to reclaim *Imperata* grasslands and increase animal production (Horne and Stür 1997). The benefits of increasing livestock production in regions with *Imperata* grasslands by this means should not be dismissed, but experience in Asia and elsewhere has shown that the introduction of new forage species into grasslands that are communally grazed is notoriously difficult. Shifting agriculture is not important in the vast majority of Indonesia and opportunities for forage production in that system will not be addressed here.

Forages as an understorey in estate cropping, or grown in rotation with other annual crops in intensive cropping systems, are likely to offer the greatest opportunities for improving forage production in Indonesia as these land uses account for most of the farmed land area and are currently under-utilised in this respect. They also provide a contrast in strategies for increased livestock. Use of improved forages under estate crops targets greater livestock numbers during the growing season, while strategies in intensive cropping systems tend to target the provision of high quality forage to overcome protein deficiencies during the dry season.

This paper will focus on these two interventions for improving livestock production.

Forages in Estate Cropping

Estate crops such as cashew, coconut, cocoa and coffee are important components of many smallholder farming systems. There are more than 5 million ha of tree crops in Indonesia and more than 20 million ha of coconut, rubber and palm oil plantations in South East Asia (Stür et al. 1994). In south east Sulawesi alone there were 230 000 ha of plantation crops in production in 1990. These crops can occupy a large proportion of individual farms and hence have the potential to produce significant forage yields.

In densely planted and mature estate crops such as cashews and cocoa the success of forages will be limited by competition for light, water and nutrients. However, light is considered the major limiting factor in determining long-term persistence and productivity of pastures. Wilson and Ludlow (1991) reported that the canopy of most low-density and immature estate crops and mature coconut plantation transmits between 50 and 80% of light, which is sufficient to maintain forage production. This means that in crops such as rubber, oil palm and cashews the period when significant forage production can be achieved is limited to the first five years of plantation establishment (Horne and Stür 1997).

Choice of species for use in estate crops is critically important, and tropical grass and legume species vary considerably in their ability to persist and produce under light limitations. A range of grasses including *Stenotaphrum secundatum*, *Brachiaria decumbens*, *B. humidicola* and *B. brizantha* have been identified as among the best adapted to this shaded environment, while the best adapted legumes include *Arachis pintoi* and some other perennial *Arachis* spp., and a range of *Desmodium* spp. including *D. ovalifolium* and *D. hetercarpon* (Stür and Shelton 1991; Stür 1991).

Shelton et al. (1987) and Shelton (1991) reviewed data on liveweight gains from improved pastures in

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

estate crops in South East Asia and the Pacific and found that liveweight gains ranged from 94 kg/ha/yr to 500 kg/ha/yr, most falling in the 200 to 300 kg/ha/yr range depending on location, species composition (especially the legume content of the pasture), light transmission and stocking rate. While these liveweight gains can be <50% of the production obtained from pastures in full sunlight in the same region, daily liveweight gains in *Bos indicus* cattle of around 0.3 kg/head/day measured under coconut and immature oil palm plantations in the Solomon Islands and in Malaysia respectively (Shelton et al. 1987) indicate a feed intake adequate to sustain Bali cattle livestock production. In the more common mixed farming systems, a major value of understorey forages is that they provide significant forage when other areas/sources are limited. For example, in South Sulawesi there is limited feed during the dry season on the cropping fields and hence quality feed in the upland plantation/estate areas is useful. Alternatively, when crops are in the ground or the fields are being prepared for planting, animals are excluded from the cropping areas. Once again, having a source of quality forage in the upland/estate areas is useful.

Relay Cropping Options in Intensive Farming Systems: an Example from Barru Regency, South Sulawesi

Horne and Stür (1997) identified the possibilities of using both fodder banks and hedgerow systems to improve forage production in intensive upland cropping systems. However in Indonesia and elsewhere in South East Asia there are opportunities for forage production in the lowland and upland cropping areas. The focus here will be to explore these opportunities using the Tanete Riaja district of Barru Regency, South Sulawesi as an example.

The Tanete Riaja district is located in central South Sulawesi. Soils, topography and farming systems are all highly variable and the region has a mean annual rainfall of about 3200 mm of which approximately 80% falls between December and May. Individual farm size ranges from one to two hectares, about 40% of it bunded and intensively cropped with rice and other secondary crops. The remaining area is upland/dryland comprising open fields for annual cropping, mixed farming areas and backyard. Rice is the major crop and peanuts, maize and sweet potato the most important secondary crops. Lowland rice is produced in bunded fields under flooded conditions. Villages operating under rainfed conditions typically produce one rice crop per year, and where residual soil moisture and rainfall permit will plant a secondary crop thereafter ((b) in Fig. 1). Fields are then left fallow for the remainder of the year. Where farmers have access to irrigation, they will often plant a second rice crop (May to August) and may even plant a third secondary crop of maize or peanuts (September to November) ((a) in Fig. 1). Upland fields set aside for annual cropping are typically unbunded and rainfed, supporting just one secondary crop during the wet season and left fallow for the remainder of the year ((c) in Fig. 1).

Farmers typically have one to three Bali cattle, which are usually tethered in open areas for grazing or fed in pens with feeds ranging from stored crop residues (rice straw, peanut and maize stover), banana stems, gliricidia and roadside/bund volunteer grasses. Free grazing of crop stubble occurs in some lowland areas post-harvest and in some upland areas that have been fenced off. Throughout the year, and especially in the dry season, many commonly used feeds are of low quality (protein contents typically <8%). Mating normally occurs in October–December, with calving in July to September at the start of the dry season. Calves are weaned in November.

There are a number of periods during the year when animal production and performance are likely to be restricted by dietary constraints. The most critical is in November–December, when conception and lactation coincide with use for draught. Labour demands are high at this time of year, when rice is being planted, so cutting and carrying forages to supplement tethered or housed animals is a relatively low priority for farmers.

Figure 1. Typical annual crop sequences in the Tanete Riaja district, Barru Regency, South Sulawesi for upland and lowland fields.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Since calving takes place in July to September, the lactation of about five months begins at the onset of the dry season when high quality feed is in short supply. This is especially so in October and November, just prior to the start of the wet season. Consequently the condition of lactating cows rapidly declines, calf growth rates are low and reproductive ability of cows is reduced.

On arable land where only one rice or secondary crop is grown per year, the wet season continues for at least two months after harvest. Sowing a forage legume such as cowpea (*Vigna unguiculata*), lablab (*Lablab purpureus*) or mucuna (*Mucuna pruriens*) as a relay crop after the harvest of the first crop would enable at least three months of growth before water availability would restrict growth. Based on published yields of lablab from elsewhere in the tropics, it would be possible then to produce approximately 3 t/ha dry matter (DM) of legume with an average protein content of about 15%. If sown in May after the harvest of the first crop, this feed resource would become available in a fresh state in late July and early August. Assuming that a lactating Bali cow with a liveweight of 280 kg requires a diet of c. 7 kg/day DM with a protein content of c. 10%, feeding 3 kg/day of legume to supplement 4 kg/day of dry season grass and crop residue would raise the overall diet protein to >10%. For two lactating cows to be supplemented for 120 days would require 960 kg legume, which could be produced on 0.3 ha of land.

The economic viability of such a strategy will depend on the relative market prices and the costs of production for crops and livestock products. At present there is a surplus of rice production in Indonesia and the market price for rice is comparatively low, while conversely, the price of beef is elevated. These market conditions may make an increased investment in livestock production an economically attractive option for farmers. However, a more detailed holistic study of potential yields, soil water availability after rice or secondary crops, soil fertility and fertiliser requirements, opportunity costs of not cropping, and sensitivity of the practice to commodity prices and interest rates is required before advancing this approach further. This is the subject of an ACIAR-funded research initiative being undertaken by BPTP, Hassanuddin University, Makassar, Indonesia and CSIRO Sustainable Ecosystems, Brisbane, Australia.

Conclusions

Strategies which enable the increased production of forage to feed Bali cattle in estate and intensive cropping systems appear to be most appropriate for eastern Indonesia, given its widespread use of these systems. However, the benefits of these strategies arise in contrasting ways. Although experimental evidence shows that improved forages in estate cropping provide improvements in liveweight gain over the course of the year, forage quantity and quality are likely to remain limiting factors during the dry season. In areas with a short growing season such as <6 months, the shortage of high quality forage for the dry season will remain a major constraint to production.

Targeting increased forage production in intensive systems provides an alternative strategy. Here the focus is on making more high quality forage available to the animal during the dry season, and there is less emphasis on improving forage quantity and quality during the growing season. This strategy applies not only to the case outlined here of relay cropping in lowland rice, but also to the use of hedgerows and fodder banks in upland cropping systems as outlined by Horne and Stür (1997). Opportunities for forage conservation should also be considered as part of this strategy.

Which combination of strategies is best for a particular region or farming system will depend on many factors, including of course the existing farming system, climate and soil characteristics, labour supply and the availability to farmers of well-adapted species. Unfortunately, the evidence is that few farmers are investing in improved forage production. Horne and Stür (1997) argue that the most important reason for this is that in most cases farmers have had little input into the development of farming practices in which these strategies can be applied.

Farmers will use improved forages provided it can be demonstrated that they meet their needs and provide enhanced livestock production and economic benefits. Given the range of well-adapted forages available and the variation in farming systems across Indonesia, it would appear that a large number of farming practices that enable the inclusion of improved forages should be possible. It is imperative that researchers and development workers involve farmers in the formulation of sustainable strategies so that acceptable practices can be identified and implemented.

References

Blackburn, H. 1998. Livestock production, the environment and mixed farming systems. In: Nell, A.J. ed., Livestock and the environment. Proceedings of the International Conference on livestock and the Environment held in Ede/Wageningen, the Netherlands, 16–20 June 1997, organised by the World Bank, the Food and Agriculture Organization of the U.N. (FAO), and the International Agricultural Centre (IAC). IAC, Wageningen, the Netherlands. 114–123.

CAST (Council for Agricultural Science and Technology) 1999. Animal agriculture and global food supply, Chapters 3 and 5. CAST, Ames, Iowa, USA (online). Available from Internet: *www.cast-science.org* (cited 18 July 2000).

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. 1999. Livestock to 2020: The Next Food Revolution. Food, Agriculture and the Environment Discussion Paper No. 28. International Food Policy Research Institute, Washington, D.C.

FAO 1988. Production Yearbook 1987. FAO Statistics Series No. 82. Food and Agriculture Organization, Rome.

FAO 1999. Livestock Industries of Indonesia prior to the Asian Financial Crisis. FAO RAP publication 1999/37. FAO Rome.

Fujisaka, S. 1994. Regional overview of upland agriculture in Southeast Asia. Proceedings of the national workshop 'Sustainable Agriculture in the Uplands', Vientiane, Lao PDR, 9–11 February 1994 (Sustainable Agriculture Forum, Vientiane 17–27.).

Gardiner, P. and Devendra, C. 1995. Global agenda for livestock research, Proceedings of a consultation, International Livestock Research Institute (ILRI), Nairobi, Kenya, 18–20 January 1995. ILRI, Nairobi.

Horne, P. and Stür, W.W. 1997. Current and future opportunities for forages in smallholder farming systems of south-east Asia. Tropical Grasslands, 31, 359–363.

Shelton, H.M. 1991. Productivity of cattle under coconuts. In: Shelton, H.M. and Stür, W.W. eds, Forages for Plantation Crops. Proceedings of a workshop, Sanur Beach, Bali, Indonesia, 27–29 June 1990. ACIAR Proceedings No. 32, 92–96.

Shelton, H.M., Humphreys, L.R. and Batello, C. 1987. Pastures in the plantations of Asia and the Pacific: performance and prospect. Tropical Grasslands, 21, 159–168.

Stür, W.W. 1991. Screening forage species for shade tolerance — a preliminary report. In: Shelton, H.M. and Stür, W.W. eds, Forages for Plantation Crops. Proceedings of a workshop, Sanur Beach, Bali, Indonesia, 27–29 June 1990. ACIAR Proceedings No. 32, 58–63.

Stür, W.W., Reynolds, S.G. and Macfarlane, D.C. 1994. Cattle production under coconuts in Agroforestry and animal production for human welfare. Copland, J.W., Djajanegra, A. and Sabrani, M. eds. ACIAR Proceedings No. 55, 106–114. ACIAR Canberra.

Stür, W.W. and Shelton, H.M. 1991. Compatibility of forages and livestock with plantation crops. In: Shelton, H.M. and Stür, W.W. eds, Forages for Plantation Crops. Proceedings of a workshop, Sanur Beach, Bali, Indonesia, 27–29 June 1990. ACIAR Proceedings No. 32, 112–116.

Wilson, J.R. and Ludlow, M.M. 1991. The environment and potential growth of herbage under plantations. In: Shelton, H.M. and Stür, W.W. eds, Forages for Plantation Crops. Proceedings of a workshop, Sanur Beach, Bali, Indonesia, 27–29 June 1990. ACIAR Proceedings No. 32, 10–24.

Molecular Genetics and Their Place in Breeding Systems

Julius van der Werf and Brian Kinghorn[1]

Abstract

Current estimation of breeding value is based on phenotypic information only. The advent of molecular markers allows determination of actual genotype at specific gene loci, without error due to random and non-random environmental effects. In the ideal situation we can directly identify genotypes at loci containing genes with substantial effects on quantitative traits (QTLs).[2] However, a more likely scenario is where we use genetic markers linked to QTLs to increase the probability of selecting the animals with the desired QTL genotype. With such indirect markers there is no guarantee of QTL genotype. Furthermore, the marker alleles linked to the preferred QTL allele can be different in different families, and information about linkage phase needs to be accumulated based on phenotypic and pedigree information (e.g. a progeny test). Marker-assisted selection is most useful for traits that are hard to measure and have low heritability. Selection of animals based on (most probable) QTL genotype will allow earlier and more accurate selection, increasing short- and medium-term selection response by up to 40%, and may aid in targeting genotypes for specific production environments or markets.

Introduction

DURING the past two decades most livestock industries have successfully developed estimated breeding values (EBVs) to allow identification of the best breeding animals. EBVs are best calculated using BLUP[3], meaning that they are based on pedigree and performance information of several traits from the individual animal and its relatives. BLUP EBVs are the most accurate criteria to identify genetically superior animals based on phenotypic performance recording.

Although the idea of genetic selection is to improve the genes in our breeding animals, we actually never really observe those genes. Selection is based on the final effect of all genes working together, resulting in the performance traits that we observe on production animals. This strategy makes sense, since we select based on what we actually want to improve. However, animal performance is affected not only by genes but also by other factors that we do not control. Selection for the best genes on animal performance alone can never reach 100% accuracy. A large progeny test comes close to such a figure of perfect selection, but this is expensive for some traits (e.g. those related to meat quality), and we have to wait several years before the benefits from a progeny test have an effect. Efficient breeding programs are characterised by selecting animals at a young age, leading to short generation intervals and faster genetic improvement per year. For selecting at younger ages, knowledge about the existence of potentially very good genes could be very helpful.

Selection of Genotypes based on Genetic Markers

The idea behind marker-assisted selection is that there may be genes with significant effects that can be targeted specifically in selection. Some traits are controlled by a single gene (e.g. hair colour) but most traits of economic importance are quantitative traits that are most likely controlled by a fairly large number of genes. However, some of these genes might have a larger effect. Such genes can be called

[1] University of New England, Armidale, NSW 2351, Australia

[2] Quantitative genetics uses phenotypic information to help identify animals with good genes. Extension to use information from techniques of molecular genetics aims to locate and exploit gene loci which have a major effect on quantitative traits (hence QTL — quantitative trait loci).

[3] Best Linear Unbiassed Prediction model

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

major genes located at QTL. Although the term QTL strictly applies to genes of any effect, in practice it refers only to major genes, as only these will be large enough to be detected and mapped on the genome. Following the pattern of inheritance QTL might assist in selection.

Figure 1 illustrates that QTL constitute only some of the many genes that affect phenotype. The other relevant genes are termed polygenes. Variation at the polygenes jointly with polymorphism at the QTL determines total genetic variation. Although QTL effects explain only a part of genetic differences between animals, knowledge of the genes located at QTL could greatly assist in estimating an animal's true genotype. Information available at QTL therefore adds to accuracy of estimation of breeding value. If genetic effects at QTL are really large, such genes could be more specifically exploited in breeding programs, e.g. to target specific production circumstances or specific markets.

Figure 1 suggests that the value or the allelic forms at individual QTL could be known. In practice, this is rarely the case. That is, currently there are few examples where QTL effects can be directly determined, but knowledge in this area is rapidly developing. Most QTL known today can be targeted only by genetic marker — 'landmarks' at the genome that can be chosen for their proximity to QTL. We cannot actually observe inheritance at the QTL itself, but we observe inheritance at the marker, which is close to the QTL.

When making selection decisions based on marker genotypes, it is important to know what information can be inferred from those genotypes. Figure 2

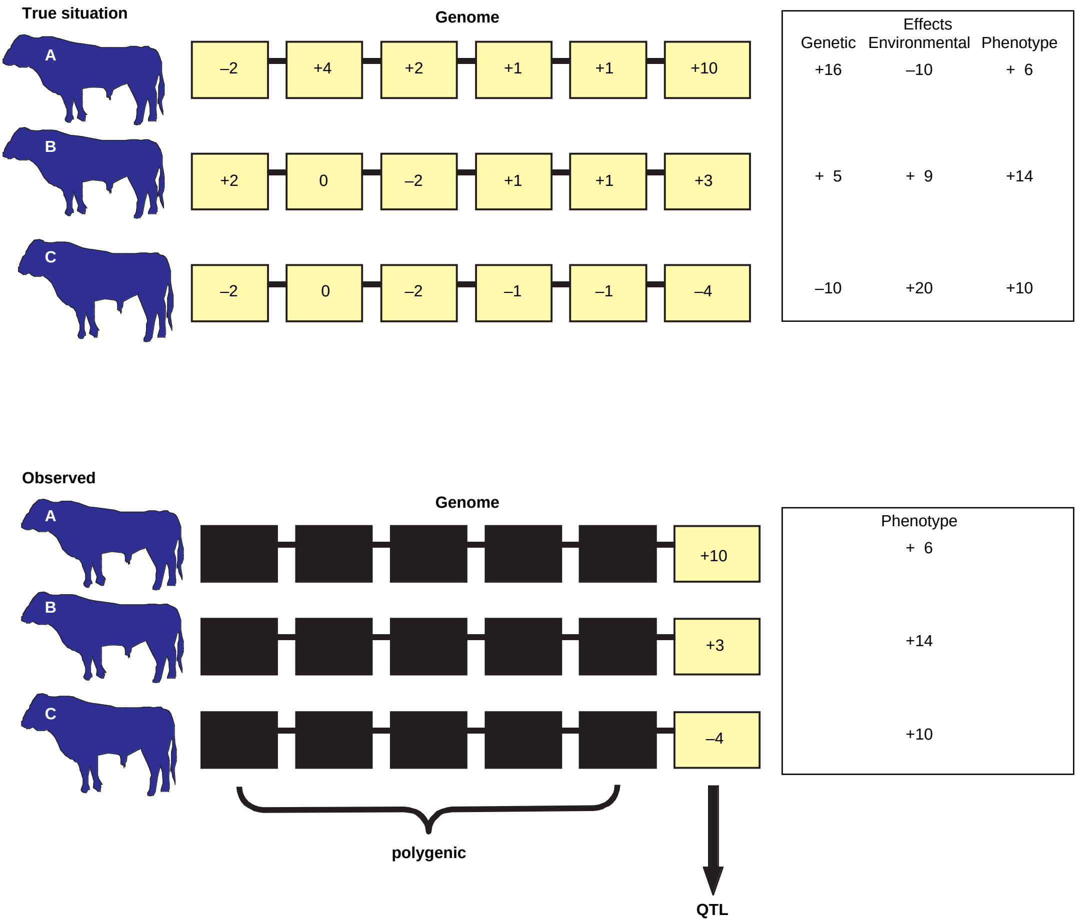


Figure 1. Illustration of three bulls with different phenotypes. The top diagram gives the true allelic values at the different genes affecting body weight; the bottom diagram illustrates what would be observed if QTL could be identified in addition to phenotype, adding significant information about true genotype.

shows the principle of inheritance of a marker and a linked QTL. We can identify the marker genotype (Mm) but not the QTL genotype (Qq). The last is really what we want to know because of its effect on economically important traits.

Let the Q allele have a positive effect, therefore being the preferred allele. In the example, the M marker allele is linked to the Q in the sire. Progeny that receive the M allele from the sire have a high chance of having also received the Q allele, and are therefore the preferred candidates in selection.

As shown in Figure 2 there are four types of progeny. All progeny will inherit m alleles and q alleles from the mother. The sire will provide them either an M allele or an m allele and either Q or q. In the figure, 90% of the progeny that receive an M allele have also received a Q allele, because M and Q alleles are linked on the same chromosome in the sire. However, in 10% of the cases after the sire reproduced, there has been a recombination between the two loci, and animals that inherited an M allele from their father have received a q allele rather than a Q allele. Therefore, marker alleles do not always provide certainty about the genotype at the linked QTL.

Selection of animals could be based on genetic information only. However, in that case the effect of other genes not covered by the marker would be ignored. Optimal selection should aim for QTL as well as for polygenes. It should be based on information from marker genotypes combined with information on animals' phenotype. The first aims to get the good QTL, the second aims at getting good 'other genes'. Selection with the aid of information at genetic markers is termed marker-assisted selection (MAS).

How Important is the Marker Information?

The question now arises: what value should be given to a particular marker genotype? Should we prefer an animal having a desired marker genotype over one that doesn't, but that performs better phenotypically? The answer is that the information from these different sources should be weighted optimally, as in BLUP. The value of having the right marker genotype (Mm in our example) depends on three things:

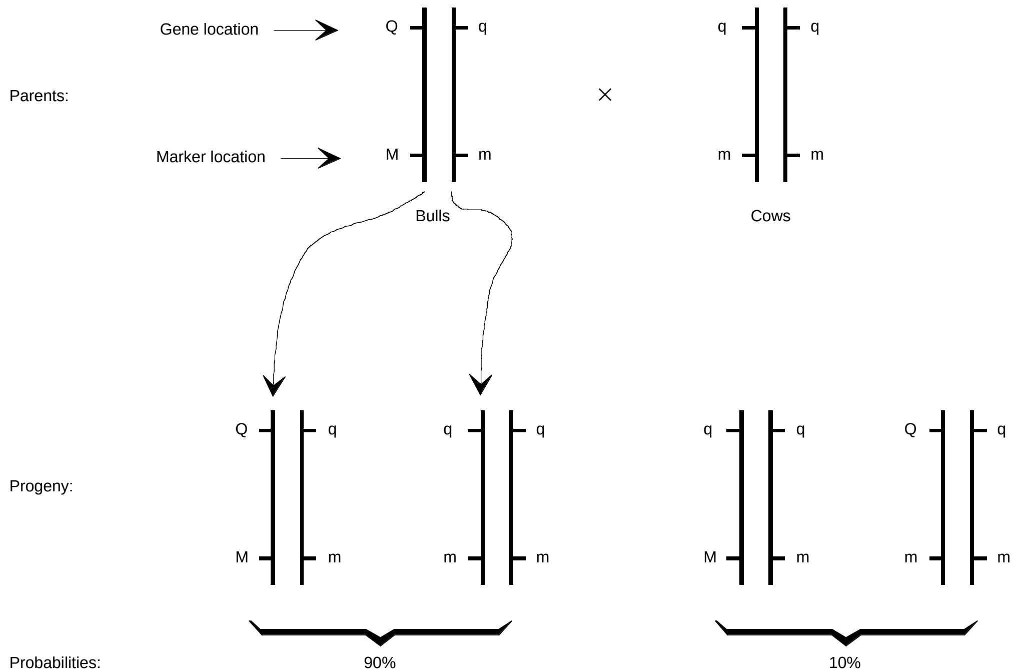


Figure 2. Following the inheritance of a major genotype affecting a quantitative trait (Q locus) with a genetic marker (M locus) closely linked to the Q locus. The sire is heterozygous for either locus and the dam is homozygous. For this example, we can determine for each progeny whether it received M or m allele from the sire. The recombination rate (10%) determines how often Q alleles join M alleles.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

- the size of the QTL effect;
- the frequency of the Q allele. If it is nearly fixed MAS will not add a lot to genetic improvement, whereas the opposite will be true if it is found in low frequency;
- the probability that an Mm animal has indeed inherited the Q allele.

With regard to the probability of how sure we can be that an *M* animal indeed has a Q allele, there is a distinction between direct markers and linked markers. If there is no recombination between marker and QTL, i.e. if the marker exactly identifies the gene, then finding an M implies finding a Q. However, if M is only near Q on the genome, M and Q have a possibility to break up at each meiosis. (Meiosis is the process that produces sperm or eggs and determines the genetic make-up of offspring.) This has the important consequence that finding an M is not a guarantee of finding a Q. Not only is the chance of having a Q allele with a frequency lower than 1, but for a randomly chosen sire we have no idea whether M or m is linked to Q. The implication is that for each family this linkage phase needs to be determined based on data. For example, in the family in Figure 2 we would see that M progeny perform better than m progeny, hence M would most probably be linked to Q (the positive allele). But some progeny will have m linked to Q, so in their offspring m will be the preferred marker genotype.

Direct markers

The easy scenario is when the marker allele M and the QTL are always together. This is the case only if the marker is actually measuring the relevant polymorphism within the gene that causes the effect. Such a direct marker is very convenient, because the marker genotype will directly inform us about the QTL genotype. However, there are currently only a few direct genetic markers for economically important traits. Examples are:

- the Halothane gene in pigs (giving increased proportion of lean meat but also stress susceptibility). This gene has been found — it is the ryanodine receptor gene;
- the double muscling gene in cattle (giving increased muscle mass). This gene has also been found — it is the myostatin gene;
- the marbling gene in cattle. This is related to the thyroglobulin gene.

The first two are typically markers for genes that were known to exist before they were mapped, and had a large effect.

Direct markers are generally much preferred to linked markers, if they are truly markers for major gene effects. Their biggest benefit is that they can be used even without trait measurement or pedigree recording. Despite this there is value in having such information, to monitor the effect of the major gene in different breeds/lines and production systems, and exploit it accordingly.

Possible risks with using direct markers are:

- There can be more than one mutation causing the desired genetic effect. A DNA test for only one of those mutations would not pick up all the animals with the desired effect. An example of this case was the myostatin gene for double muscling, where several mutations within the gene caused the same desired effect. If only some of the single direct markers had been adopted, there could have been false negatives in diagnostic tests.
- There is also some potential to incorrectly identify a candidate gene as a major gene directly affecting the trait of interest, just because it is near the true causative gene. In that case there is a risk of false positives: we pick the 'positive gene' but it turns out to be an indirect marker and recombination might have made it linked to the 'negative allele'.

This highlights the value of re-evaluation of markers in distinctly different stock, and a continuous need for trait recording for monitoring purposes.

Linked markers

Linked markers are only near QTL on the genome, and are not the causative mutation in the gene concerned. For a randomly chosen animal in the population, we have no clue whether one or another marker allele is associated with a preferable QTL allele. If we observe within the progeny of one sire a difference in performance between different marker alleles (as M and m in Fig. 2) we can determine which of the marker alleles is associated with the preferred QTL allele. But this information is useful only for this particular sire and its family! The information on linkage phase is also useful for its progeny, since for them we can determine the probability of whether or not they inherited the preferred QTL allele (depending on the recombination rate). Within the family, the marker and the QTL are said to be in linkage disequilibrium. Note that we can detect linkage only in heterozygous sires. When sires do not show a difference in progeny for the different marker genotypes, they may be homozygous for the QTL.[3]

[3] With linked markers, the information on which marker genotype is linked to the positive QTL allele is family specific. This linkage phase has to be determined by genotyping at least two generations (a sire and its progeny) and using phenotypic information on the progeny. In a number of families we cannot detect linkage, because the sires are homozygous for either the marker or the QTL, or both.

Sires should also be heterozygous for the markers; in addition it will be useful to genotype dams, since otherwise it can be unclear which marker allele an animal received from its sire. However, with markers abundantly available, animals could be genotyped for a panel of markers, thereby reducing the need for genotype information on dams.

It may be obvious that there is a considerable need to gather trait and pedigree information in order to establish links with genetic markers, because for each family the linkage phase between marker and QTL needs to be established. However, many breeding populations already have a performance and pedigree recording system in place. Furthermore, the need for large half-sib families (i.e. offspring by the same sire) is also reduced over time, as marker and trait information is gathered on a deeper pedigree. This is because we now have methods to use information from all relatives to make inferences about which marker variant is linked to the superior gene variants in each animal. Once a linkage phase has been established for a family, as is the case for a tested sire, trait measurement is not required for additional progeny of that sire (Fig. 3).

Besides the need for a lot more genotyping, other disadvantages of linked markers are that it may be more difficult to market the concept that bull X has a 95% chance of carrying the major gene Y, as opposed to a virtual guarantee from a direct marker test. However, the fact that linked markers cover a region of chromosome means that they could be more robust in some ways. A strategy using linked markers will lean on trait recording, and be more likely to track a major gene than relying on a direct marker that turns out to be only closely linked to the causative gene. Moreover, the information gathered in linked marker programs could be of direct benefit in verifying parentage, finding direct markers, and detecting other QTL affecting the measured traits.

In conclusion, direct markers and linked markers may both be useful. They should go hand-in-hand in application, driven by commercial demands, with a natural progression from linked markers to direct markers as more information becomes available for location of QTL.

Selecting for QTL Genotypes

Where a direct marker (DNA test) exists for a QTL, we can use direct MAS (sometimes known as genotype-assisted selection (GAS)). Where only linked markers exist for a QTL, we must use indirect MAS.

In either case, the aim is to determine QTL genotypes to assist selection decisions, either by increasing the frequency of favourable QTL alleles, or targeting their introgression into their lines. The value of this depends on a number of factors:

- Where heritability is low, the value of information on individual QTL tends to be higher because accuracy of breeding is increased by a relatively larger amount.
- Where the trait(s) of interest cannot be measured on one sex, marker information gives a basis to rank animals of that sex. This is particularly useful to determine which males should be progeny tested.
- If the trait is not measurable before sexual maturity, marker information can be used to select at a juvenile stage.
- If a trait is difficult to measure or requires sacrifice (as with many carcass traits) marker information can be used instead.

Most evaluations of MAS have considered short-time horizons. Applications that have been looked at by computer simulation are:

- the value of MAS in young bulls prior to entering a progeny testing scheme. Use of single markers gave increases in the rate of genetic gain of 5–20%, and this was improved by use of groups of markers, pointing at larger parts of the genome (haplotypes);
- the use of MAS in nucleus breeding schemes using new reproductive technologies. Marker-assisted selection is generally more useful when combined with reproductive technologies such as AI and embryo transfer and/or IVF. More progeny per élite parent allows earlier selection at reasonable accuracies, but also relies heavily on the use of family information. MAS is able to utilise more of the information that is available from the rest of the animal's family. MAS can be of value to select candidates within families before they are old enough to have individual records of their own. Improvements in genetic gain of up to 40% have been found in such schemes.

Selecting at QTL will be most useful if the positive QTL allele is found in low frequencies. However, with low frequencies there will be little variation at the QTL. Especially with linked markers, it may then be hard to detect heterozygous parents. These are needed, as illustrated in the examples, because we need both 'haves' and 'have nots' among the progeny to be able to pick out the ones which have indeed inherited the good variant from the sire. Initially we cannot distinguish sires with two desired alleles from the ones that have none of the desired alleles. Again, the combination of pedigree and performance data may allow us to link different families, conferring some to calculate genotype probabilities for (yet unmarked) major genes. This would help to pre-select potential heterozygous sires.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

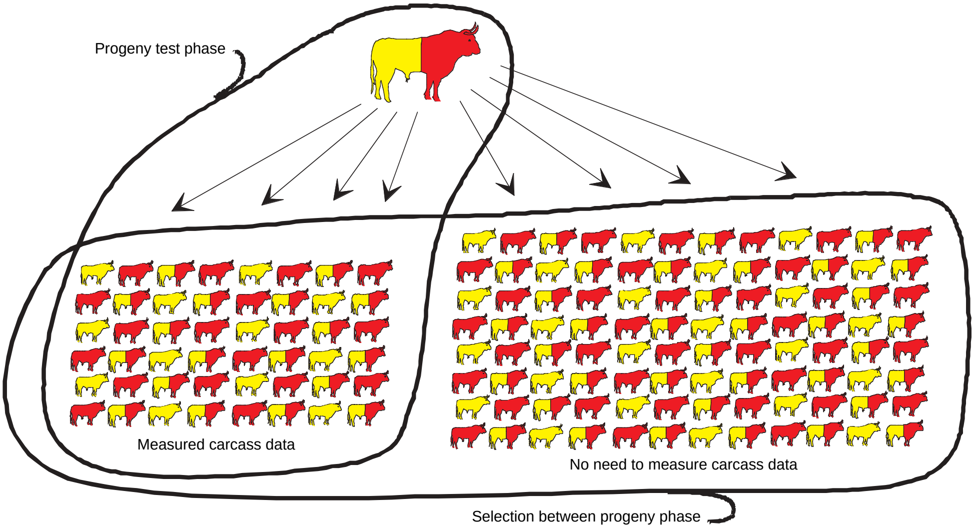


Figure 3. A sire needs to be progeny tested to establish the linkage phase between marker and QTL. Once this is established, more progeny can be generated and these can be selected on the basis of marker genotype only, without the need for trait recording.

Non-additive Genetic Effects and Mate Selection

Genetic value is the value of an animal's genes to itself. Breeding value is the value of an animal's genes to its progeny. These two are not the same when there is dominance. The effect of dominance is illustrated in Table 1. When the Q allele is dominant over the q allele, the genetic value of the heterozygote Qq is close to the effect of the homozygous QQ. The breeding value of QQ is twice the value of giving a Q allele to offspring. The breeding value of Qq is intermediate between the breeding values of QQ and qq, as a heterozygous animal will give a Q in 50% of cases and a q in the other 50%. Therefore, the breeding value of QQ and Qq animals is quite different. Such differences depend on the degree of dominance (the difference between genetic value of Qq and the average of the homozygotes QQ and qq) and on the frequency of Q alleles in the population. Dominance is quite common. It is indicated as a non-additive genetic effect as it causes genetic values of Q and q alleles to be non-additive. Dominance forms the genetic basis of the existence of heterosis in which combinations of heterozygotes are produced that have the same influence as homozygotes.

In general, breeding value has been of much more importance to animal breeders. It reflects the merit which can be transmitted to the next generation. It is the sum of the average effects of alleles carried by the animal, and because of the large number of loci classically assumed, there is no power to capitalise on anything but the average effects of these alleles, as dominance deviations in progeny cannot be predicted under normal circumstances.

However, when dealing with individual QTL we have the power to set up matings designed to exploit favourable non-additive interaction in the progeny. This means that prediction of breeding value at individual QTL will be of only partial value in many circumstances. Accordingly we should consider both prediction of breeding values and prediction of QTL genotypes, and therefore genetic values, at individual QTL.

Continuing the example of Table 1, if a Qq bull were mated consistently to QQ dams, its progeny would on average have nearly the same eye muscle area as the progeny of a QQ bull. However, if the Qq bull were mated to average dams, some of its progeny could have unfavourable qq genotypes.

Of course prediction of QTL genotype of candidates is of real value only in helping to predict genetic values of their progeny — because the object is to improve performance of descendants. This in turn means that the evaluation system should be intimately associated with the mate allocation process, wherever non-additive effects are to be exploited. The combination of animal selection and mate allocation can be termed mate selection. Application of evaluation systems to exploit individual QTL will thus frequently involve mate selection strategies in addition to the simpler ranking processes we are used to with selection.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Table 1. Hypothetical example of a dominance effect on eye muscle area. Suppose the Q allele has a major positive effect and the difference between QQ and qq genotypes is 20 cm^2. The heterozygote's mean is close to that of the QQ genotype, as the Q allele is dominant over the q allele. The genetic values of QQ and Qq are similar, but breeding values (the value of the alleles that are passed on) are quite different. Breeding values are always additive. The example is for a population frequency of the Q allele of 0.325.

Genotype	Average eye muscle area (cm^2)	Genetic value	Breeding value
QQ	80	+10	+17.3
Qq	78	+ 8	+ 4.5
qq	60	–10	– 8.3

Another consequence of dominance is that the difference between marker genotypes will be very dependent on the dam population. If a marker were tested using a sire on a dam population with only q alleles, a large effect would be found (basically the difference between Qq and qq genotypes). However, if the same sire were tested on a population with predominantly Q alleles, the difference between marker genotypes would be the difference between QQ and Qq genotypes, which could be quite small.

Long-term Response

MAS combines the information at genetic markers with the phenotypic measurements on breeding animals and their relatives. When only parents with the major gene are selected, we will miss some animals with very good polygenic values; hence more emphasis on major genes implies less improvement of the other genes. Ultimately, the QTL will be fixed but the variance at the polygenes remains to be exploited. Therefore when considering genetic improvement after many generations, the selection for 'other genes' should not be ignored. A compromise needs to be found, and the longer the term considered the less emphasis there should be on selection for major genes (Fig. 4). However, it should be noted that the effect shown in Figure 4 is related to simple selection on a trait that can be measured in both sexes, and before selection takes place. It is when these conditions do not exist that MAS shows its real superiority.

Conclusion

Marker-assisted selection can improve selection response. Its value is limited for traits that we can breed for easily by classical methods, especially in the longer term. However, there seems great potential for MAS to generate change in traits such as pigmented fibres, meat quality, milk quality and disease resistance. Biological systems are complex, so interaction between loci should be of importance. The effect of MAS should be assessed with respect to the whole breeding goal, including animals' health. QTL effects on all relevant traits should therefore be somewhat known before MAS begins, as selection based on actual genes is likely to have more impact than selection based on phenotypic characteristics only. Given this, there will be challenging tasks in biological modelling and breeding program design to produce ideal genotypes.

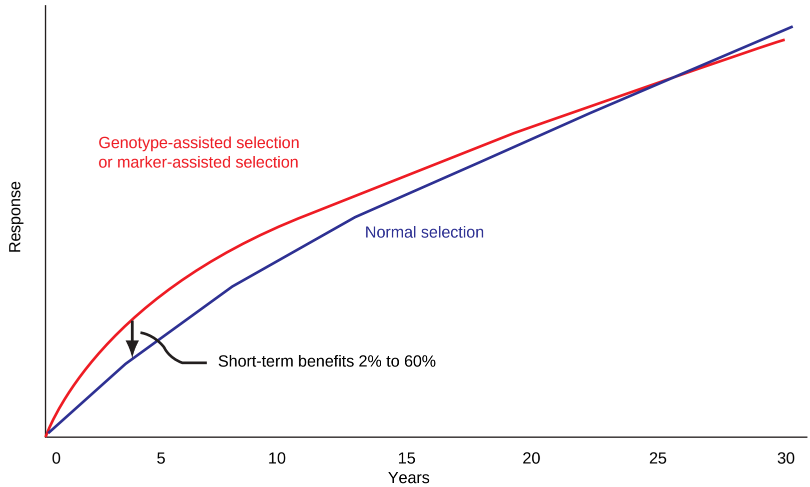


Figure 4. Long-term response compared for GAS/MAS and normal selection.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Implementing Pedigree Systems

Hans Graser[1]

Abstract

Modern pedigree systems are based on computers that store and manipulate pedigree and performance data. It is essential that each animal has a unique identification to distinguish it from other animals in a large population. There are a number of methods of doing this and they may or may not be backed up with sophisticated electronic reading systems. For the time being in Indonesia, the use of ear tags, preferably two of them for security, will be the system of choice. Establishing accurate pedigrees in extensive systems is not easy as there may be multiple matings of females, failures to record the birth of calves or simple errors of transcription. New methods of DNA parentage are very accurate and should soon be practicable as their price and precision improve. It should not be long, for example, before there is a simple on-farm kit to enable accurate pedigrees of whole herds without needing to know the mating or calving information. With this information modern PC computers and software programs can handle sufficient information for at least the nucleus population of a large breeding scheme in Indonesia.

Introduction

MODERN genetic improvement programs currently require two important components for genetic evaluation, namely pedigree and performance data. While enormous efforts are being made to discover genes and gene actions that affect the performance of our livestock, I believe that for many years to come we cannot forgo the collection of pedigree and performance data.

Unique Identification

Today, pedigree systems have to be computer based. Gone are the days when each animal had its own card, which after years filled endless filing cabinets.

The first step for a proper computer-based pedigree system is individual animal identification with a unique number. The emphasis is on uniqueness and not on number, as any unique combination of letters and numbers can be used. Cultural differences might favour one or the other. With the very large number of animals we are dealing with in livestock populations, it is difficult to develop a unique system which might have any meaning to identify an animal as one of a group within the population, and which doesn't get too cumbersome for the user.

A commonly used system in Australia is:

Herd code	Grade code (some breeds)	Year of birth letter	Within-herd number
ABC	P	X	0012

This is not a unique code, as different breeds might use the same herd code and the year of birth code will repeat itself about every 25 years. However, it is sufficient for day-to-day operations of breed society. In the database, this animal number is supplemented with a unique but meaningless number of more digits, with which the computer and all evaluation software will work.

For quality performance recording it is important that an animal's identification can be read easily. Different methods of on-animal identification are available. The best ones are those which are permanent, last for a lifetime and can be read at a distance. While an ear tattoo is permanent it cannot be read from a distance. Ear tags are the most commonly used animal identification device in Australia; however, they might need replacing and for breeding animals it is quite common to duplicate the system using tags in both ears, as the tags frequently get lost.

[1] Animal Genetics and Breeding Unit, University of New England, Armidale, NSW 2351, Australia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Electronic devices incorporated into ear tags or carried in the rumen are also used and can identify an animal for life. The latter cannot be removed from a live animal, which has certain advantages. The use of electronic ear tags requires special readers that can display the signal in a readable form. However, these readers are required all the time and one has to get close to the animal for identification. Using such devices allows for a considerable amount of automation in pedigree and performance recording with minimal errors in data transcription and data transfer. However, electronic identification system are currently too expensive to be widely adopted, particularly in breeding programs where the use of available labour is an important side effect, or where adequate electronic servicing capacity is not available.

Other options are freeze branding or hot brands; however, they damage the hide and their use is not acceptable in some countries for a range of cultural and welfare reasons.

A Pedigree System

A pedigree is a record of details of the parents of each animal. This is sufficient to establish any relationships within the population and to provide pedigree certificates covering any number of generations.

Establishing correct pedigrees in extensive beef cattle operations can be quite difficult. Commonly more than one bull is running with a group of cows and matings are not observed. On the female side, calves occasionally swap dams before the calf is tagged and its mother recorded. DNA parentage verification is one way to solve the problem, and for some management systems might be cheaper and more reliable than separating groups of cows into single-sire mating groups in separate paddocks or enclosures. DNA parent verification is becoming cheaper with increasing automation and multiplexing of DNA tests. In the future it might well become a process performed on-farm with standard kits, only the most difficult cases being sent to central laboratories for analysis and identification.

Today the use of AI without follow-up natural service with sires makes the recording of pedigrees easier, provided technicians follow the guidelines of recording inseminations and are competent in reading and transferring numbers. In systems using fresh semen the process can be made more secure, as date and sire availability could be checked at a central distribution centre. The same can be organised with frozen semen: providing AI technicians use semen from a limited number of sires, AI records can be verified and corrected against the AI centre database.

However, even with our best efforts, we can expect that between 5% and 10% of our pedigrees are incorrect unless DNA parent verification can be carried out. I do not see this as a great problem; however, it affects the estimation of genetic parameters and the prediction of breeding values.

Use of Computers

To utilise and manage animal breeding data, computers are a necessity. The size, speed and cost of current PCs should allow every serious breeding program to have a central database containing the pedigree and performance data of at least the nucleus population. A number of software programs are available which provide low-cost solutions for beef cattle breeding programs.

A Simple Selection Program for Smallholder Bali Cattle Farmers

H. Martojo[1]

Abstract

The failure of many animal breeding programs in developing countries was discussed by members of the AGDG (Animal Genetics Discussion Group) on the Internet. Village breeding programs may be the animal breeding programs most likely to succeed in the long term. Simple genetic selection methods are proposed, that could be applied in village smallholder cattle herds. A simple method to estimate calving rate in smallholder herds is suggested. Its simplicity and low implementation costs should ensure its applicability and sustainability and it should be applicable to Bali cattle in rural areas, separately or in combination with the simple selection method outlined.

Introduction

THERE has been indiscriminate importation of breeding stock into Indonesia since the late 1960s. Despite the massive amounts of foreign exchange involved, these imports have made little impact on the overall level of animal productivity in any species except poultry. In particular, imports of exotic cattle germplasms and stock has been a long-term threat to the conservation of the main indigenous cattle breed, Bali cattle. The disadvantage of using indigenous cattle genotypes is that this approach is not as glamorous as importing new genotypes and appears less likely to attract aid funding, since no massive expenditure on imports from donor countries is involved.

Local breeds can be improved by within-breed selection, without crossing with imported genetic material. However, it may be difficult to predict whether the result would justify the investment. The strategy most likely to work is the village breeding scheme, whereby the breeding activities are carried out by participating communities of smallholder farmers.

[1] Faculty of Animal Science, Bogor Agricultural University, Bogor, Indonesia

Failure of Breeding Programs in Developing Countries

A discussion group on the Internet, the Animal Genetics Discussion Group, discussed in June 2002 a topic put forward by Dr Keith Hammond of FAO, who indicated that FAO for the next year or more will seriously examine the issues:

> ‘Why have so few animal breeding programs in developing countries succeeded? Where are we going? After all, why are we here?’

Hammond further mentioned that the vast majority (greater than 90%) of genetic improvement initiatives in this major sector of the world (>130 countries, involving most of humankind and most of the world’s livestock) have failed to achieve sustainable improvements in food and agricultural production.

The group responded with a heated discussion and some important responses were:

- Animal breeding programs do not exist in a vacuum, but are a small part of complex production systems involving land use, feed production, housing, daily tending to animal needs, feeding, veterinary treatments, and the harvesting, manufacturing, transporting and marketing of animal products.
- Successful programs:
  - are initiated and/or supported by local people to meet local needs;
  - are those where progress is measured regularly by every participant

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

  - establish realistic short- and long-term goals, and all participants regularly review progress toward meeting these goals.
- Programs are not likely to succeed if they:
  - focus on grandiose schemes;
  - are based on finding an application for new or expensive technologies;
  - are run by governments or international agencies;
  - are driven by societal goals with few benefits to participants.
- Animal breeding projects are especially difficult because gains are slow and long term, and significant gain requires stable genetic improvement goals over long periods.
  - Germplasm preservation programs illustrate some of the problems. They have long-term societal goals with little or no immediate returns to participants, with no long-term selection goals, and have dubious potential applications in the future.
  - Improvement programs depend on the development of a genetic level that is in unison with the environment. In most cases the environment is not coping with the genetic level of imported strains and people are not trained accordingly. Environmental changes are more expensive and, if done properly, require more people than those involved simply in the distribution of imported semen — if this is at all the right way.
  - In most cases information on the effect of imports is not available, but the upgrading is continuing in the absence of significant results. In most cases, favourable conditions are found for the first imports and the interaction between genetics and environment (G×E) has no chance to be expressed or investigated.
  - Most projects in developing countries have a time perspective that is too short to investigate all possible problems, and the generation interval of those responsible is often less than half that of a generation of cattle.
  - Breeding programs and goals are inappropriate. The model used in developed countries is not necessarily the way forward for developing countries. For example, the drive for high milk yields in dairy cows in the 'developed' world has been accompanied by increased reliance on feed inputs and higher incidences of disease (e.g. mastitis, lameness). Poorer countries cannot afford to implement such improvement programs without the ability, knowledge or resources to increase the level of animal husbandry in tandem with improved performance through selection. It is easy to see why introducing animals of high genetic merit directly into low-input animal production systems is frequently a recipe for disaster.
  - Solutions: it would be beneficial if developing countries could learn from the mistakes that more developed countries have made, and include broader breeding goals in the breeding objective right from the start. For example, combining somatic cell count, lifespan and calving interval information with conventional dairy breeding goals will improve milk production, but not at the expense of cow health, longevity or fertility.
- Appropriate breeding strategies should be tailor-made to suit both the country and sector for which they are intended, not simply copied from Western models. This requires careful examination of economic values specific to each situation.
  - Technical knowledge: any animal improvement program should be an integrated one that combines methods for pasture/nutrition/husbandry improvements in conjunction with genetic improvements. Arguably, this needs to be well in place before selection is introduced.
  - Experience in South America has shown that where the level of knowledge of animal husbandry in general is very poor, any basic improvements will go a long way without even considering genetics. For example, including animal husbandry/agricultural science in the rural school curriculum would go a long way to improving general farming knowledge; it could be supported by a good network of technical back-up to the farming community. For instance, implementing such things as basic heat detection records, providing salt licks and preserving forage for the dry season doubled milk production in a dairy cooperative with indigenous 'Criollo' cattle, with no introduction of imported breeds. Such 'new' strategies had never been practised before, and certainly not documented in the native Indian language. So one reason why improvement programs have failed to make an impact is the inability to put in place other 'husbandry' factors (for whatever reason).
  - In many developing countries most projects fail because of lack of adequate capabilities, poor organisation, lack of self-sustained funding, lack of flexibility, excessive bureaucracy and — we must recognise — rampant corruption.

Those are the comments of some AGDG members that may help us ponder further the issues raised by Dr Hammond.

Village Breeding Programs

Along with the points mentioned above I would like to concentrate on the implementation of animal breeding through the village breeding program approach.

Sölkner et al. (1998) discussed the difficulties of transferring animal production technologies requiring high inputs of capital and high levels of organisation to developing countries. There was a further effort to define 'Village breeding programs':

> 'Village breeding programs are carried out by communities of smallholder farmers (villagers), often at subsistence level. The feed availability is far from optimal with large seasonal variations. Pressure from diseases may be high. The level of organisation is low with problems in the flow of information. Data recording in the sense used by animal breeders will often be missing.'

An important component in the success of an animal breeding program is a range of sociological factors, including the human–animal interrelationships that distinguish between livestock users, livestock keepers, livestock producers and livestock breeders (Neidhart et al. 1996). Livestock users have a purely exploitative relationship with animals and simply take precautions to protect their property through night corrals; the animals are left on their own to find feed and water and to reproduce. The gaps between the four groups are enormous and will take much effort and time to bridge. Neidhart et al. (1996) point out that the application of breeding programs at the livestock user level will fail until the farmer has reached the level of livestock breeder.

This failure may be caused by the implementation of a too complicated and over-organised type of village breeding scheme, which should be replaced by a simpler method that can be implemented by farmers still in the livestock users phase of development. One such simple breeding program is discussed in the following section.

Appropriate (Simple) Breeding Programs

Simple breeding techniques appropriate for village breeding programs were proposed by Martojo (1991). These techniques were a further improvement on long-tested methods practised earlier by the Dutch colonial government (Merkens 1926). Briefly, the proposed simple breeding scheme is as follows:

Several villages with the sufficient numbers and quality of cattle, with good farmer attitudes and a conducive environment, should be selected and approached. Care needs to be taken to explain the proposal.

- Every three months, a group of extension workers will help the village breeding group, consisting of smallholder cattle owners, to measure the body weights (estimated by heart-girth measurement) of the total herd. They should then calculate group averages and rank the weaner calves (6–7 months), and the cows and bulls in the herd.
- They should then select the highest-ranking 20–25% of animals and identify them with permanent iron branding marks ('A' brand, meaning A class). The second-best 25% would be branded as B class. Below average animals would not be branded.
- The farmer group would agree to keep the best A class bulls as long as possible in the herd for mating, and to keep the class A cows to produce future replacement animals. The class A bull calves would be considered as future young bulls, the class A female calves as future replacements. Cows producing the best calves should also be marked by branding, together with the quarter of birth (I–IV), thus enabling farmers to establish calving intervals when the following calf is measured and recorded at the next branding.
- Class B animals may also be retained, but can also be marketed if there is a need for cash. The below average animals should be marketed and replaced as soon as the opportunity arises. The lowest 10% of ranked animals should be culled as soon as possible. The lowest-ranking bulls and male calves should be castrated immediately.
- Culling low-performing cows will result in higher calving rates as the earliest detectable improvement in the herd.
- All decisions would be in the hands of the farmer as an individual, after consultation with the group. After a few quarterly rounds of selection the group should have the capability to conduct the whole activity without outside advice. Calving rate observations, discussed next, could be carried out at the same time.

Calving Rate Measurement

A method exists of obtaining basic information on calving rate (percentage)/calf crop in smallholder herds within one day (Stonaker et al. 1975, as quoted by Martojo (1991)). Since its inception in 1975, its application in Colombia and its introduction to Indonesia (Martojo 1991), this method has not attracted the attention of field researchers in other areas. Another decade has passed, and this time I hope the method will attract the attention of participants in this workshop. It can be used to detect also the presence of breeding or calving seasons, and the influence of early weaning/nursing on the fertility of nursing cows.

The method requires experienced pregnancy palpators or, if available, expensive but more accurate ultrasonic pregnancy detectors.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Deducing the total number of calves produced in a given year from a one day observation of a herd (the total cow population in a village owned by a group of village smallholders) requires combining the information on:

- the number and estimated ages of calves;
- the number of cows found pregnant, along with estimated ages of their foetuses.

The following errors may enter into this calculation:

- biased estimates of calf ages and the ages of foetuses;
- a lack of information related to calf losses and abortion.

It is hoped that these errors would be minimised if one counted calves at the age of five months or more, and if foetuses were estimated to be two months or more.

Table 1 shows the classifications of cows for computing the annual calving rate.

Table 1. Classification of cows for computation of annual calving rate (first method).

Condition of cows	Dry	Nursing to 6 months	Nursing ≥ 6 months
Open	a	b	c
Pregnant < 2 months	d	e	f
Pregnant ≥ 2 months	g	h	i

$$\text{Calving rate} = \frac{\text{Total calves due in one year}}{\text{Total cows and heifers palpated}}$$

$$= \frac{b + e + g + 2h + i}{a + b + c + d + e + f + g + h + i}$$

The date of observation is the first day of the year.

- The a group may be cows with infertility problems.
- The b group will have ample time to get pregnant and deliver a calf during the year.
- The c group will not have enough time to get pregnant and deliver in that year.
- The d group is also a group that is not nursing and should be heavily pregnant but is not, and may be considered as one with reproductive problems and with no calf that year.
- The e group should stop nursing within a month and may get pregnant in another month and still have time to deliver within the year.
- The f group may still be lactating in the 3rd month of the year and even if they get pregnant right after that may not be able to calve in that year.
- The g, h and i groups will certainly deliver calves within the year. While the g group, with minor reproductive problems, will not be able to have two calves that year, the h group may be in an advanced stage of pregnancy, may calve early in the first month of the year and may get pregnant again in the third month, and so can still deliver a second calf within the year. Because this group can produce two calves in one year it is correct to count it twice. Lastly, the i group may have trouble getting pregnant again because of their extended nursing and may even stay open after calving within that year. In the case of *Bos taurus* or local Criollo cattle of South America, nursing cows are nearly always open.

Working with Bali Cattle

With Bali cattle we may not need to worry about nursing cows being open, as Bali cows by nature almost never wean their calves; an older calf with a younger calf, both being nursed by a single cow, is not an unusual sight. This shows how high the potential fertility rate is.

What we have here (Table 2) is much simpler.

Table 2. Computation of annual calving rate (second method).

Condition of cows	Dry	Nursing
Open	a	b
Pregnant < 2 months	c	d
Pregnant ≥ 2 months	e	f

$$\text{Calving rate} = \frac{\text{Total calves due in one year}}{\text{Total cows and heifers palpated}}$$

$$= \frac{b + c + d + e + 2f}{a + b + c + d + e + f}$$

- Dry cows found to be open (a group) may be the few cows having reproductive problems that can be diagnosed at the time of palpation, and may be culled if in an incurable condition.
- Nursing cows still open (b group) at least have proven themselves to be fertile, and may be at an early pregnancy phase or will soon be pregnant and deliver a calf within the year.
- The c group, if not found to have reproductive problems, may soon become pregnant and will very likely have a calf within the year.
- Cows in the d group are fertile and should deliver at least one calf that year.
- Cows in the e group will certainly deliver a calf that year; they may have a minor reproductive problem or be at an advanced age, and will not have two calves within the year.
- Cows in the f group, depending on stage of pregnancy, will be able to deliver two calves within the same year.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

In some areas in the Eastern Islands of Indonesia there is a distinct natural mating and calving season, and in these areas there is a wonderful sight to be seen when a group of ruminating cows are lying down with their calves lying near them. In such cases calving rate can be estimated directly by deciding to count the start of the year from a few months earlier — at the approximate average birth date of the calves. One can easily count the numbers of cows and calves; older calves in the herd should not be included.

Thus the calculation under this third method will be:

$$\text{Calving rate} = \frac{\text{total calves}}{\text{total cows and heifers}}$$

To get a more accurate estimate using this method, palpation may be included to confirm that open cows or heifers are not pregnant and some out-of-season cows are still pregnant ($\geq$ 2 months). Of those at an advanced stage of pregnancy, some may be counted as capable of delivering two calves in the one year. Some of the nursing cows may also be at an early stage of pregnancy and so may be counted twice. If the observation date is before the calving season, palpation will have to be done as in the second method.

Other modifications to the methods outlined above may be developed to improve their accuracy. In any event those methods will produce more accurate calving rate data for Bali cattle than are usually available.

References

Martojo, H. 1991. Appropriate technology of reproduction and breeding in livestock development in the tropics. In: Livestock and Feed Development in the Tropics. Proceedings of an International Seminar, Brawijaya University, Malang, Indonesia. 251–260.

Merkens, J. 1926. De paard en runderteelt in Nederlandsch-Indie. Veeartsenijkundige Mededeeling. Landsdrukkerij-Weltevreden.

Neidhardt, R., Grell, H., Schrecke, W. and Jakob, H. 1996. Sustainable livestock farming in East Africa. Animal Research and Development. 43/44, 44–52.

Sölkner, J., Nakimbugwe, H. and Valle Zarate, A. 1998. Analysis of determinants for success and failure of village breeding programmes. Proceedings of the 6th World Congress Genet Appl Livest Prod. 11–16 January 1998. Armidale Australia. 25, 273–280.

Stonaker, H.H., Salazar, J., Bushman, D.H., Gomez, J., Vilar, J. and Osorio, G. 1975. Influence of management practices and productivity. In: Proceedings of the seminar on potential to increase beef production in tropical America, Cali Columbia. 63–81.

Increasing the Success Rate and Adoption of Artificial Insemination for Genetic Improvement of Bali Cattle

Mozes R. Toelihere[1]

Abstract

Bali cattle (*Bos sondaicus, Bos javanicus, Bos/Bebos Banteng*) are the indigenous cattle that play an important role in livestock development in Indonesia, particularly in the eastern region, but there is a general perception that the genetic quality of this species is gradually decreasing. However, no major effort has been made to improve the genetics of this animal. Adoption and application of AI is probably the single most important practical tool available to overcome this problem.

Bali cows show longer oestrous periods than other breeds of cattle, and this might increase the possibility of extending the period during which insemination is possible and increasing fertilisation rates. Fertility may reach 80–100%, but calf mortality is also high (around 30%). AI has been introduced, adopted and applied in this breed of cattle since 1975 but most farmers prefer their cows to be inseminated with *Bos taurus* semen (Simmental, Limousin, Brangus) to obtain larger, faster-growing calves than pure Bali calves.

This paper argues that to increase the success rate of AI, a Bali cattle breeding centre should be established in a suitable area and supported by the intergovernmental organisations of eastern Indonesia. Superior bulls and cows may be produced through this breeding centre for acceleration and use in AI and ET to enhance genetic improvement of the breed. Oestrous synchronisation using progesterone treatment could be applied for mass AI activities and higher success rates.

Introduction

INDIGENOUS Bali cattle have played an important role in livestock development in Indonesia for more than a century. The advantageous characteristics of the breed, such as its high fertility, its survival and capacity to prosper under poor environmental and climatic conditions in harsh dryland areas such as in eastern Indonesia, and its capacity to maintain the quality of its lean beef, have made it the preferred beef cattle in Indonesia. On the other hand it is susceptible to infectious diseases, especially Jembrana disease, and has high calf mortality, probably due to a poor milk supply.

Despite this, little attention has been paid to improving the quality, quantity and productivity of Bali cattle. Some areas in eastern Indonesia such as East Nusa Tenggara (NTT), West Nusa Tenggara (NTB) and South Sulawesi, which were formerly known or even famous as the main sources of Bali cattle, have now restricted the outflow due to the continuous decrease of its population. In terms of quality a 'negative selection' seems to have been imposed on Bali cattle in these areas, because of the policy of selling only bulls with high body weight (more than 300 kg) for 'export' and for slaughter, leaving the small inferior bulls as breeders. In addition, poor nutrition has continuously added to the deterioration of the quality and productivity of this animal.

Clearly, measures should be taken to improve the genetic quality of Bali cattle. Probably the most effective of these would be the adoption, application and acceleration of mass artificial insemination (AI) with superior bull semen to increase the success rate of AI and stimulate genetic improvement.

Origin and Distribution of Bali Cattle in Indonesia

Bali cattle originated from the wild 'Banteng' cattle that are kept in sanctuaries in Ujung Kulon, West Java or Sundanese region and in Baluran, East Java

[1] Department of Obstetrics and Reproduction, Faculty of Veterinary Medicine, Bogor Agricultural University (IPB), Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

— hence the name *Bos sondaicus* or *Bos javanicus*. The name 'Bali cattle' derives from the fact that the first domestication of this animal was carried out on the island of Bali (Darmadja 1980).

It was then distributed to the island of Lombok (NTB) and to South Sulawesi, which was formerly better known for its population of swamp buffaloes.

In 1912 Bali cattle were brought to the island of Timor (NTT). The breed seems to be ideally adapted to the dryland of NTT because its population has reached around 800 000 head (Toelihere 1994). Bali cattle also adapt to a variety of other environmental conditions. Therefore the breed has been distributed to almost all parts of Indonesia, particularly to the transmigration areas in Sumatra and Kalimantan.

Bali cattle are a true tropical animal. They have high heat tolerance even when crossed with *Bos taurus* (Yusran et al. 1990). Under poor environmental conditions Bali cattle maintain their productivity by producing calves every year, and they quickly recover their body weight after exposure to poor nutritional conditions or heavy work. In this respect they are a better breed than the Sumba Ongole cattle (Toelihere et al. 1990).

Due to its origin and its many advantageous characteristics the breed is claimed as the national beef cattle breed of Indonesia, and its export for breeding purposes is restricted or, in many cases, prohibited. Nevertheless, Bali cattle are also found in small numbers in northern Australia and Malaysia.

Reproductive Characteristics

Puberty and first mating

Bali cattle are late-maturing animals. They reach puberty at around 600 days (Pane 1991) or even longer (Darmadja 1980). At this stage body weight is around 140–165 kg (Fattah 1998). Age and body weight at the onset of puberty depend on factors other than genetics, particularly nutrition.

The first natural mating is around two years of age (Fattah 1998). To avoid dystocia after AI using *Bos taurus* semen, the author in his practice in south-east Sulawesi in 1975 recommended that the first insemination be carried out in cows of more than 200 kg body weight (Toelihere 1981). Insemination of cows below that body weight should be with pure Bali bulls. It was recommended that insemination using *Bos taurus* semen only be carried out when cows have either reached a body weight of more than 200 kg or have calved at least once following natural mating with Bali bulls.

Oestrus and oestrous cycle

Bali cows show the same oestrous symptoms as other breeds of cattle, i.e. standing heat (standing still while being mounted by other cows), transparent vaginal discharge, changes in the vulva (it becomes warm, oedematous and reddish in colour), and uneasiness. The most important symptom is the standing heat, which can be observed in a herd of cows kept in a restricted fenced area early in the morning (5.00 to 6.00 a.m.) or late in the afternoon (5.00 to 6.00 p.m.). Vaginal discharge usually appears after rectal exploration during insemination. Other signs are relatively insignificant.

The average length of oestrus is around 23 hours (Toelihere et al. 1989), ranging from 18 to 48 hours (Payne and Rollinson 1973; Mulyono 1977; Fattah 1998). This is longer than in most other cattle breeds and should enable Bali cows in heat to have ample time for mating in natural conditions which, in turn, might increase the possibility of fertilisation.

Most normal cows show oestrous symptoms within two to three months of calving (Fattah 1998). Under normal natural conditions, these cows could be expected to mate at this time and produce successive calves within one year. Indeed, the actual calving interval of one year shown by some Bali cows reflects the high inherent fertility of this animal. Post-partum anoestrus is an abnormal condition and, when apparent, usually lasts for four to six months, although it may reach more than 10 months in some cows (Pohan 2000).

The length of the oestrous cycle in Bali cows does not differ from that of other cattle breeds. It ranges from 17 to 24 days (Fattah 1998), with an average of 21 days (Toelihere et al. 1989). Silent heat or undetected oestrus sometimes extends the cycle length to twice or three times normal.

Although Bali cows show intensive signs of heat during or after the rainy season, this does not mean that they are seasonal breeders. It is not directly the season, but the availability of forage during the rainy season that improves the intensity of oestrus and raises fertility (Toelihere et al. 1989; Toelihere 1994).

Fertility rate

Bali cattle are considered to be as fertile as other breeds of cattle. Their fertility reaches around 80% (Darmadja 1980; Wardoyo 1950; Devendra et al. 1973) or even up to 90–100% in Australia (Moran 1971; Kirby 1972). However, under harsh dryland conditions in Timor the rate is about 75% (Fattah 1998).

According to reports at meetings of AI supervisors during the 1980s, the conception rate at first service usually reaches more than 70%. Even embryo

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

transfer in Bali cows results in conception rates of around 50% (Toelihere et al. 1989).

Unfortunately calf mortality in Bali cattle is high, reaching 30% (Toelihere 1994). Bali cows usually mate and conceive during the rainy season and calving occurs during the dry season, so the cows have a poor milk supply.

Adoption and Application of AI

Introduction and adoption of AI in Bali cattle

AI was first introduced in Bali cattle in south-east Sulawesi and in Timor by the author from 1975 to 1976 (Toelihere 1981). The first introduction was carried out through a pilot project at a mining operation (PT. Aneka Tambang) in Pornalaa, south-east Sulawesi in 1975.

Later, AI in Bali cattle was introduced through training courses for veterinary officers in Makassar, South Sulawesi as well as in Kupang, NTT in 1976. An AI campaign was later carried out on Bali cattle farms in both areas as part of practical work during the training courses. AI technology was later adopted by the veterinary services in Bali, NTB and Lampung.

Except in Bali, the adoption of AI technology was stimulated mainly by the results of crossbreeding between Bali cows and *Bos taurus* bulls. Crossbreds of the F1 generation were relatively superior in quality to the indigenous cattle due to heterosis. This superiority included birth weights of 20–30 kg compared with only 13–15 kg in pure Bali cattle, and an average daily gain (ADG) twice or three times faster than that of the purebred animals. There was a positive correlation between birth weight and growth rate of the animals.

Technical aspects

The cattle management system in the Eastern Islands, which is still extensive, makes it difficult to observe heat and to conduct insemination. Therefore in the early introductory campaign of AI, oestrus had to be synchronised using prostaglandinF2α (PGF2α) or progesterone hormone treatments. All the Bali cows in a single village were pooled, kept in a fenced grassland area built cooperatively by the village farmers and treated with hormones, and they came in heat 2–3 days later. Oestrous symptoms were shown to the farmers to remind them to observe such symptoms even without hormone treatment in the future.

Most farmers, except in Bali, expected and preferred their cows to be inseminated using frozen semen of Simmental or Limousine bulls. Semen of Angus or Brangus bulls was also preferred to Bali semen if no Simmental semen was available.

AI technicians were trained nationally or locally in each province. The Directorate General of Livestock Services (DGLS) soon established the national AI program, including Bali cattle, throughout the country. Frozen semen from Bali, Simmental and Limousine bulls was produced at the AI centres in Singosari (East Java) and Lembang (West Java), and distributed for AI programs in provinces throughout the country.

Social and economic aspects

A survey conducted by the author and staff of social economic aspects of AI, conducted on the island of Timor (West), concluded that community elders and government officials strongly support AI programs in Bali cattle because it improves farmers' income (Toelihere et al. 1995). This support has been proven by establishing organised AI programs in districts and villages in the province. Most farmers are eager to participate in the AI program, but unfortunately some have no cows. Farmers are motivated after witnessing better results from AI than from natural mating.

An AI program in Bali cattle creates financial benefits for farmers. When farmers participate in an AI program they can usually repay their credits within 5 years. The shorter the time required for full repayment, and greater the opportunity of more farmers to own cows and increase their income in a relatively short period.

Factors limiting farmers' participation in AI programs include a low level of education, failure of pregnancy and calving in some cows, and failure to follow recommendations from officials, particularly in the provision of forages and better nutrition for cows.

Intensification of extension activities would result in better farm management and better nutrition for cows. AI programs could be effectively carried out through the establishment of groups and associations of farmers, better organisation aimed at using the rural and religious communities as media for communicating information, and improving the income and welfare of farmers.

Efforts to Increase the Success Rate of AI

Establishment of a Bali cattle breeding centre

A good AI program needs an ample supply of semen from superior bulls, while an embryo transfer (ET) program requires the availability of superior donor cows. These superior animals should be selected from rural farms, reselected, kept, managed, and provided to farmers by a properly established livestock management organisation.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

The establishment of a Bali cattle breeding centre is needed to provide superior bulls for an AI program and superior donor cows for an ET program, and to function as a breeding stock unit to provide and distribute fertile cows for farmers as the commercial stock providers.

Ideally, the breeding centre should be organised by, and under the supervision of, an association of livestock service officers or an intergovernmental collaboration of provinces of eastern Indonesia, for the common benefit of improving Bali cattle in this region. This intergovernmental collaboration might include the meat marketing group, DKI, Jakarta, which is concerned with a continuous supply of lean Bali beef for its large population of consumers.

The location of the breeding centre could be determined by the association, taking into account the availability of a relatively large and suitable land area for development of a large supply of improved pasture, buildings for laboratories and paddocks for grazing.

Laboratories and units in the breeding centre could include an AI lab., an ET lab., an animal genetics lab., an animal health lab. and a forage and nutrition lab., along with basic laboratories or units to support them. A small training unit might also be included in the centre.

A laboratory for frozen Bali bull semen production has been established on the island of Bali. It could be a component or sub-unit of the breeding centre, wherever it might be located. Unfortunately the land area of the Bali bull frozen semen production unit at its present location is not sufficient for establishment of a breeding centre. Other locations on another, larger eastern island may be more suitable.

Financial support for establishment of the breeding centre with all its facilities and human resources could be obtained from local governments in the region and from other national entities as well as international institutions and organisations.

Breeding policy: crossbreeding and purebreeding

The intergovernmental organisation of eastern Indonesia should create a breeding policy on Bali cattle production in the region. This policy should be based on the conservation of a pure and superior Bali cattle breed, and on crossbreeding with *Bos taurus* to increase farmers' income. Conservation of the pure Bali breed should be conducted in isolated upland areas, while crossbreeding could be carried out on farms in the lowland areas close to the routes to market, on the outskirts of cities and ports to facilitate fast marketing and transport.

Crossbreeding using AI and *Bos taurus* semen significantly increases the productivity of the F1 generation. Birth weight (ADG), and body weight at three and six months of age are all greater than for pure Bali cattle (Toelihere et al. 1990). The F1 males are infertile and should be sold for slaughter.

Bali cows are good cows for crossbreeding, and should therefore be available in relatively large numbers. However, farmers need compensation for running only Bali cattle and — given that Bali cattle are better breeding cows in a crossbreeding program — the price of pure Bali cattle will need to be raised, as determined by the intergovernmental association of the Eastern provinces.

To enhance this program, the island of Bali should be kept free from other breeds of cattle and AI in Bali cows on this island should use semen from pure Bali bulls only. A decision to keep certain islands or areas of an island in eastern Indonesia for breeding pure Bali cattle while allowing crossbreeding on other islands or other areas of the islands might be taken and implemented by local governments in the association mentioned earlier.

Inter-island trading and the export of the Bali breed and its crossbreds could also be arranged through that association, along with other governments or associations within or outside the country, and is recommended for their mutual benefit.

Acceleration of AI activities through oestrous synchronisation

It is generally believed that the AI program conducted for more than 20 years in Indonesia has increased the productivity of dairy and beef cattle in this country (DGLS 1997). Nevertheless, consumers' demand for beef has never been fulfilled due to the rapid increase in the human population and the rise in living standards. Despite this, the welfare of the farming community has not been raised significantly during these years. A new paradigm, based on increasing farmers' welfare rather than increasing commodity productivity, should be considered (Winoto 2001).

AI activities in Bali cattle can be accelerated through oestrous synchronisation and mass insemination to improve the economic situation of farmers in eastern Indonesia. Synchronisation of oestrus is based on the use of one or other of two hormones: PGF2α and progesterone. Both methods induce oestrus in a large number of cows in a herd during a relatively synchronised period of two to three days after the end of treatment. Bali cows respond very well (about 92% came in heat) to intra-uterine administration of PGF2α with an effective dose as low as 3 mg (Toelihere et al. 1989). However the conception rate in insemination after oestrous synchronisation with PGF2α is relatively low. The

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

target organ of PGF2α is the corpus luteum (CL) in the ovary. The lifetime of the CL is around 12 to 15 days of the 21 day oestrous cycle, while the follicular waves rise and fall in two to three periods of the cycle. Regression of the CL due to PGF2α administration may not occur in congruence with the dominant follicular growth. Hence, CL regression and the appearance of heat may not occur synchronously with ovulation.

Treatment with progesterone hormone seems to show better results. Progesterone treatment not only synchronises oestrus, but also induces cyclic activity in post-partum anoestrous cows. Intra-vaginal implants of progesterone (CIDR-B; controlled internal drug release — bovine)[1] for seven days in anoestrous dairy cows resulted in 80% cows in heat with a conception rate of 71.4%. Injection of PGF2α on day 6 during a 7 day treatment with progesterone (CIDR-B) and estradiol benzoate (CIDIROL) gave even better results (90.0% oestrus and 77.8% conception rate (Solihati 1998)). The author has used progesterone implants (CIDR-B) to synchronise oestrus in Bali cows in Timor with almost identical results.

Intramuscular injections of progesterone hormone (Potahormon[2]) in post-partum anoestrous Bali cows with a single injection of 62.5 mg and double injections of 46.87 mg, each five days apart, resulted in 90–100% oestrus and the conception rate reached more than 75% (Poha 2000). Oestrous symptoms become more intensive if progesterone treatment is combined with estradiol benzoate injection about three days after the progesterone injection.

Conclusions

1. Bali cattle are the indigenous cattle in Indonesia with high heat tolerance, and are well adapted to this tropical country. They still reproduce with high fertility even under poor nutrition and poor environmental conditions.
2. The genetic quality of Bali cattle is continuously declining due to a) ‘negative selection’ in which large, superior bulls are sold for slaughter and inferior ones are left to mate with cows, and b) inbreeding and constant poor nutrition.
3. The oestrous period in Bali cows lasts as long as or longer than in other species of cattle, which gives them ample time for mating and results in high fertility compared with other breeds.
4. Artificial insemination (AI) technology is technically applicable, socially accepted and economically feasible in a Bali cattle production system.
5. Lack of identified superior bulls and cows may cause a setback in AI and ET programs designed to increase the genetic quality of Bali cattle.
6. Uncertain and unclear breeding policies also obscure the strategy and ultimate goals of Bali cattle husbandry.
7. Crossbreeding of Bali cows with semen of *Bos taurus* bulls produces an F1 generation of superior quality due to heterosis, although the F1 males are infertile.
8. AI activities can be accelerated through oestrous synchronisation using PGF2α or progesterone treatments.
9. Oestrous synchronisation using seven day intravaginal progesterone implant (CIDR-B) or injection of progesterone hormone results in more than 80% oestrus and more than 70% conception rate.

[1] Produced by Interag, New Zealand
[2] Produced by CV Wonder, Jakarta

References

Darmadja, D. 1980. Setengah Abad Peternakan Traditional dalam Ekosistem Pertanian di Bali. Disertasi. UNPAD, Bandung.

Devendra, C.T., Choo, L.K. and Pathmasingan, M. 1973. The productivity of Bali cattle in Malaysia. Malay. Agric. I.49, 183–197.

Directorate General of Livestock Services (DGLS) 1997. Evaluasi Kinerja Pelaksanaan Inseminasi Buatan. PT. Galih Karsa Utama Jakarta Selatan.

Fattah, S. 1998. Produktivitas Sapi Bali yang Dipelihara di Padang Penggembalaan Alam (Kasus Oesu’u, NTT). Disertasi. UNPAD, Bandung.

Kirby, G.W.M. 1972. Bantengs — A New Sources of Genes. Turnoff., 4, 6–8.

Moran, J.B. 1971. Advance in Northern Cattle Breeds. Chiasma, 9, 59.

Mulyono, E. 1977. Penelitian Penggunaan Prostaglandin pada IB di Bali. Insp. Dir. Pet. Dati I Bali & FKH-UGM.

Payne, W.J.A. and Rollinson, D.H.L. 1973. Bali Cattle. World Anim. Rev. 7, 13–21.

Pohan, A. 2000. Perbaikan Penampilan Reproduksi Sapi Bali Anestrus Postpartum melalui Pemberian Progesterone dan Estrogen. Thesis. IPB, Bogor.

Solihati, N. 1998. Penggunaan Kombinasi Progesterone Intravaginal dengan PGF2α dan Estrogen dalam menimbulkan Estrus dan Kebuntingan pada Sapi Perah Anestrus. Thesis. IPB, Bogor.

Toelihere, M.R. 1981. Inseminasi Buatan pada Ternak. Angkasa, Bandung.

Toelihere, M.R. 1994. Tinjauan Aspek Reproduksi dan Pemuliaan Ternak Sapi Potong di Kawasan Timur Indonesia. Makalah. Lokakarya Pengembangan Peternakan Sapi di Kawasan Timur Indonesia. Mataram, 6–8 February.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Toelihere, M.R., Yusuf, T.L., Burhanuddin, Belli, H.L.L. and Dewi, I.G.M.K. 1989. Studi tentang Transfer Embrio Tampa Pembedahan pada Ternak Sapi Bali. FAPET, UNDANA, Kupang.

Toelihere, M.R., Jelantik, I.G.N., Kune dan, P.L. and Yusuf, T.L. 1990. Pengaruh Musim terhadap Kesuburan Ternak Sapi Bali di Besipae. Laporan Penelitian, FAPET, UNDANA, Kupang.

Toelihere, M.R., Yusuf, T.L., Burhanuddin, Belli, H.L.L., Kune, P., Tahitor, K. and Krova, M. 1995. Produksi Semen dan Embrio serta Penerapan Teknologi Inseminasi Buatan dan Transfer Embrio pada Sapi Bali di Timor. Laporan Penelitian Hibah Bersaing Perguruan Tinggi. FAPET, UNDANA, Kupang.

Wardoyo, M. 1950. Peternakan Sapi di Sulawesi Selatan. Hamera Zoa 56, 116–118.

Winoto, J. 2001. Kebijakan Pembangunan Pertanian dalam Paradigma Baru Pembangunan Pertanian. Makalah. Forum Diskusi Pembangunan Pertanian dan Pedesaan. IPB, Bogor.

Yusran, M.A., Wardhani, N.K. and Ma'sum, K. 1990. Kecepatan Tumbuh dan Konversi Pakan Sapi Bali Jantan Muda dan Hasil Persilangan dengan Hereford. Proc. Sem. Nas. Sapi Bali. C17–C19.

Livestock Improvement: Issues related to Autonomy

Kedi Suradisastra[1]

Abstract

The effort to develop livestock production is strongly related to decisions made by institutions in various fields and sectors in a given area or region. The opportunity to develop animal production results from interactions between commodity, sectoral and location factors as well as between the proper use of human resources and related factors in development such as technology, socio-economic conditions and variations in ecosystems within a particular area. It should be sustained by appropriate policy, by infrastructure, by capital and investment, by appropriate technology and by the participation of stakeholders. Furthermore, the direction and objectives of livestock industry development should be guided by a national initiative in the form of a macro-policy to be adjusted and implemented at the local level.

Livestock Development: a Policy Overview

The stakeholders in livestock development

The stakeholders in livestock development, and its beneficiaries, consist of:
- local people and institutions;
- government and related institutions;
- private companies and industry, including domestic and foreign corporations;
- education and research institutions;
- development organisations.

These groups of stakeholders and beneficiaries interact one with another and, in turn, provide support and necessary input as well as producing output for policy makers and stakeholders in livestock development.

Determining factors in livestock production

In general, five inter-related determinants in the process of livestock development are recognised:
- the supporting policy on development;
- capital and appropriate investment;
- appropriate knowledge and technology;
- infrastructure and external factors;
- participation of stakeholders.

[1] Deputy for Investment and Finance, Office of the State Minister for Development Acceleration of Eastern Indonesia, JI. Merdeka Barat No. 15, Jakarta 10340, Indonesia

The supporting policy on livestock development

Coordination and cooperation among sectors, between both government and non-government institutions, to accelerate the growth and development of livestock industries in Indonesia requires a direction that can be adjusted according to various situations in the country. Indonesia's vast ecosystem and cultural and economic discrepancies require a flexible yet well-directed livestock industry development policy. To support this objective, a national initiative that functions as a broad guide to the process of livestock industry development is essential. The intended policy needs to be a product of inter-sectoral, inter-institution interaction and coordination. The key requirement is that the development of a livestock industry should be inseparable from national integrity — whether technical, biophysical, socio-cultural or economic — and needs to be delineated in the following strategies:

- expansion of livestock production centres to enhance employment opportunities and to add value through proper livestock industry investment and development;
- expansion of participatory cooperation between sectors to expand the industry;
- improved performance of livestock-related industries and institutions.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Capital and appropriate investment

It is obvious that capital and investment are significant factors capable of accelerating livestock development. In the context of autonomy, local authorities are now responsible for expanding local development plans and seeking capital for their region's development. Yet, there are particular approaches that should be considered for livestock production:

- selection of capital and investment appropriate to the area in question;
- an approach to infrastructure development that supports development of the livestock industry;
- selection of appropriate livestock technology.

Appropriate knowledge and technology

The design and availability of livestock technology are key factors in livestock development at the regional level, from the point of view of both investment and the end-user of the technology. Technological support that is appropriate to the existing ecology, relevant to the goal of development, socially accepted, and suitable in competitive terms, is the ultimate key to better livestock development. The major problem is how to introduce such a technology in a package that serves the needs of a livestock enterprise in terms of both physical and economic size, and which is also sufficiently flexible and robust.

Infrastructure and external factors

Physical infrastructure and external factors — such as markets and marketing facilities, ports and harbours, transport and other communication infrastructures — all have a significant impact on livestock production and development. From the institutional side, it is imperative to note the significant roles of local and traditional institutional infrastructures. Local institutions usually possess social energy to accelerate livestock production and development. Examples of existing institutions relevant to livestock production are traditional sharing arrangements such as the *sumba* contract in East Nusa Tenggara, and *epawaa* and *iyoobai* in the Regency of Paniai, Papua.

Participation of stakeholders

The stakeholders in livestock development are both the subjects and the users of a livestock development program. They are the primary participants in the process of technology adoption and adjustment and in capitalisation and investment, and the primary users of infrastructure and other development facilities. Their participation is therefore essential as a major ingredient in local and regional development.

The participation of stakeholders in livestock industry development is inseparable from the existing policy and from the political and socio-economic situation and the level of 'operationalisation' of livestock technology. A policy that supports livestock development should be able to appeal to the values of the industry's stakeholders and beneficiaries. Such values vary among development areas, ecosystems and local economies and socio-cultures. In view of this variability, proper strategies and approaches are required to harness stakeholders' potential so that they can properly participate in local livestock industry development.

Autonomy Issues

The future of livestock development is facing various challenges, including:

- inter-relationships among sectors such as industry, trade and the environment;
- the need for sustainability of sub-sector development;
- the increasing and dynamic demand for livestock products;
- more market-oriented policies.

These challenges will affect both the behaviour and the situation of livestock producers. One of their consequences is that small farmers are expected to be directly involved in both domestic and global marketing activities. Yet the future direction of livestock development at the provincial level is a result of interaction between the determining factors and issues related to autonomy.

Governmental decree No. 25/2000 embodies both an autonomy policy and the strategies for implementing it. The transfer of authority from central to local government will be accompanied by a shift in the development paradigm, as well as a change in implementation of the development policy. The implementation of autonomy as set out in decree 25/2000 in the sector of agriculture has raised the following issues:

- Centralised management is changing to decentralisation in terms of the implementation of local policy, finance, and the decision-making process. The centralised mind-set is changing into area-specific patterns of thought in terms of techno-socio-economy and cultural issues, so that the future decision-making process involves all elements in a designated system of development. Therefore, given their knowledge of the genetic potential and variation of animals, involving local and traditional communities in such a process may help accelerate and direct the process of genetic improvement.

- The function of the bureaucracy, which often appears obstructionist, will change to a form of regulation that is more facilitating in nature. Within this context local government is expected to develop local initiatives to select animal breeds, determine numbers, and invite experts and investors in the livestock industry to participate in an improved way.
- Material needs in terms of labour will be transformed from a mere number of units into a requirement for knowledgeable manpower. Consequently, the management style should also be shifted: from quantitative management to qualitative supervision. This could provide qualified experts in animal production and genetics with a great opportunity to design and develop appropriate genetic improvement programs.
- The decision-making process in the management of agricultural development will become a competitive management arrangement. The monopoly of central government change to a more facilitating process that will suit specific situations, be more populist, and be directed towards positive competition in terms of opting for decisions that provide greater advantages for the system.
- The use of telecommunication infrastructure will be replaced by the use of information technology infrastructure — the outcome of convergent interaction between telecommunications and computer, and information technology. The new paradigm is that local government will have more freedom to seek information and technology related to its specific needs, including information on technology for livestock production.

A further implication of these paradigms for livestock development is a requirement for a regulatory arrangement that can anticipate possible changes in both production and market situations. The transformation of these paradigms will emphasise the uniqueness and specific needs of the locality (e.g. at the provincial or regency level). As a consequence, a transformation from a decision-oriented management style to coordinated management will take place. The central government (e.g. the Directorate General for Livestock Services) will play a more coordinating role to anticipate the needs of livestock development at the provincial level. The future role of the central government will be to produce macro-initiatives instead of merely developing standardised livestock and genetic improvement policies. Such macro-initiatives are required to anticipate specific situations that cannot be resolved by local government.

At the local level, the shift of the development paradigm in the agricultural sector changes the measure of sectoral development. The inter-sectoral approach will change for the strategy for individual commodities, due to the different targets at the local level. Agricultural development at both national and local levels will aim at a system equilibrium in relation to other sectors, other development systems or other provinces. Both inter-insular and inter-regional links will increase. Competition in production, motivation and inter-sectoral enterprises will sharpen.

The concept of development components will also change, in accordance with the goal of local development. The old paradigm assumed that job opportunities were quantitatively related to the capacity of the development activity, the type of project, and the number of companies or local development institutions involved. The greater the number of projects, the better the possibility of generating employment.

On the contrary, the new paradigm emphasises rather the quality of available resources. In the context of autonomy, the human resources currently available cannot be channelled into particular development activity; local development policy should be adjusted to take account of the available resources and potential. The consequence of such a shift is that the speed of the development process will not be the same for each locality due to the differences in local resources and potential.

The new paradigm also brings about changes in strategy for each sector of development. In the agriculture sector, single-sector or single-commodity approaches will be transformed into an approach where biophysical elements, technology and socio-economic issues are all considered in an integrated and holistic fashion.

At the same time, technical approaches to local assets and potential that have relied on comparative advantage will change into approaches based on competitive advantage. The perception of competitive advantage should be founded on an inter-sectoral and inter-commodity approach, both vertically and horizontally.

The Approach

The partial development approach that has been employed in livestock development so far has widened socio-economic gaps between farming communities. It also contributed to the existing institutional competition and institutional imbalance. This pattern needs to be converted into a holistic, inter-sectoral and inter-institution approach embodying shared objectives to develop particular areas and regions in a system of development. In such an approach, livestock should be viewed as an element of the system. Its potential should be evaluated and systematically analysed so it can be given either a supplementary or a complementary function within a development area, or even play a substitute role to other elements in a development system. The system approach that includes physical, technical, socio-economic and institutional elements based on real needs could bridge the gap between a number of points of view and help bring about optimum development output.

Since local policy and issues of autonomy play important roles in the implementation of technical know-how, a shared understanding of the philosophy and policy strategy behind livestock development is required. Shared understanding is needed of the following issues:

- The area or region to be chosen for development: An area envisaged for development should be selected and carefully defined, based on the technical and biological requirements for livestock development. Cognisance should be taken of the existing ecosystem, the livestock commodity to be developed, the genetic variability of the animals involved, and stakeholders' knowledge and command of technology related to livestock development. An area of development should be viewed as a total system that consists of physical, technological, socio-cultural and economic elements.
- An integrated approach: The approach should apply the philosophy of a total system with holistic, inter-sectoral and inter-institution methods embodying shared objectives to develop the area or region as a system. In relation to the genetic improvement of cattle, the primary concern should be to establish a process for mobilising livestock-related sectors to review and to analyse each sector's partial estimate of the likely goals. It is also important to scrutinise the possible inter-sectoral effect of a genetic improvement program in a development area.
- The need for affirmative action: Since livestock rearing is often considered a slow-return activity, it is important to adopt an affirmative policy to accelerate livestock production in particular production pockets, through genetic improvement. In many parts of the country, social conditions are generally less supportive of livestock breeding, for understandable reasons. Therefore, it is imperative to apply a tailored social reconstruction strategy through farmer education programs. It is also important to approach livestock production problems from an institutional point of view and to use the views of institutions as a basis or direction for genetic improvement in the area. Local institutions are generally able to accommodate farmers' aspirations and are also capable of transformation into new and better organisations serving the needs of local people.

References

German Advisory Council on Global Change. 1997. World in Transition — The Research Challenge. Springer Verlag, Berlin.

Keputusan Menteri Pertanian Nomor 798/Kpts/OT.210/94 Tentang Organisasi dan Tata Kerja Balai Pengkajian Teknologi Pertanian dan Loka Pengkajian Teknologi Pertanian.

Peraturan Pemerintah Republik Indonesia Nomor 25 Tahun 2000 Tentang Kewenangan Pemerintah dan Kewenangan Propinsi Sebagai Daerah Otonom.

Undang-undang Republik Indonesia Nomor 22 Tahun 1999 Tentang Pemerintahan Daerah.

Undangndang Republik Indonesia Nomor 25 Tahun 1999 Tentang Perimbangan Keuangan Antara Pemerintah Pusat dan Daerah.

Options for Genetic Improvement of Bali Cattle — Assessing the Strengths and Weaknesses of Alternative Strategies

Option 1. Full program with all technologies and facilities available

Brian Kinghorn[1]

Abstract

There are many reproductive technologies available to cattle breeders and those breeders or, more particularly, groups of breeders who use them will need to shift their breeding and selection practices and philosophies to get maximum benefit from them. Techniques such as artificial insemination, multiple ovulation and embryo transfer and cloning have the capacity to increase fecundity many-fold in individual animals. Others, such as molecular assisted selection, may assist in improving accuracy of selection for individual traits. Boosting reproductive performance can enhance genetic gain considerably, but at both a financial and genetic cost. The major genetic penalties are the increase in inbreeding and loss of genetic diversity. By using a program called GENUP we can predict the sort of improvement in genetic gain that is possible. This paper discusses the magnitude and importance of a range of technologies in improving genetic gain. In general, reproductive technologies have much greater impact than molecular assisted selection, which should be confined to areas where it has maximum benefit such as carcass traits and disease resistance.

Introduction

IN any animal breeding operation there are two key questions to ask:

- Where to go?
- How to get there?

'Where to go?' is about breeding objectives. There are two basic approaches to developing breeding objectives. One is to describe the types of animal we would like to breed. We can do this most efficiently if we use a method or computer program that constrains our thinking to the range of possible genetic change that can be made. The other approach is to be more economically rational, calculating the economic benefits of each unit change in each trait of commercial importance.

'How to get there?' relates to the methods that we can use to most efficiently generate genetic change in the desired direction. This involves a range of issues, including the following:

Issue	Comment
Selection value	As indicated by estimated breeding values
Inbreeding	Avoid loss of merit and genetic variance
Crossbreeding value	Breed differences and heterosis
Connection	Comparing animals from different groups
Assortative mating	Elite matings, giving longer-term gains
Measurement strategies	e.g. progeny testing; multi-stage selection
Quantitative trait loci	Detection and use of 'major genes'
Parameter estimation	e.g. heritability — good for longer-term gains

[1] School of Rural Science and Agriculture, University of New England, Armidale, NSW 2351, Australia

[2] Multiple ovulation and embryo transfer

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Issue	Comment
Lifetime value	For ongoing harvesting and reproduction
Reproductive manipulation	MOET[2], IVF, sexing, cloning etc.
Running costs	Number of breeding females, semen costs, etc.
Risk	Staying in business

Ideally, we need to pay attention to all these issues — and we need to tie them strongly together, using progressive information systems. This paper discusses what can be done if there are no constraints on funds, resources and expertise.

Reproductive Technology and Designs to Exploit it

Reproductive technologies such as artificial insemination (AI) and multiple ovulation and embryo transfer (MOET) can be used to increase fecundity by a large amount. This increases selection intensity and, in turn, genetic gains.

The best design for a breeding program often changes when these technologies are used. As someone once said, turning a cow into a sow means we should shift from cattle to pig designs.

Cloning is an extreme form of reproductive boosting. It has different consequences for breeding and production programs because it does not involve production of genetic variation through sexual propagation.

Multiple ovulation and embryo transfer

In MOET, females are superovulated by hormone injection and mated; multiple embryos are then collected and transferred to host females. These host females play no part in the genetics of the breeding program.

Unfertilised ova can be collected from both adult and juvenile females in a process referred to as oocyte pickup. A description of the state of the art in MOET, oocyte pickup and related technologies is provided in Kinghorn (2000b).

MOET improves the rate of genetic improvement because of the favourable effects of high reproductive rate on three key factors:

- increased selection differential;
- reduced generation interval;
- increased accuracy of estimated breeding values.

Increased selection differential and reduced generation interval

The above factors can be shown by example, using the program GENUP, which can be downloaded from Website http://metz.une.edu.au/~bkinghor.

If you want to try this example, run the GENUP module AGES, and:

> If the default GENUP data set has been retained, you should find a response of 0.077 kg fleece weight per year. Optimise age structure and this should increase to 0.082 kg per year, keeping males and females for 2 and 4 matings respectively. For help in running AGES, hit key F1 after loading it.
>
> Without MOET the weaning rate is taken as 0.95 lambs weaned per ewe mated. Increase this fourfold, to 3.8 lambs weaned per donor ewe mated, to simulate MOET, and optimise age structure. The response should increase from 0.082 kg to 0.1412 kg. Notice that this affects the values of selection intensity, *i*, and generation interval, *L*, considerably, and the optimum age structure is now considerably younger — keeping males and females for 1 and 2 matings respectively.
>
> Notice that with MOET we have both higher selection intensity and lower generation interval for both sexes, not just females: higher reproduction means fewer females to get the same number of progeny — and these fewer females can be mated by fewer males!
>
> Notice also that with MOET, the figure of 1000 breeding females relates only to superovulated donor ewes. The breeder needs to maintain a large pool of recipients, making this a very expensive program to run.

Increased accuracy of estimating breeding values (EBVs)

Recall that increased accuracy of estimating breeding values leads to wider distributions for EBV. This is illustrated in Figure 1.

Figure 2 illustrates the value in placing more emphasis on measuring males. The lower proportion required for breeding can be capitalised on by more measurement and thus wider EBV distribution.

We can use this approach to illustrate the effect of boosting male and female fecundity through AI and MOET (Fig. 3).

Natural matings EBVs calculated properly from a selection index calculation or a BLUP analysis have one very useful property: The predicted merit of progeny is simply the average of the EBVs of the two parents used, as shown in Figures 2 and 3.

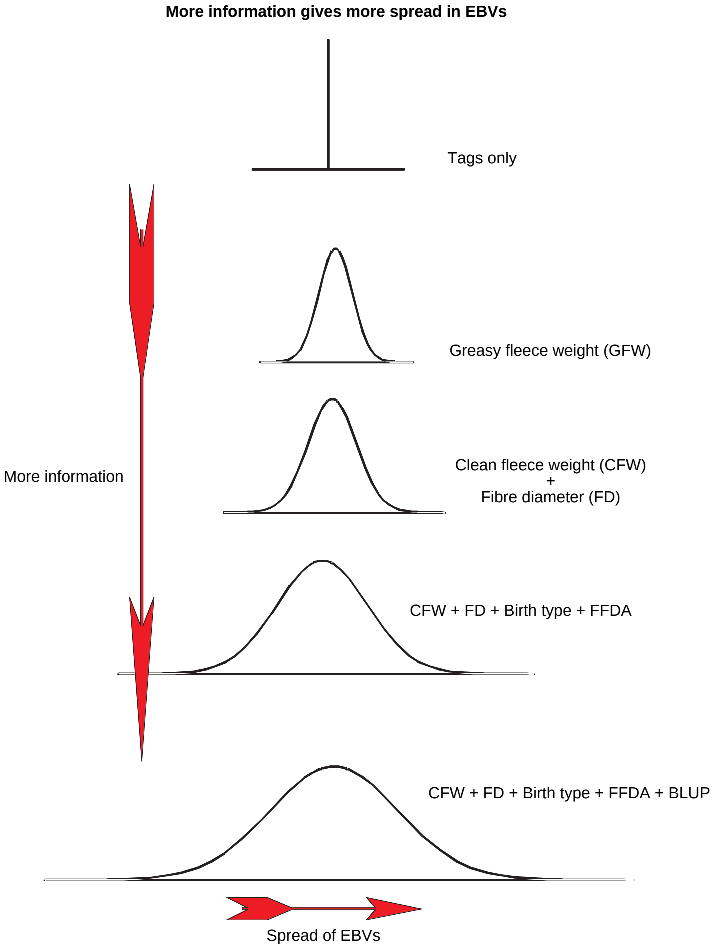


Figure 1. The relationship between amount of measurement made and the width of EBV distributions.
If the only information available is animals' tag numbers, there is no power to identify superior (or inferior) animals and no variation in EBVs.
If GFW is known there is some such power — and yet if FD is of key importance in the objective this power is obviously limited. Animals of exceptional breeding value are difficult to identify as the most important trait is not measured.
As more information is gathered, there is more power to identify animals of low and high breeding value, and the EBV distribution widens.
Information from relatives also helps here, as in the distribution at the bottom, which uses BLUP genetic evaluation.

A smaller proportion of rams than ewes can be selected for breeding, contributing to their high mean EBV. The other factor, in this case, is the greater amount of information used to calculate ram EBVs, reflected by a wider EBV distribution. If using MOET, the value of taking more measurements in ewes (as well as rams) becomes higher.

Notice in Figures 2 and 3 that the predicted merit of progeny is simply the average (or half-way point) between the selected rams' and ewes' mean EBVs. The width of the EBV distribution of the progeny depends on how intensively they are measured.

AI: increased selection intensity With the use of AI the best few rams can be selected for breeding. This means that the average EBV of rams used is higher, as can be seen in Figure 3 — only the very best rams contribute to the average EBV of rams. This increase is diluted 50% by the ewe contribution, but in Figure 3 the net increase in predicted merit of

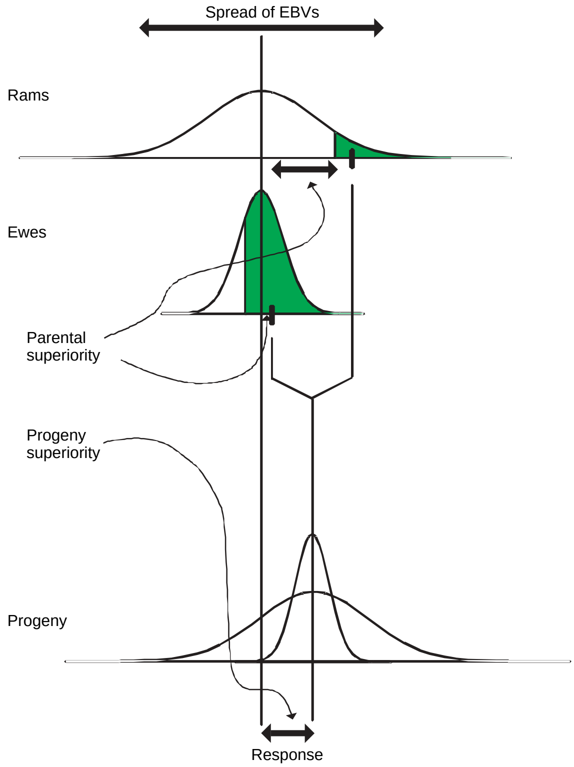


Figure 2. Response to selection over one generation depends on accuracy of selection (reflected in width of EBV distribution depicted by the bell-shaped curves), and proportion selected. Males are measured more here, giving wider distributions.

progeny is quite visible compared with natural mating, where the selection intensity of rams is lower.

MOET: increased selection intensity and more information for estimating breeding value With MOET, each selected ewe can contribute not just one or two lambs, but up to about six lambs per donor ewe, a figure which continues to improve. As with AI, this brings about the ability to select fewer ewes as donors of genetic material (though many recipient ewes are still required to carry the lambs). Moreover, in an ongoing breeding program using MOET, candidates for selection will usually have a number of full brothers and sisters available with records. This information helps to improve the accuracy of EBVs, and the distribution of EBVs increases accordingly. Both these favourable effects are seen in the bottom diagram in Figure 3.

The favourable effects of reduced generation interval cannot be shown in this simple manner, but are discussed in the next section.

Even so, Figure 3 shows that AI and MOET, if properly used, can bring about a notable increase in the response to selection. Current theoretical predictions suggest that a MOET program will give up to about 25% extra gain over a normal breeding program. Steps to avoid increased rates of inbreeding have moderated predictions substantially.

Juvenile MOET schemes versus adult MOET schemes

Beef MOET schemes differ from dairy MOET schemes because key traits can usually be recorded before or close to sexual maturity, rather than well after this stage as in dairy cattle. Figures 4.1a–c illustrate the life history in an adult MOET scheme for beef cattle.

A 'juvenile' MOET scheme in beef implies collecting oocytes before sexual maturity, as in Figure 4(a).

In Figure 4(b) the oocyte pickup is carried out on 6 month old females (e.g. 21 months into the scheme) based on their parents' records (at 14 months). In Figure 4(c) the oocyte pickup is carried out on 3 month old females (e.g. 15 months into the scheme) based on their parents' records (at 14 months).

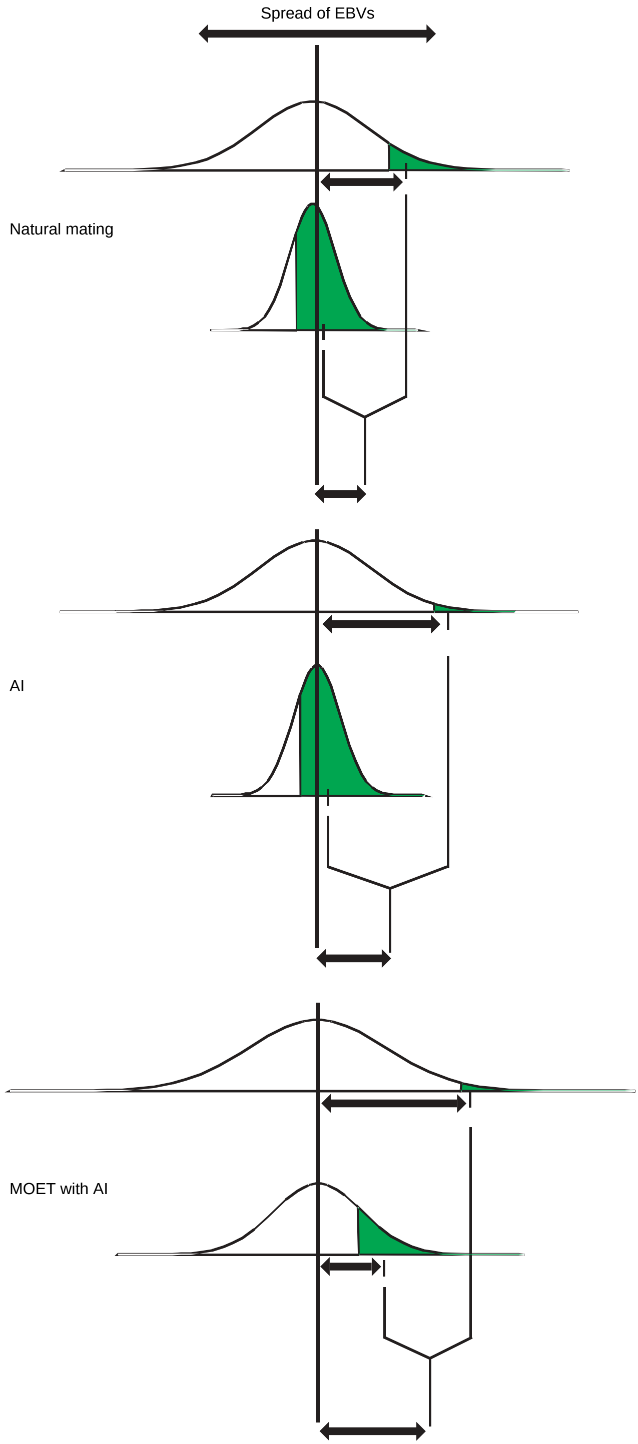


Figure 3. The impact of AI and MOET (middle and lower diagrams) on selection response, compared with natural mating (upper diagram). Refer to Figure 2 for orientation and to text for explanation.

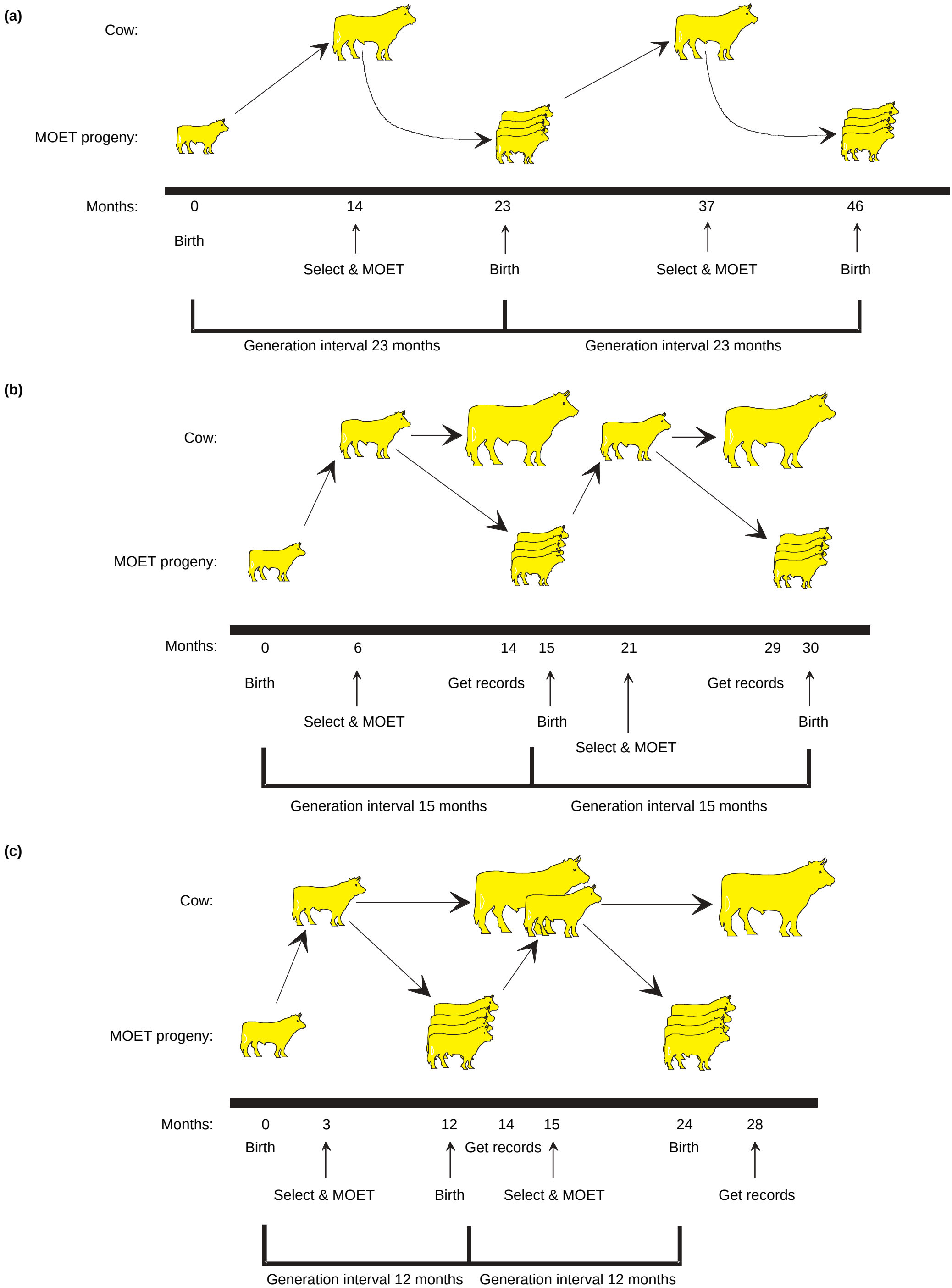

(a)
Cow:
MOET progeny:
Months:
0
14
23
37
46
Birth
Select & MOET
Birth
Select & MOET
Birth
Generation interval 23 months
Generation interval 23 months
(b)
Cow:
MOET progeny:
Months:
0
6
14
15
21
29
30
Birth
Get records
Get records
Select & MOET
Birth
Birth
Select & MOET
Generation interval 15 months
Generation interval 15 months
(c)
Cow:
MOET progeny:
Months:
0
3
12
14
15
24
28
Birth
Get records
Birth
Select & MOET
Birth
Select & MOET
Get records
Generation interval 12 months
Generation interval 12 months

Figure 4(a–c).

Carrying out oocyte pickup earlier than 3 months (see JIVET below) means that slaughter records on 14 month old parents will not be available. Again, information from genetic markers might well make oocyte pickup of value at younger ages, even pre-natally.

Juvenile in-vitro embryo transfer (JIVET) JIVET involves collection of ova from sexually immature females, followed by in-vitro fertilisation (IVF). JIVET has already been implied in the last selection, wherever fertilisation takes place in vitro.

Techniques for manipulating waves of follicular activity have resulted in recovery of high numbers of oocytes from females. This has also been successful at a research level with juvenile animals such as six week old lambs and eight month old calves, whereby the reduction in generation interval is expected to lead to notable increases in rates of genetic gain. However, it should be noted that there are considerable animal welfare issues associated with these procedures on juvenile animals.

By carrying out IVF it is possible to mate each female with many males. If we can collect an unlimited number of eggs, a good design is to mate every male and female together in a cross-classified design. Simulation results suggest that such a scheme could give twice the response to selection that a full national dairy program can, with similar rates of inbreeding (Kinghorn et al. 1991).

If we succeed in having a high degree of control over fecundity, we are left with the decision of how best to use it. Reproductive boosting gives higher genetic gain, but at a penalty of increased inbreeding and lost genetic diversity. At the extreme it also constitutes high risk, by 'putting all the eggs in one basket'. These problems can be handled in an appropriate mate selection scheme, such as Total Genetic Resource Management (TGRM) (Kinghorn 2000a).

Sexing of Semen or Embryos

Sexing of semen or embryos has long been a dream of animal scientists. There has been a long history of effort in this area, but there are prospects for practical implementation in the near future. As with cloning, the main impact of semen sexing is to raise efficiency of production systems rather than to improve the rates of ongoing genetic improvement.

The value of sexing for genetic improvement programs

Sire selection is the main driver of most breeding programs — because we need to select only a small number of sires from the same number of candidates as we have for dams. However, it is interesting to contemplate that if we generated fewer male candidates and more female candidates, perhaps making the selection proportions equal, we might make better selection responses. Unfortunately, as Figure 5 shows, this approach leads to very little extra selection response. Using such simple models, it is difficult to generate a prediction of more than 5% extra response compared with using a 50:50 sex ratio.

However, we can improve on this for production systems such as dairy, where key measurements can be made only on females. The argument is not simple — we would still need to milk more females to get more information, and milking spaces are usually the limiting factor. Increasing the number of female offspring from matings to progeny test young bulls would lead to higher selection accuracies, and/or the ability to test more bulls. Increasing the number of male offspring from elite matings contracted by breeding centres to produce bull candidates for progeny testing would also give some benefits, essentially increasing pressure on the cow-to-breed-bull pathway.

Semen or embryo sexing can be used as part of an IVF program to help improve response. However, results have been disappointing. Sexing in the cross-classified dairy scheme described earlier added only between 1.3% and 3.0% to predicted response. This sort of gain is unlikely to be worth the cost and the reduction in birth rate, which were not accounted for in the study by Kinghorn (2000b).

Sexing of semen and embryos holds much more promise for animal production systems than for genetic improvement systems (Kinghorn 2000b).

Cloning Technology and Designs to Exploit It

Introduction

Cloning is an extreme form of reproductive boosting. Clonal propagation has long been used in plant breeding. It exploits the genes in the best individuals, but it also exploits the favourable way in which these genes work with each other in these individuals. Such favourable partnerships can be broken down when they are mixed with other genes in the normal breeding cycle.

Thus, clones are somewhat static — they are good at providing high productivity, but not so good at creating future generations of better-performing individuals. The latter requires genetic variation — variation from which the new elite can be chosen.

This variation is generally not lost with other forms of reproductive boosting such as oocyte pickup (Kinghorn 2000b). These can lead to some of the direct benefits of clones, through widespread use of elite individuals, but with a maintenance of genetic diversity which can lead to further gains in the following generations.

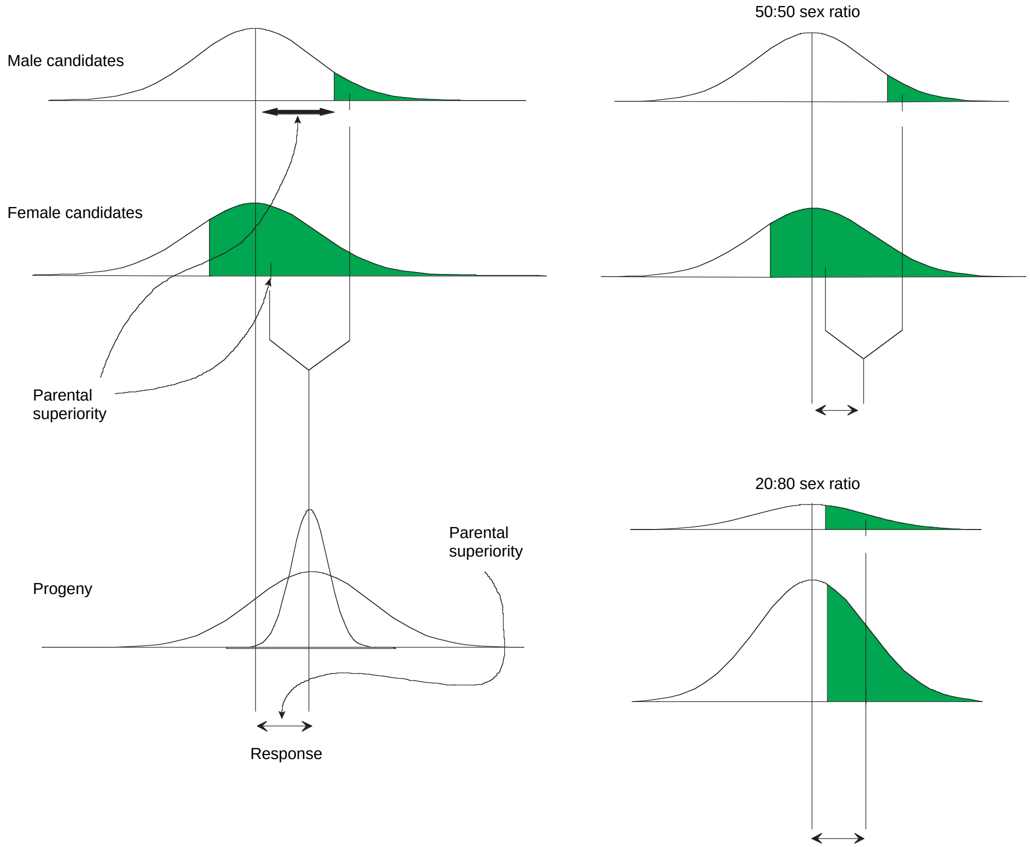


Figure 5. The left half of the figure illustrates selection in males and females on EBV, and transmission of the resulting superiority to the progeny generation. This is repeated more simply at upper right, with a 50:50 sex ratio. At lower right, the sex ratio has been altered using semen sexing such that there are more female candidates than male candidates for selection — and yet the same number of candidates of each sex need to be selected as parents (the shaded areas have the same area as for 50:50 sex ratio). Notice that semen sexing has added little to response.

We can now generate genetically identical individuals from embryonic or even adult tissue (Kinghorn 2000c). For current processes using nuclear transfer, the nuclear genes are identical between clones. Only the cell organelles are non-identical. We cannot know that the resulting animals will be genetically elite — we can only aim at this by using elite parents to generate embryonic tissue, or using elite adults that have performed well. This section considers how we might choose which animals to clone, how to use the clones, and what impact this might have.

A simple example

As with normal breeding practices, luck can still play a big role in the choice of individuals to clone. Figure 6 compares exploiting a superior ram, either through cloning or through generating progeny. First of all, some of the ram's observed superiority of 1 kg fleece weight is expected to be due to luck in the environmental factors which have affected his performance. This accounts for about 40% of his performance at the top of the left-hand bar in the diagram.

About 40% (the heritability of fleece weight) of his performance is expected to be reflected by the value of his genes to his progeny, giving an EBV based on his own performance of 0.4 kg. However, favourable interactions among his own genes are expected to result in about 60% of his superiority being due to the value of his own genes to himself. This is also the expected value of his genes to his identical clones, such that the expected superiority (merit) of his clones is not 1 kg, but 0.6 kg.

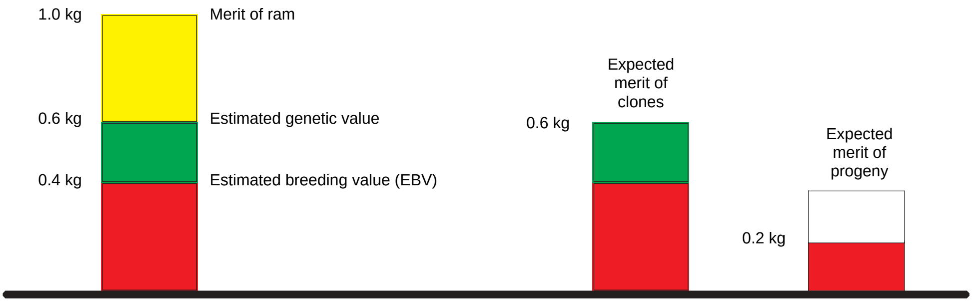


Figure 6. Merit of clones and merit of progeny from a ram with a 1 kg superiority in fleece weight.

If the ram is mated to average ewes, the performance of his progeny is expected to be the average of his EBV (0.4 kg) and that of average ewes (0 kg superiority), or 0.2 kg. Thus cloning would be expected to yield about three times as much extra merit (0.6 kg) versus 0.2 kg. Whether we could spread an individual's genes as widely through cloning as we can through AI remains to be seen.

However, these predictions of clones and progeny merit are exactly that — predictions. The actual outcome in any one case is subject to luck. The ram may not have had a particularly favourable environment, and his clones could well be as good as he is. However, on average across all such cases, the clones will not perform as well.

We can minimise the risks involved by using good data records, and using them properly with due attention to how we want to use the clones.

Genetic evaluation using clones

One key use of clones is to make genetic evaluations. There are two parameters that we may want to estimate:

- *Breeding value*. This is the value of an animal's genes to its progeny. We want to make estimates of breeding values (EBVs) whenever we want to make judgments about breeding animals for generating progeny. We also need EBVs when making decisions about which animals to clone, if the clones are to be used for breeding rather than production — as in the cloning of bulls to use widely for natural mating.
- *Genetic value*, or genotypic value. This is the value of an animal's genes to itself. We want to make estimates of genetic values (EGVs) whenever we want to select animals to make clones of themselves to generate product to be harvested.

We can estimate both breeding and genetic values from a number of sources. However, two key sources to be examined here are progeny and clones. Kinghorn (2000c) gives the predicted accuracy for selection on breeding value and on genetic value, when progeny or clones are the source of data.

Figure 7 uses the prediction equations to show these accuracies of evaluation. For this result, narrow-sense heritability was taken as V_A*/V_P* = 0.25 and broad-sense heritability as V_G*/V_P* = 0.45. This assumes that the way that genes interact within individuals has quite a major influence on their performance, explaining 20% of observed variation (0.45 minus 0.25). This value is well within the range reported.

For a small number of progeny or clones tested, clones give more accurate evaluation, because they share all of their genes with the animal being evaluated, as opposed to only half in the case of progeny. However, clone data contain some unwanted baggage for the estimation of breeding values. This is the component of genetic value that is due to the particular interactions between genes in each individual: for example, an animal that has a favourable heterozygous state at a given gene locus (i.e. dominance expressed due to inheriting different gene variants from its two parents) cannot transmit this benefit to its offspring — it can transmit only one variant and not both. The mean of many clones contains this benefit, which is unwanted bias when estimating the breeding value of this animal.

Thus using clones to evaluate breeding value is not competitive with normal progeny testing for more than about 16 progeny or clones recorded (Fig. 7). When very many progeny are tested almost full breeding value accuracy is reached — after all, breeding value is about the value of an animal's genes to its progeny. However, when very many clones are tested the highest breeding value accuracy is limited, because of the unwanted influence of the components in genetic value that cannot be transmitted to the next generation.

---

* V_A = additive variance
V_G = genetic variance
V_P = phenotypic variance

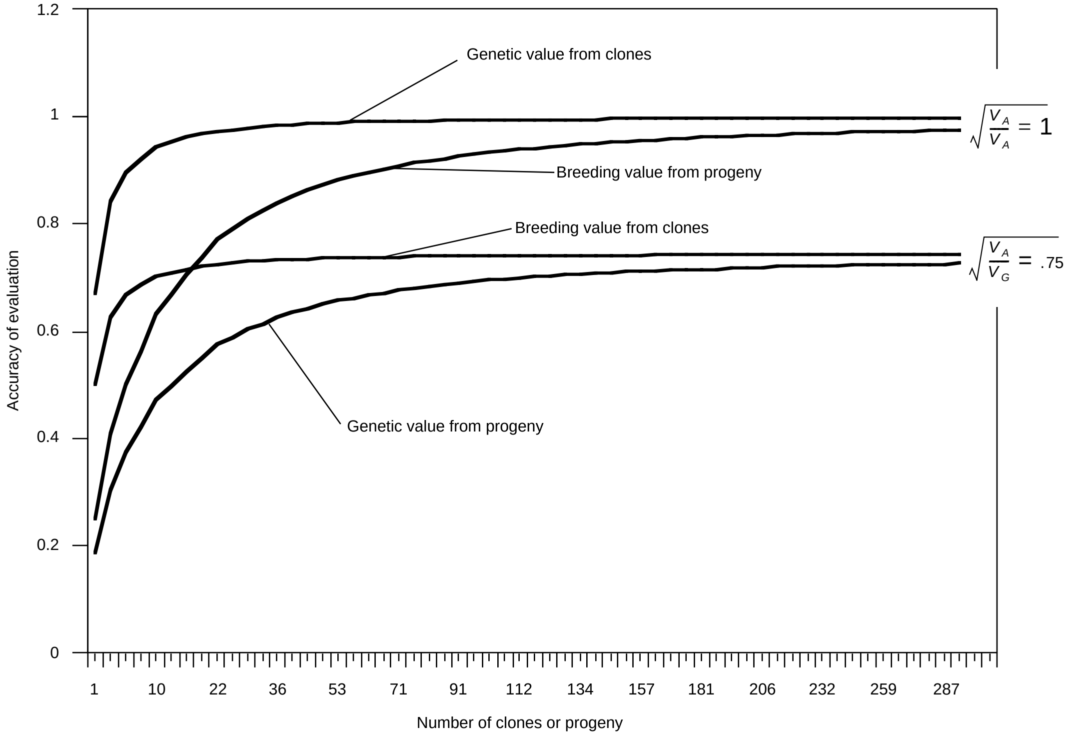


Figure 7. Accuracy of evaluation of breeding value and of genetic value when the source of information is records on *n* progeny or *n* clones. See text for assumptions.

Genetic gain from cloning

This limit in the value of clones for estimating breeding value, together with the much higher cost of cloning, helps to illustrate why clones are not expected to be of great value in generating faster ongoing rates of genetic change. The other factor against clones in this regard is the narrowing of the genetic pool: there are far fewer genetically distinct individuals within breeding programs using clones, leading to higher inbreeding and lower genetic variation in the longer term.

Using a simulated dairy population, de Boer et al. (1994) predicted a 1.4% increase in the ongoing rate of response through clone testing for milk production traits, while maintaining similar inbreeding levels, in the absence of genetic dominance. There was no increase in the presence of dominance. However, they did find useful improvements in production levels due to clones, and concluded that reliable commercial clone lines could be produced effectively, presumably if costs are sufficiently low.

One major disadvantage of using clones in dairy breeding programs is that we cannot carry out a clone test on a bull for milk production. However, clone tests can be useful in any species for traits that require sacrifice for measurement, such as many carcass traits and some disease resistance traits. This is the most promising area for using clones to increase ongoing rates of genetic gain.

Production gain from cloning is expected to be much more fruitful (Kinghorn 2000c).

Molecular Genetics

Molecular genetics and their place in breeding systems have already been described during this workshop (Van der Werf and Kinghorn 2002). This paper will make a simple illustration of the value of marker-assisted selection using simulation. It should be noted that markers for easy-to-measure traits such as growth are expected to be much less valuable than markers for traits such as disease resistance and carcass traits.

Information systems

Figure 8 illustrates the relationships among some of the key progressive information systems in animal breeding.

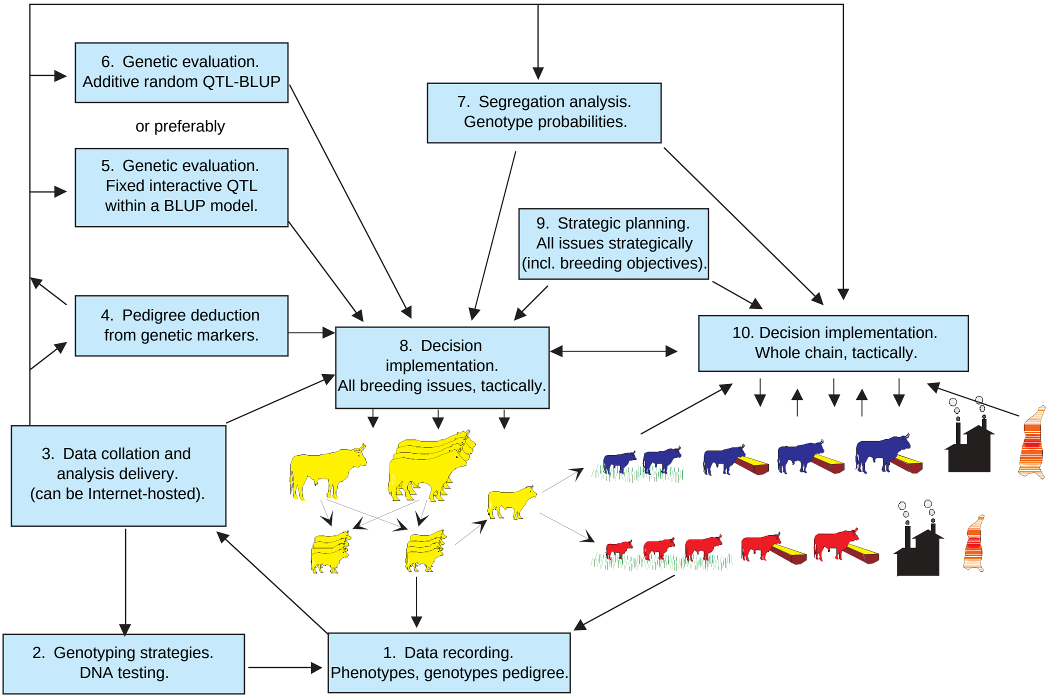


Figure 8. Some key information systems in animal breeding.

The rest of this section briefly describes the different information systems shown in Figure 8.

1. *Data recording*: This is a key component. In some cases special tools and methods are required to make measurements, especially for traits related to carcass quality and disease resistance.
2. *Genotyping strategies*: Genotyping is becoming increasingly widely practised, with applications using both genetic marker loci and known gene loci. The cost of genotyping is generally high, such that inferring genotype from the known genotypes of relatives and/or linked loci has the potential to play a useful role in reducing costs. Segregation analysis, described below, can be used for calculating genotype probabilities. These in turn can be used in an iterative genotyping strategy — they are used to help choose which individuals and loci to genotype in each iteration (see for example http://www.beef.crc.org.au/publications/bkinghor/aaabg99_359.pdf). Individuals and loci to be genotyped in each cycle are chosen in a manner designed to maximise the utility of the resulting information across the whole population. Genotyping can proceed until perfect information is known on all individuals of interest (which can be accomplished with only part of the population actually genotyped), or it can proceed until a nominated genotyping cost has been spent, or until some function of utility and cost has been maximised.
3. *Data collation and delivery of analysed data*: Our experience is that the Internet facilitates very effective distributed deployment of services using operators located close to end-users/customers. Data and software are fully up-to-date — we now have fully automatic upgrading of client software, with no action by operators other than launching the application. Internet hosting also provides software security, full tracking of activities for billing purposes, excellent opportunities for technical support, a simpler path to scaling up operations, and opportunity for e-commerce of products as well as services.
4. *Pedigree deduction*: Good method and software can be used to solve complex parent-allocation problems — such to deduce the parents of 250 progeny out of a syndicate mating of 300 cows and 10 bulls. An appropriate feature is to go beyond allocation by exclusion, to using marker genotype probabilities. This will enable a reduction in the number of marker loci run — one target being to have just one multiplexed marker

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

set. For example software, see Tristan Marshall's 'Cervus' at http://helios.bto.ed.ac.uk/evolgen/cervus/cervus.html.

5. *Genetic evaluation — fixed interactive quantitative trait loci (QTL) within a Best Linear Unbiassed Prediction (BLUP) model*: This is a preferred approach to genetic evaluation (see for example http://www.beef.crc.org.au/ publications/bkinghor/allerton.pdf or, more concisely, http://www.beef.crc.org.au/publications/bkinghor/isag98.pdf). Direct or 'diagnostic' markers are simplest to use here, as we can treat them as fixed but interacting effects. Operationally, they almost remove the need for trait measurements and pedigree information. (However, multiple alleleism means that only complete sequence markers are fully reliable, as otherwise alleles of identical marker type can have different effects.) For linked markers, we can modify transmission probabilities in segregation analysis to calculate QTL genotype probabilities. Typically two QTL alleles would be considered to be involved and QTL genotype effects treated as fixed. This is probably preferable where few effectively distinct alleles are known to be segregating, and where dominance and/or epistasis are important.
6. *Genetic evaluation — additive random QTL within a BLUP model*: This is increasingly being used for genetic evaluation where genetic marker information is available. It is a relatively simple extension of classical method. Markers are used to infer the probability of identity by descent of contributing QTL alleles, with QTL effects treated as random and no assumption about the number of alleles at each QTL. However, it aims to evaluate more accurately the average genetic merit of individuals for given traits, and misses the added opportunities to exploit the known mode of action of discovered genes, and the interactions among them that we increasingly find to be important. Without modification or extension, it misses out on the potential marketing advantage of labelling individual animals with probabilities of carrying certain gene variants. It also misses out on ability to target outcomes with respect to the marked genes, which is especially important for non-additive modes of inheritance.
7. *Segregation analysis*: This type of analysis is the key to a number of genetic information systems, including items 2, 4, 5 and 8 in this list. Kerr and Kinghorn (1996) have developed a method that operates on large populations.
8. *Decision implementation for breeding*: A new method makes tactical decisions on selection and mate allocation in animal breeding systems. This is total (tactical) genetic resource management (TGRM), which integrates technical, logistical and cost issues affecting breeding decisions into a single framework (Kinghorn 2000a).
9. *Strategic planning tools*: This can be thought of as 'strategic genetic resource management', SGRM. The idea is to integrate a range of design evaluation and planning tools into a single project-planning framework. The program 'Z-Plan' from Gerhard Nitter can be used to evaluate a range of animal breeding designs. Various other components have been produced, including cohort-based simulation of optimal strategies for major genes and crossbreeding, predictors of genetic gain and inbreeding under realistic conditions, and variation in outcome to give risk assessments.
10. *Decision implementation for whole supply chain*: *Total Resource Management*. This is the subject of current research in the Australian Beef Quality Cooperative Research Centre.

Design in animal breeding and production programs is classically implemented through sets of rules to be followed. However, a tactical approach uses all prevailing information to develop an action report that dictates management decisions directly. These problems can be very complex, with no hope of solution using analytical methods. However, evolutionary algorithms have proved to be very powerful in this regard. There has been good success in developing and implementing such a tactical approach in animal breeding, using evolutionary algorithms for optimisation (see 8 above). For other parts of the supply chain, a simple example has been developed so far, involving feedlotting one starting group of cattle to four different end-points of date and target body weight. The objective function included management costs, feed costs and penalties for missing target weights. Parameters optimised are pattern and dates of drafting into sub-groups, and feeding levels over time within each sub-group (see http:/www.beef.crc.org.au/publications/bkinghor/AI99_BK.pdf).

Potential Genetic Responses

This section will use computer simulation to give a feel for the potential impact of reproductive and molecular technology on responses to selection. The Genup module PopQTL was used to simulate a population with parameters as shown in Figure 9.

In the following table, AI is represented by using just 2 sires over 200 dams, rather than 8 sires over

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

(a)
Yearling Beef
Save for this session
Save to disk
Close
(b)
Run
(c)
View graph only
View input parameters

Figure 9(a–c).

200 dams. MOET is represented by cows that calve leaving three offspring rather than just one. Molecular assisted selection (MAS) is represented by genotyping of a known gene at an initial frequency of 0.1, the effects of one and two copies of this gene being 3 and 5 units (0.3 and 0.5 of a phenotypic standard deviation) compared with having zero copies.

Table 1. Results after 20 years of breeding, depending on use of technology. Two replicates are shown for each treatment. Note that these results are very highly dependent on conditions assumed, and must be taken as a rough guide only.

AI	MOET	MAS	Response (%)	Inbreeding (F)	QTL freq.
×	×	×	23.70 20.64	0.0676 0.0538	0.129 0.670
✓	×	×	28.04 28.31	0.2193 0.2067	0.386 0.458
✓	✓	×	38.80 37.72	0.2226 0.3426	0.963 0.823
×	×	✓	22.16 21.82	0.0589 0.0585	0.918 0.977
✓	×	✓	27.77 21.05	0.1866 0.1735	0.985 0.980
✓	✓	✓	39.82 31.63	0.4011 0.3417	1.000 1.000

In these scenarios, reproductive technology has much more impact than molecular technology. However, it must be remembered that MAS is of less use for traits that are easy to measure, are expressed in both sexes, and are expressed before selection. Moreover, the longer-term consequences of MAS are lower because favourable genes can be selected ‘unintentionally’ by normal methods over longer periods. These factors underline the fact that any QTL mapping work should be directed at traits for which MAS has higher benefit — such as disease resistance and carcass traits.

References

de Boer, I.J.M., Meuwissen, T.H.E. and van Arendork, J.A.M. 1994. Combining the genetic and clonal responses in a closed dairy cattle nucleus scheme. Animal Production. 59, 345–358.

Davis, G.P., D’Occhio, M.J. and Hetzel, D.J.S. 1997. Smart breeding: Selection with markers and advanced reproductive technologies. Proceedings of the Association for the Advancement of Animal Breeding and Genetics, 12, 429–432.

Kerr, R.J. and Kinghorn, B.P. 1996. An efficient algorithm for segregation analysis in large populations. J. Anim. Breed. Genet., 113, 457–469.

Kinghorn, B.P. 2000a. The tactical approach to implementing breeding programs. In: Kinghorn, B.P., Van der Werf, J.H.J. and Ryan, M. (ed.), Animal Breeding — use of new technologies. The Post Graduate Foundation in Veterinarian Science of the University of Sydney: ISBN 0 646 38713 8.

Kinghorn, B.P. 2000b. Boosting fecundity — the roles and value of AI, MOET, oocyte pickup and IVF in animal breeding. In: Kinghorn, B.P., Van der Werf, J.H.J. and Ryan, M. (ed.), Animal Breeding — Use of New Technologies. The Post Graduate Foundation in Veterinarian Science of the University of Sydney. ISBN 0 646 38713 8.

Kinghorn, B.P. 2000c. Animal production and breeding systems to exploit cloning technology. In: Kinghorn, B.P., Van der Werf, J.H.J. and Ryan, M. (ed.), Animal Breeding — Use of New Technologies. The Post Graduate Foundation in Veterinarian Science of the University of Sydney. ISBN 0 646 38713 8.

Kinghorn, B.P., Smith, C. and Dekkers, J.C.M. 1991. Potential genetic gains with gamete harvesting and in vitro fertilization in dairy cattle. Journal of Dairy Science, 74, 611–622.

McClintock, A.E. 1998. Impact of cloning on cattle breeding systems. In: New technologies for animal breeding. Beef CRC, University of New England, Armidale, NSW, 14–15 September. 55–59.

Ruane, J., Klemetsdal, G. and Sehested, E. 1997. Views on the potential impact of cloning of animal breeding and production. Acta. Agric. Scand., Sect. A, Animal Sci., 47, 209–212.

Options for Genetic Improvement of Bali Cattle — Assessing the Strengths and Weaknesses of Alternative Strategies

Option 2. Expensive technologies deleted, AI still included

A.R. Siregar[1], I. Inounu[1], C. Talib[1] and K. Diwyanto[1]

Abstract

A proposal is presented in this paper for the widespread use of artificial insemination as a tool to assist breeding of Bali cattle while ignoring most of the other reproductive and molecular techniques that *could* be used. It is recommended that small farmers in both extensive and intensive production regimes should be encouraged to unite to form larger breeding units. These units would then act as breeding centres using artificial insemination and modern techniques for data collection. Regional government institutions would then carry out computerised data analysis to determine estimated breeding values as a basis for selection within the breeding unit on the one hand and sale of breeding stock on the other.

Introduction

BALI cattle are produced under a wide range of different environmental and management conditions. Generally these can be divided into three management systems: grazing on open land; grazing within plantations; and intensive cut and carry management with animals held in separated individual farmer housing or in communal cattle housing. The first two systems could be regarded as extensive management, the third as intensive management. Strategies for genetic improvement will differ according to the management system they are applied in. Efficient production is dependent on traits influencing growth rate, feed efficiency, reproduction and survival rate, and on farm size. Improvements in genetics, although slow, do however have permanent effects. Traits with different heritabilities and expressions could be included in different strategies for genetic improvement (Politiek 1987).

The genetic improvement of Bali cattle should be carried out in sire evaluation programs that include performance testing (when necessary) and progeny testing. For dams, if there is a possibility for recording such data they could be included in dam evaluation; however if no dam records are available it is enough that the dams have an average mature weight in line with Indonesian standards for Bali cattle (Ditjenak unpublished), along with good reproduction and mothering abilities. There are many techniques for genetic improvement in beef cattle such as molecular genetic manipulation, sperm selection, sex determination, multiple ovulation and embryo transfer (MOET), artificial insemination (AI) and natural mating, which — combined with quantitative genetic analysis techniques (BLUP) — raised many expectations. Indonesia has problems with the recording of beef cattle, including Bali cattle (an exception is the P3 Bali project). A sophisticated model should therefore be developed for integrating the data of related institutions to record cattle, to collect records and to analyse such data partially and simultaneously. In this way it could be expected that in some provinces Indonesia would be able to produce selected cattle from proven bulls and cows.

Selection attempts to increase the frequency of favourable alleles, and concomitantly to decrease the frequency of unfavourable alleles at genetic loci influencing the traits of interest. In a selected herd

[1] Central Research Institute of Animal Science, Bogor, Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

the performance of the animals is likely to be similar, with less variety in genotype than for a herd of unselected cattle. Application of selection in smallholder farmers is not easy because of small numbers of animals (2–4 head/farmer), a priority for rearing females, high rates of animal movement, and a trend to sell the best bulls for fattening. The number of animals on a farm usually depends on the availability of family labour and feed sources. To increase cattle production efficiency, raising the number of animals per farm is an important factor. The techniques for genetic improvement that could be applied for smallholders in Indonesia include technologies such as AI, which has been used in almost all provinces for producing stock for slaughter.

Existing Breeding Systems with AI Technologies

AI has been use din Indonesian beef cattle since the 1970s. From the beginning, at least 11 breeds of imported taurine and zebu breeds were used as sources of semen. In the period 1990–2000 farmers showed a preference for choosing only four taurine breeds and two zebu breeds; in fact in each province usually only two taurine breeds and one zebu breed were chosen (Talib 1989; Talib and Siregar 1999; Bestari et al. 1999; Talib 2001; Ditjenak 2001). There are two AI centres that produce all of the frozen semen for smallholders — Lembang and Singosari. In 2000 they produced 1.5 million doses of distributed frozen semen, including 50 000 doses of Bali cattle semen. In the past ten years the centres distributed 19 million doses of frozen semen, and predicted calving rate was 30% (Ditjenak 2001). Although that prediction should be re-evaluated, the centres' records have been a major achievement.

AI techniques provide many advantages for cattle development such as control of certain venereal diseases, the need for fewer bulls on farms, the recording of information on reproduction, the harvesting of fertile sperm, and the efficiency of using proven bulls. In Indonesia, AI is also used for crossing to produce commercial crossbred stock for smallholders. Its impact has been on farmers with small farms, rearing females only and highly dependent on an inseminator. Calving difficulties increased and calving rates fell, but the price per calf increased. Most farmers with female crossbreds kept the females as dams for the next generation and to reduce the calving difficulties, but the amount of roughage required per head increased, and in future generations the rates of adaptation or survival may decline, especially for crosses with taurine breeds.

The success of AI depends on numbers of inseminators per area, cattle density, transport infrastructure and the experience of the inseminator. Semen quality at the time of insemination and the reproductive status of the female are also important. Usually, in country areas one inseminator would serve only one cow per day, though in communal animal housing the rate would be higher because of easier access to the cattle. Litik (2001) reported that inseminators do not work in insemination alone but also have other roles such as pregnancy detection, the care of calving nurseries and vaccination; these responsibilities could have an impact of the success of their AI work. In addition, AI is easier to introduce in cases of intensive management because the cows are housed and more tame; in pastoral areas it is very difficult to apply because of untamed animals.

In males, crosses between Bali and taurine or indicus cattle are infertile; however the female cattle are fertile (Kirby 1979; Bestari et al. 1999). Calving difficulties as a result of crossing between small and large breeds are quite common for Bali cattle (Talib 1989). To reduce the risks, farmers in East Nusa Tenggara (NTT) and West Nusa Tenggara (NTB) use crossing only for large cows and do not crossbreed heifers and small cows, both of which are bred to Bali bulls or inseminated with Bali semen.

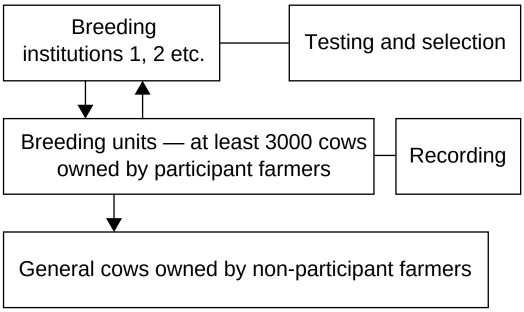
Previous papers have called attention to the many kinds of breeding institutions that exist in Indonesia, but the effectiveness of these institutions needs to be evaluated. Their location, their programs (and the effectiveness of those programs), the target of their operations and the extent of integration between them have to be looked at carefully. It would be advantageous if all institutions working together to improve the productivity of Bali cattle were to create a good recording system for their breeding cattle.

Recording Organisations and Selection Applied

The model of P3Bali (Pane 1990), an open nucleus breeding scheme, could be introduced to other breeding institutions, but the selection criteria, together with the performance and progeny tests, should be applied carefully to achieve success in such a program. In Bali one of the weaknesses of P3Bali is the problem of disease within the area. As a result the products of its breeding program could be used only in Bali itself. Another factor is the application of the program in the operational sense. It would be difficult for any institution to build up a good sustained program like the Bali cattle breeding program in P3Bali. Such an institution needs autonomy for using funds at the right time and the right place to run the program properly. It should have a commercial management orientation, with a view to becoming self-supporting or with a minimum subsidy. As

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

members of the program farmers should develop their own association, and through it could easily obtain bank credit to increase their farm size. It would be very useful if some breeding units were developed in certain locations, especially in areas with at least 3000 cows. An outline of the suggested program is presented below.



In each unit cattle have to be recorded and weighed once or twice yearly, the data including pedigree information from a breeding institution. All data could be collected for computerised analyses with BLUP models, depending on the complexity of the data. Estimated breeding values (EBVs) would be calculated as a basis of selection to identify superior bulls and heifers and to determine genetic trends of the population from selection over time. The model should also include all the environmental factors and site effects that could influence productivity. Since the results need to be applied in cattle herds, integration between institutions should be built up, as well as a direct relationship between institutions and the smallholder farmers who use their products. In addition, farm size should be increased to allow at least five cows per farmer so that farmers can live off the products of their farm. The breeding institution would be a source of quality bulls and heifers for farmers, helping them to raise their cattle product and their incomes.

Performance Test

Such a breeding program could run properly without a performance test if the selection is based on individual EBVs. However, in cases of doubt, or for demonstrating to the farmer how good the superior selected cattle are, the performance test could be applied in some breeding units/institutions with a similar standard of nutrition and management. The best performing cattle (those with the best EBVs) would be distributed among the breeding units and institutions. Others with a medium performance could be distributed to herds that do not participate in a breeding program. The selected bulls could also be placed across the provinces in a rotation system, while semen collection for producing frozen and chilled semen from proven bulls could be continued. Both AI and natural mating could be used in the genetic improvement program.

Future Expectations

It would be expected that distributing bulls, semen and heifers to the breeding units and to pastoral farmers, and distributing semen to participating farmers and general farmers in areas of intensive production, would be a mechanism that would work well to improve Bali cattle production in Indonesia.

Another expectation is that cattle could be sold on the basis of not only their body weight but also their EBVs. High quality cattle should be certified. Through their association, farmers would get some additional income from semen and high quality bulls and heifers sold to increase the efficiency of cattle breeding programs, as well as from animal breeding strategies.

Conclusions

1. Bali cattle are run under two major management systems, namely extensive and intensive, distributed through pastoral, plantation and cropping areas.
2. Farmers should be stimulated and helped to develop their farm size under their own association/institution, and a breeding program could be applied in the participating farmer areas in the form of breeding units.
3. Government could develop a cattle breeding institution or broaden the function of existing research institutions, to undertake computerised data collection and analysis in order to select cattle based on their EBVs.
4. High quality bulls and cows should be certified and distributed to the breeding units to improve genetic potential.

References

Bestari, J., Siregar, A.R., Sani, Y. and Situmorang, P. 1999. Produktivitas empat bangsa pedet sapi potong hasil IB di Kabupaten Agam Propinsi Sumatera Barat: 1. Perubahan bobot badan sampai umur 120 hari. Prosiding Seminar Nasional Peternakan dan Veteriner 1–2 Desember 1998. Proceedings of Livestock Meeting. CRIAS, Puslitbangnak. 181.

Ditjenak. 2001. Statistical book of livestock in Indonesia. DGLS. 73.

Kirby, G.M.W. 1979. Bali cattle in Australia. World Review of Animal Production 31, 24.

Litik, M. 2001. Improvement of livestock production system to support economic development in NTT. Regional Economic Meeting, Kupang, 1 Dec.

Pane, I. 1990. Improving the genetic quality of Bali cattle (Upaya Peningkatan mutu genetic sapi Bali). In: Proceedings of a Bali cattle meeting, Denpassar A42, Sept.

Politiek, R.D. 1987. Discussion (session). Proceedings of EAAP seminar on cattle production and animal genetics, Wageningen, Netherlands, 27–29 April. 70.

Talib, C. 1989. Effects of breed of sires, sex and season on birth weight of crossbreds *Bos taurus* × *Bos banteng* cows and their gestation length. Prosiding Pertemuan Ilmiah Ruminansia, Bogor, 8–10 Nov. Proceedings Livestock Meeting. CRIAS, Puslitbangnak. 175.

Talib, C. 2001. Improvement of national beef cattle breeding system in Indonesia. Wartazoa Animal Science, Vol. 11, 1:10.

Talib, C. and Siregar, A.R. 1999. Faktor-faktor yang mempengaruhi pertumbuhan pedet PO dan crossbrednya dengan *Bos indicus* dan *Bos Taurus* dalam pemeliharaan tradisiional. Prosiding Seminar Nasional Peternakan dan Veteriner 1–2 December 1998, Proceedings of Livestock Meeting, CRIAS, Puslitbangnak. 200.

Options for Genetic Improvement of Bali Cattle — Assessing the Strengths and Weaknesses of Alternative Strategies

Option 3. Expensive technologies and AI deleted

C. Talib[1], A.R. Siregar[1] and K. Diwyanto[1]

Abstract

Most Bali cattle in Indonesia are bred naturally in both extensive and intensive management systems. Most of the bulls used are unselected or are those that are not sufficiently grown or finished for sale. This leads to a low chance of genetic improvement and, where new animals are not introduced from other herds, an increase in inbreeding. To overcome these problems systems have to be devised that will coordinate the breeding programs with the status of the grasslands and the feed available. In addition, education programs will need to be put in place to increase both the participation and the understanding of farmers so that, eventually, selection will be based on the calculated breeding values of individual animals rather than their mere availability or some form of subjective appraisal. This may mean certification of selected bulls and heifers and recognition that such certification denotes superior breeding potential.

Introduction

ALMOST all the data for Bali cattle breeding are from field and research station studies where natural mating was used. Although AI was introduced into Indonesia in the 1970s for beef production, the area of semen distribution is still limited. These limitations are caused by bad transport facilities, the absence of inseminators or their small numbers relative to cow density, the absence of facilities for AI, a low level of acceptance by farmers resulting from their low educational levels, and in some cases the unmanageability of cattle. Highest acceptance of AI technology is found in intensive cattle management situations because cows are easy to handle; the lowest adoption rates are in the pastoral lands.

Indonesia had around 5.4 million productive cows in 2000, of which only 0.5 million were involved in AI, the balance of 4.9 million head being naturally mated (Siregar et al. 2001a). This indicates that Indonesian beef productivity is very dependent on natural mating. The overall calving rate is around 17–18%, with rates of mortality between 5% and 6%.

The effectiveness of natural mating is higher than that of AI in terms of calving rate because mating occurs at the right time and sometimes frequently. The prerequisites for success with natural mating are that the nutritional status and body condition of both bull and female should be good to support mating, maintenance of pregnancy and post-partum milk production. To obtain best results cattle should be of a high quality, the bull-to-female ratio good, the degree of inbreeding minimal and nutrition and management good.

Natural mating is widely practised in all management systems; under pastoral conditions mating is dependent on bull and female condition, nutritional status and bull-to-female ratio. Under intensive management, mating success is not only dependent on the condition and nutritional status of the animal but also very dependent on the availability of bulls to serve cows at the right time of oestrus. Hence the role of farmers in understanding cow reproductive status for ‘hand mating’ is very important for the

[1] Central Research Institute of Animal Science, Bogor, Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

successful outcome of this form of natural mating. As a result calving rate in the pasture situation is usually higher than under hand mating conditions.

All the factors that could influence success should be taken into account in a breeding improvement program based on natural mating. The priority should be to use selected bulls of known fertility and to rotate bulls between herds to increase their effectiveness.

Existing Breeding Programs using Natural Mating

Existing breeding programs for Bali cattle using natural mating can be divided into two different mating management systems: natural mating in the pastoral lands (extensive management) and natural hand mating under intensive management. Both these systems have weaknesses and advantages. In the grazing lands many cattle graze in an area owned by some farmers, and farm size (cattle per farmer) is from 10 to more than 100 cows. Many cattle graze on pastoral communal land, but the status of the land used is very unstable because it is not individually owned by anybody and regional policy makers could change its status to that of non-pastoral land.

The weaknesses of the natural mating system practised in the pastoral lands are firstly the cattle. The bulls used are unselected, and usually are not the best bulls in the herd because these animals are disposed of for fattening before reaching two years (C. Talib unpublished data). Cows used for breeding are however the fertile cows, many of which are more than ten years old. Secondly, pasture conditions and pasture management are problem areas. As for other native pastures in developing tropical countries, pasture production has a wide seasonal fluctuation in quantity and quality. Consequently cattle on these pastures experience body weight loss annually because no feed supplements are introduced when nutrition is poor. Little is done for long-term sustainability of the pasture, so over-grazing occurs in some places and high weed populations predominate in others. The dynamics of cattle growth, including that of dams and calves, parallel changes in pasture production, so the pattern of available nutrition will influence breeding patterns (Wirdahayati and Bamualim 1990; Talib et al. 1999). Thus the breeding season will start at the time when cattle are in good body condition.

The weaknesses of hand mating systems are that bull quality is similar to that in pastoral lands because farmers will not permit fattening bulls to be used for breeding purposes. For that reason, cow–bull interaction is very dependent on the farmer/ keeper and the availability of bulls at the correct time. Cow owners sometimes have to pay the owner of the bull for mating activities and usually the calving rate is less than with natural mating in the grazing areas.

The advantages of natural mating are calving rates up to 80% (Kirby 1979; Wirdahayati and Bamualim 1990; Talib et al. 1999) and the fact that mating incurs no special costs. For natural hand mating, cow condition is usually better than that of cows grazing pastures and calves are usually also better grown.

Cattle grazing pastures are the source of heifer replacements for cows under intensive management systems, and of bulls for fattening. Farmers under intensive systems are more aware of commercial factors than extensive farmers, so the movement of cattle between farmers is quite high. If prices are right farmers sell their cattle at any time, and will then buy cattle in again from the pastoral lands as replacements.

The situation described above also indicates that cattle owners in the pastoral areas are very interested in participating in genetic improvement programs for Bali cattle. Consequently they keep their cows for a long time, depending on cow longevity. This could have both advantageous and disadvantageous consequences for improvement programs. The positive aspect is that good cows will have many opportunities for producing calves in parallel with their reproductive abilities. The downside is that there are increased risks of inbreeding in the herd, with older cows mating with their offspring or other relatives.

Genetic Improvement Programs using Natural Mating

Genetic improvement programs for Bali cattle in the pastoral lands and the intensive areas will need different strategies if they are to succeed. Those strategies should recognise the status and sustainability of pasture as animal feed resources, the need for participation by farmers in the program, the need for better cattle nutrition, and the nature of the genetic improvement program.

Firstly, policy makers must take into consideration the status and sustainability of the pastural land for cattle grazing and create a way for farmers to participate as users of the grasslands. If this is not done the numbers and quality of cattle on a pasture will decrease in parallel with degradation of the feed available. Recently, for the first time, smaller Bali cows have been observed on very poor grasslands in South Sulawesi, along with their small calves (Siregar et al. 2001b).

Secondly, advocacy by extension workers of genetic improvement to improve productivity is important to secure the participation of farmers. Easily available bank credits could encourage farmers to participate in breeding programs, increase their farm size, improve their cattle facilities and enhance family welfare. In Indonesia bank credits are given to dairy farmers under dairy cooperative schemes for these purposes, and similar arrangements should be established for beef farmers. Farmers could build up their formal organisation in many ways, such as through cooperatives, associations or other arrangements that would inspire confidence.

Thirdly, in the dry season or when other environmental stresses or conditions occur that limit feed availability, feed supplementation should be adopted. Talib et al. (1999) reported that Bali cows grazing on native pasture can lose up to 80 kg of body weight in the dry season and calf growth rates are almost zero. Wirdahayati (1994) showed that feed supplementation (legume tree leaves) can reduce body weight loss, increase milk production and lower calf mortality in the Bali herd.

Fourthly, emphasis should be given to genetic improvement programs by organising the recording, collection and analysis of data. Farmer participation rates and understanding should be increased by functional extension workers/institutes and the whole program needs an integrated approach taking account of social factors and also involving agronomic, nutrition and genetic scientists and other supporting institutions such as banks and land-use organisations. The model of P3Bali as an open nucleus breeding scheme (Pane and Packard, 1987) could be adopted; a flow chart of breeding units and their activities was proposed in an earlier presentation at this workshop (Talib et al. 2003). The disadvantages of breeding practices currently used by farmers could be reduced by using proven bulls in a rotational system between breeding units to minimise inbreeding. Selection could be focused on body weight at 120, 365 and 440 days (Talib et al. 1999). Body weight at 120 days would be representative of mothering ability of the cow and of calf survival rates; weight at 365 days would be an indication of calf growth rates; and weight at 440 days would give a preliminary picture for identification of bulls for fattening or good heifers for dams. Selection should be based on individual EBVs to ensure good results.

Using this approach, selected bulls and heifers should be certified, and it is hoped that in the future cattle prices in the market could be based on animals' phenotype and genotype.

References

Kirby, G.M.W. 1979. Bali Cattle in Australia. World Review of Animal Production **31**, 24.

Pane, I. and Packard, P.M. (1987). Bali Cattle Improvement Programme. Proc. Asian Australasian Annual Production Congress (NZ) p350.

Siregar, A.R., Talib, C., Situmorang, P. and Kuswandi. 2001a. Mapping and pattern of natural mating in rearing cattle at some provinces in Indonesia. DGLS (Directorate General of Livestock Services), Budi Daya, Indonesia.

Siregar, A.R., Talib, C., Sariubang, M., Purba and Priadi, I. 2001b. Increasing survival and growth rates of Bali calves through breeding systems. Proceedings of Ruminant Meeting, University of Diponegoro. 192.

Talib, C., Hinch, G.N., Sivarajasingham, S. and Bamualim, A. 1998. Factors influencing preweaning and weaning weights of Bali (*Bos sundaicus*) calves. Proceedings of 6th World Congress on Genetics Applied to Livestock Production, Armidale, NSW, Australia, 11–16 Jan. Vol. 23, 141.

Talib, C., Pohan, A. and Bamualim, A. 1999. Problematika pengembangan sapi Bali dalam pemeliharaan di padang penggembalaan. Prosiding Seminar nasional peternakan dan veteriner 1–2 December 1998. Jilid 1. Proceedings of Livestock Meeting. CRIAS Puslitbangnak. 248.

Wirdahayati, R.B. 1994. Reproductivity of Bali cattle in Nusa Tenggara Islands — Indonesia. PhD thesis, The University of Queensland, Brisbane, Australia.

Wirdahayati, R.B. and Bamualim, A. 1990. Performance production and population structure of Bali cattle in Timor, East Nusa Tenggara (Penampilan produksi dan struktur ternak sapi Bali di Pulau Timor, Nusa Tenggara Timur). In: Proceedings of Bali Cattle Meeting, 20–23 September, Denpasar, Indonesia. C1.

Options for Genetic Improvement of Bali Cattle — Assessing the Strengths and Weaknesses of Alternative Strategies

Option 4. Basic breeding system with limited selection options

Hans Graser[1]

Abstract

This paper discusses breeding programs for Bali cattle that could be practicable and economically feasible under Indonesian conditions. It assumes that there are constraints that preclude the widespread use of artificial insemination, that there will not be the opportunity or the information to carry out sophisticated analysis of data and that selection is restricted to within (and not between) management groups. Simple practices such as measuring girth diameter as an estimation of weigh might replace scales, which are probably not readily accessible anyway.

It is concluded that simple techniques of identification and recording can be used in an effective breeding system provided that certain basic guidelines are followed by the farmers and the agents who advise them.

Introduction

BREEDING programs with intensive recording (pedigree and performance data) could be too difficult and too expensive as a first attempt to develop a sustainable breeding program for Bali cattle, since the initial and ongoing financial investments and required infrastructure might not be available. In this paper I will therefore discuss options that might be used in some sections of the cattle population or across all cattle to bring about some genetic progress.

Some Assumptions

To discuss a breeding system with any form of selection it is necessary to identify the breeding objective. Without knowing what you want to improve there is no logic in recording anything to make selection decisions. The only reasons for recording would be to document the current level of performance and for management purposes in larger breeding units.

[1] Animal Genetics and Breeding Unit, University of New England, Armidale, NSW 2351, Australia

I assume that we would like Bali cattle to grow faster and bigger and that we do not want them to loose their environmental adaptation. We cannot use AI for most cows and hence multiple-sire joining will occur in most village herds, so that sire pedigree will be commonly unknown. Under these conditions, the use of Best Linear Unbiassed Prediction (BLUP) technology or contemporary comparisons (CC) is not possible. Selection has to be practised within management groups, and cannot be extended across them. So we will have to restrict selection to the village level. However recording at village level should ensure that we maintain adaptation, as less-adapted females will reproduce at a slower rate and less-adapted bulls might grow slower.

I have also assumed that it is possible to castrate male calves early and that castration is a common practice. If early castration can be practised, birth weight and body measurements shortly after birth will become a useful tool for selection between very young (<3 months) bull calves. Analysis of Indicus, Taurus and Buffalo data have shown that very early body measurements and weight records are sufficiently genetically correlated with yearling and later

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

weights (they are often higher than weaning weight correlations) to be useful for genetic evaluation and subsequent selection for larger mature size and faster growth (Meyer et al. 2000; Burrow 2001). This however needs to be verified for Bali cattle.

Recording Males

Recording weight and/or some body measurements (e.g. heart girth, hip height and cannon bone length) of every male calf using portable hand-held scales and simple measuring tapes within the first week of life should be possible. Calves should be identified with ear tags to make possible culling (castration) of half of the smallest and lightest calves say every three months, assuming there is no distinct calving season. If any data on age-of-dam effect (perhaps only year of birth) and season are available, calf records can be pre-adjusted. If those data are not available, implementing a recording system with the necessary details will provide such information after a couple of years.

A second culling stage has to be implemented when young bulls are eighteen months to two years of age. Such bulls should have been managed together at village level separately from any heifers and cows. Selection criteria at this stage could include weight (if transportable scales are available) and body size records, testicular size, heat tolerance test — all adjusted for age differences if necessary — and if available, a score for functionality. It is important to clearly specify how much weight has to be given to each selection criterion, and one should rely as much as possible on objective records.

A simple selection (SI) index of animal i combining the information on n traits can be calculated as

$$SI_i = \sum_{j=1}^{n} b_j \ (x - \underline{\xi} j)$$

The weighting factors b_j are dependent on the parameters (heritability, genetic and environmental correlations) of the records and the economic weights. With a computerised recording system these indices can be calculate very quickly for all animals in a management group.

Use of Bulls

To avoid inbreeding, selected bulls from one village should be sent to another village in a very planned and systematic way and used for only two years. This will ensure that no father–daughter matings will occur and that a relatively short generation interval can be achieved (see for example Trinderup et al. 1999 and Villanueva et al. 2000). If exceptional sires can be identified at village level, they could be later used for AI or moved to another village. Bulls not selected should be castrated if required for draught purposes, or slaughtered.

Data Collection

Data recording at village level needs to be undertaken by trained and responsible staff and not by individual farmers (animal owners). These staff should be equipped with the required hardware (hand-held scales and measuring tape) and also be responsible for tagging all calves (male and female) and, in early years, all cows. Included in their responsibilities is data transfer to the 'central management unit'. Depending on the number of cows in a village and distances between villages, one trained person could service more than one village and could also provide other livestock services, e.g. AI, nutritional advice, veterinary assistance and castration.

Data Management

Although the performance recording system described is very simple it is essential that the collected data be recorded on a central computer, though it might be necessary to use paper as interim records. Such central processing will allow the use of mass selection indices (a combination of different traits of a single animal) and, as time progresses, will lead to an integrated pedigree performance database once the AI records, which already exist, are added.

Selection of Females

Without a clear knowledge of reproduction rate and replacement requirements it is difficult to develop any recording system for females. The simplest system might be to tag only female calves and record birth data, to mate every reasonably grown heifer at say 18 to 24 months of age, and to slaughter all those who do not calve within 12 months. If progeny records are related to females it might be possible after a number of years to identify highly productive animals (regular calving and fast-growing male progeny) to select as élite cows, which might be specially used for AI with the very best bulls, or which could be transferred to a nucleus herd.

References

Burrow, H.M. 2001. Variances and covariances between productive and adaptive traits and temperament in a composite breed of tropical beef cattle. Livestock Production Science, 70, 213–233.

Meyer, K., Graser, H.-U. and Na-Chiangmai, A. 2000. Estimates of genetic parameters for growth and skeletal measurements in Thai swamp buffalo. Journal of Animal Science, 70, 399–406.

Trinderup, M., Jorgensen, J.N. and Hansen, M. 1999. Inbreeding and loss of founder alleles in four variations of a conservation programme using circular mating, for Danish Shorthorn cattle. Animal Genetics Resource Information 25, 101–108 (FAO publication).

Villanueva, B., Bijma, P. and Wooliams, J.A. 2000. Optimal mass selection policies for schemes with overlapping generations and restricted inbreeding. Genetics, Selection and Evolution, 32, 339–355.

Implementation of a Breeding Program for Bali Cattle Technical issues at national and regional levels

C. Talib[1], A.R. Siregar[1], S. Budiarti-Turner[2] and K. Diwyanto[1]

Abstract

Bali cattle are reared in Indonesia under both extensive and intensive management systems. Under both systems, the expansion of communal grazing and communal housing is recommended in order to set up a solid base for breeding programs. Some breeding programs have been attempted, but they have had little success and almost no impact. This may mean the establishment of better-focused village breeding centres or breeding associations under the guidance of regional or national government institutions.

Introduction

CATTLE productivity is dependent on two primary factors, namely genetics and environment, and cattle can reach their genetic potential only if the environment provides optimum conditions. Breeds of cattle are adapted to different environments and may have special characteristics, including their adaptability to certain locations. Consequently, even in the same locality, the same breed of cattle managed in different herds could vary in their level of productivity.

Selection aims at increasing the frequency of favourable alleles and concomitantly decreasing the frequency of unfavourable alleles at genetic loci influencing the traits of interest. In this way, offspring from the next generation could be expected to have better genetic potential than their parents. In a selected herd the performance of animals is likely to be similar, with less variation in genotype than in an unselected herd. For an unselected herd, manipulation of environmental factors such as nutrition may alter productivity in the short term, but for the longer term, a combination of improvements in the genotype as well as in the environment is likely to be the best way to raise productivity.

Farmers in tropical regions consistently diversify the use of their resources to provide food for family consumption and to maximise family income. The number of animals on a farm usually depends on farm size, the availability of family labour, the sources and availability of feed, and the amount and distribution of rainfall. Most animal production in the South East Asian tropics is associated with smallholder production systems. These systems are complex, and vary greatly depending on the local culture and management practices. Bali cattle, which are well adapted to Indonesia, are run under two environments and management systems: at pasture under extensive management, or under a more intensive system involving housing with cut and carry forages. Because of these management differences, they also have different performance and behavioural attributes.

To improve Bali cattle production, some breeding programs have been applied nationally and regionally, though evaluation of existing breeding planning is needed. There is also a need to examine alternative improvement programs that would be suitable at national and regional levels. Furthermore, affecting the implementation of improvements to breeding programs have also to be considered.

Existing Bali Cattle Management

Under extensive management, Bali cattle graze on pastoral land all day and consume only available

[1] Central Research Institute of Animal Science, Bogar, Indonesia
[2] Directorate General of Livestock Services, Jakarta, Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

roughages, generally without any supplements, though water is supplied. The productivity of most unimproved tropical pasture is low, and both quality and availability fluctuate widely between rainy and dry seasons (Wirdahayati 1994; Hidayati et al. 2001). For security cattle are housed at night in some herds.

Under intensive management, Bali cattle are supplied with most of their nutritional needs through cut and carry forages, but sometimes also receive supplements.

There are some variations in these two systems between sites: for example, in the extensive system, grazing in natural pasture areas, paddy fields, plantation areas or the forest with or without a 'cattle boy' in the intensive system; and 'paron' arrangement (tethered cattled) in East Nusa Tenggara (NTT), caging in some places, communal caged housing in West Nusa Tenggara (NTB) for intensive rearing, and fattening in communal housing on plantation farms.

Because of these wide variations in management systems and diets between and within the two rearing systems, the performance of cattle also varies widely. Therefore the performance traits recorded by research teams do not directly indicate the genetic quality or genetic potential of Bali cattle, but reflect general production levels influenced by specific management and nutrition at individual locations.

Existing Bali Cattle Breeding Programs and Supporting Institutions

As the primary resource for Bali cattle in Indonesia, the island of Bali is closed to the introduction of other cattle breeds in order to maintain the genetic resource base and germplasm of the breed. Conversely the export of cattle from Bali to other locations is now limited because of disease risks, particularly of Jembrana disease.

In contrast to commercial beef cattle farms, productivity of Bali cattle that graze under pastoral management is based on their adaptive and survival abilities without any feed supplementation. Usually each herd of 10–100 head has one cattle boy, who follows the movements of the cattle on natural pasture all day for security reasons. The boy will record in his mind information about calving, mortalities and injured animals. In Thailand some farmers create a schedule for grazing communal livestock, so that cattle are observed by a larger number of people.

The status of the pasture in communal pastoral areas is of concern, since no single individual is the owner or has responsibilities for the sustainability of the pasture. As a result there is no responsibility for management to sustain pasture productivity and maintain carrying capacity. In fact, the production and quality of these pastures fluctuates widely during the year (Talib 2002). In some areas weeds are increasingly significant, placing further pressure on pastures already suffering overgrazing (Litik 2001; Hidayati et al. 2001). Under these harsh conditions the grazing cattle do not receive any feed supplements, so cows experience severe body weight loss (up to 30–40%) in the dry season, and calves manage only to maintain their weight in the same period (Talib et al. 1999).

Breeding management for cattle in extensive systems almost always involves natural mating using bulls available in the herd. In intensive rearing systems, even though natural mating is still predominant, around 20–30% of offspring are crossbreds. Usually all of the best bulls in a locality are assigned to a fattening program in caged housing for export and slaughter without being used for mating, and almost all females are kept by farmers. The remaining bulls in the herd, used for breeding, are the younger and inferior ones in terms of growth rates and size, and few bulls are introduced to the herd from outside. In cases where there is a need for ready money, productive cows will also be sold for slaughter. Under these conditions, calving rates of herds in NTT, NTB, Bali and South Sulawesi varied between and within provinces in a range from 40% to 70% (Wirdahayati 1994; Siregar et al. 2001; Entwistle et al. 2001). Mature body weight for females is 110–300 kg (Wirdahayati 1994; Wirdahayati and Bamualim 1990; Talib 2002; Siregar et al. 2001; Entwistle et al. 2001).

Cattle under intensive management are often mated through AI to produce commercial crossbred stock. In some circumstances, if AI is unsuccessful farmers use natural mating as the alternative. Farmers rear all females to breeding age, including pure Bali and crossbreds. In NTB, an intensive management system has developed involving a communal animal housing system of 100–300 cows per housing group, with 50–100 owners. Even though housing was initially adapted for reasons of security, because of the many advantages of this management system many farmers accept and use it. The breeding practice for heifers is that at the first breeding they will be mated to pure Bali bulls or inseminated with Bali semen to minimise calving difficulties, while protecting the purebred population. This practice is also followed for cows of small mature body size regardless of age. The inseminator has an office close to the communal housing, so it is easy for him to inseminate animals at the appropriate time and also easy to control animal health problems. This model of management could be usefully introduced into other provinces.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Martojo (1988) indicated that the genetic potential of Bali cattle may be declining because of inbreeding. Siregar et al. (2001) observed very light cows (110–120 kg) in South Sulawesi rearing very light calves. Talib (2002) reported that in NTT, calves of light birth weight (<10 kg) frequently die soon after birth. The ACIAR-INDONESIA survey team observed some possibly inbred Bali cattle in NTT, NTB, Bali and South Sulawesi that were still called Bali cattle by farmers but whose colour was significantly different from that of standard Bali cattle. All available information indicates that breeding systems currently practised by farmers should be re-evaluated and improved.

The Indonesian Government, through the Directorate General of Livestock Services (DGLS/Ditjenak), has developed some breeding programs to improve beef cattle production, including Bali cattle. Those programs are outlined in Table 1.

The CBI and P3Bali programs record the performance of cattle, including herd population dynamics, but only P3Bali at Bali has applied selection in the herd and produced proven bulls for improving the basic population and for supply to breeding centre herds. Ideally, proven bulls should be sent to the AI centre for producing semen. Only one bull was sent to the Singosari AI centre from P3Bali for producing frozen semen to be distributed to the Eastern Islands. Evaluation of P3Bali selection activities for the past 20 years also suggests that the process applied, and the consequent selection pressure, have been ineffective, based on estimated breeding values (Table 2) (Sukmasari et al. 2002).

Table 1. Activities carried out under existing breeding programs for Bali cattle.

Province	Activity		
	Conservation	Purebreeding	Crossbreeding
NTT	✓ Lili (VBC, CBU)	✓ Lili (CBU)	✓ CS
NTB	✓ Sarading (CBU)	✓ Sarading (CBU)	✓
Bali	✓ (whole Island)	✓ Pulukan etc. (P3B)	—
South Sulawesi	✓ Bone	✓ Bone (P3B)	✓ CS
Lampung	—	✓ (P3B)	✓ CS

VBC = village breeding centre; CBU = cattle breeding unit — UPT; CS = commercial stock; P3B = special breeding project for Bali cattle — P3Bali

The flow chart of the breeding scheme for P3Bali is good (Pane 1990), so the ineffective selection practised has to be evaluated carefully and in depth to detect the causes and to avoid such problems in the future.

Table 2. Estimated breeding value (EBV) of Bali cattle at P3Bali in Bali.

Year	Weaning weight	Yearling weight	Daily weight gain
1983	–1.49	–3.46	–12.36
1984	–1.2	–2.47	–7.93
1985	0.02	–0.55	–3.58
1986	1.07	0.64	–2.72
1987	NA	NA	NA
1988	1.41	2.42	6.34
1989	0.66	2.28	10.21
1990	–2.96	–1.62	8.35
1991	–2.4	–2.44	–0.36
1992	–2.61	–2.85	–1.55
1993	–1.95	–2.03	–0.55
1994	–0.63	1.24	11.69
1995	–0.54	0.18	4.48
1996	0.81	0.97	1.04
1997	1.78	2.07	1.84
1998	1.92	2.36	2.72
1999	1.21	1.31	0.59

In addition to the CBU and P3Bali programs, in some areas there are selected herds belonging to the government and distributed under contract. If these selected herds could constitute the basic cattle population of a village breeding centre or unit and be integrated with one of the breeding institutions, Bali cattle programs could be implemented more easily in the villages.

Technical Issues for Improvement of the Breeding Program

Following are some technical issues and suggestions from related institutes and farmers for improvement of the breeding program:

- The number of Bali cattle protected under the Indonesian germplasm program in Bali and at other breeding institutes is around 600 000, which is too many. The positive side of this situation, however, is that Indonesia requires a lot of beef for its domestic consumption; if cows in Bali could be used in crossbreeding programs for producing final stock, this would provide a significant contribution to beef production. Moreover crossbred animals, because of their larger size, could command higher prices than purebred Bali cattle, thus increasing a farmer's income. However if a crossbreeding program is permitted on Bali, there is no guarantee that Indonesia could preserve the genetic resource of purebred Bali cattle in the future.

- Some Bali cattle resource areas should develop their own Bali cattle breeding institutes, because distribution of cattle from P3Bali in Bali to other provinces as part of a national breeding program is restricted by disease constraints.
- Some districts should develop their own laws for the export of animals, as well as some policies under district rules to develop cattle production locally in terms of quantity and quality.
- Under conditions of district autonomy, some districts should develop their own AI office to fulfil requirements for semen. It appears that the National Artificial Insemination Centre (Singosari) cannot satisfy regional needs in terms of semen quality, quantity and price. District governments could increase their income by sale of the semen and proven bulls.
- Under pastoral management, farmers as the users of the communal pastures should be expected to manage and control pastures through a farmers' association. The communal animal grazing system used in Thailand could be introduced into the Indonesian pastoral lands under the control of such associations.
- The model of communal animal housing in NTB could be introduced into other districts for producing commercial crossbreds as well as raising the productivity of purebreds.

References

Entwistle, K., Talib, C., Siregar, A.R. and Lindsay, D. 2001. Bali cattle performance: current population dynamics and performance and some strategies for improvement (a preliminary report). Seminar Nasional Teknologi Peternakan dan Veteriner, 17–18 September, Bogor, Indonesia. Proceedings of National Livestock Meeting. CRIAS, Puslitbangnak. 32.

Hidayati, N., Talib, C. and Pohan, A. 2001. Produktivitas padang penggembalaan rumput alam untuk menghasilkan sapi bibit di Kupang Timur, Nusa Tenggara Timur. Seminar Nasional Teknologi Peternakan dan Veteriner. 17–18 September, Bogor, Indonesia. Proceedings of National Livestock Meeting. CRIAS, Puslitbangnak. 345.

Litik, A. 2001. Special communication (Director of Livestock Services Office, NTT province, Indonesia).

Martojo, H. 1988. (A review) Productivity of Bali Cattle and their crossbred (Productivitas sapi Bali dan Persilangannya). In: Proceedings of Seminar Ekspor Ternak Potong (Animal Products as exported commodity) 2–3 September. Jakarta. A35.

Pane, I. 1990. Improving the genetic quality of Bali cattle (Upaya Peningkatan mutu genetic sapi Bali). In: Proceedings of a Bali cattle meeting Sept. UNUD. Denpasar. A42.

Siregar, A.R., Talib, C., Sariubang, M., Purba and Priadi, I. 2001. Increasing survival and growth rates of Bali calves through breeding system. Proceedings of Ruminant Meeting, University of Diponegoro. 192.

Talib, C. 2002. Productivity and reproductivity of Bali cattle. PhD thesis, University of New England, Australia.

Talib, C., Pohan, A. and Bamualim, A. 1999. Problematika pengembangan sapi Bali dalam pemeliharaan di padang penggembalaan. Prosiding Seminar nasional peternakan dan veteriner 1–2 Desember 1998. Jilid 1. Proceedings of Livestock Meeting. CRIAS, Puslitbangnak. 248.

Wirdahayati, R.B. 1994. Reproductivity of Bali cattle in Nusa Tenggara Islands — Indonesia. PhD thesis, The University of Qld, Brisbane, Australia.

Wirdahayati, R.B. and Bamualim, A. 1990. Performance production and population structure of Bali cattle in Timor, East Nusa Tenggara (Penampilan produksi dan struktur ternak sapi Bali di Pulau Timor, Nusa Tenggara Timur). In: Proceedings of Bali Cattle Meeting, 20–23 September, Denpasar. C1.

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

Economic Issues at a National and Regional Level

Ir. Don P. Utoyo[1]

Abstract

In Indonesia the Directorate of Livestock Breeding is responsible for the establishment of the strategic actions and directions of livestock breeding development, including semen, embryos, hatchery eggs and live animals. Current conditions, problems encountered and policies for national livestock breeding are outlined.

There is no doubt that efforts are required to enhance the effectiveness and efficiency of breeding stock for each species, and for different breeds within species. The mainstream activities of the national livestock breeding policy are conservation, maintaining crossbreeds and creating new breeds.

One of Indonesia's native cattle species is the Bali breed. These animals represent the country's second largest cattle population. Their advantages are that they are fertile and well muscled and have good adaptability to harsh conditions. They have also been utilised for crossing, usually to Simmental or Limousin sires, but this crossing is still prohibited on the island of Bali. There are indications that Bali cattle have been subjected to negative selection, while their susceptibility to Jembrana disease is still an obstacle to their more widespread use.

Measures for local autonomy are now being introduced in Indonesia, but one thing to keep in mind is that a better and clearer understanding among stakeholders will support a breakthrough in animal breeding approaches so that eventually the goals will be reached.

Introduction

THE Directorate General of Livestock Services, through the Directorate of Livestock Breeding, is responsible for the establishment of national livestock breeding policies associated with standardisation, the formulation of technical procedures, norms, the development of systems for varieties and livestock breeding, and certification of the quality, distribution, monitoring and evaluation of breeding stock in farm animals including semen, embryos, oocytes and hatching eggs.

Many species of livestock, and many breeds for each species, are found in Indonesia.

There are three categories of livestock breeders in Indonesia:

- village breeding centres (VBQs), which account for about 90% of livestock farmers — mostly dairy, beef, buffalo, goat, sheep and ducks;
- private breeder enterprises, which are involved particularly in layers, broilers and pigs. The private sector is expected to invest capital in all types of livestock except native chickens. Native chicken breeding is allowed for farmers who run small but economical-scale units in rural areas.
- government breeding stations such as Livestock Embryo Centre, Cipelang; Lembang AI Centre; and Singosari AI Centre. The breeding centres are located at Indrapuri Aceh, Siborong-borong Sumatera Utara, Padangmangatas Sumatera Barat, Sembawa Sumatera Selatan, Baturaden Jawa Tengah and Pleihari Kalimantan Selatan.

Problems Encountered in Breeding Activities

Since Indonesia is a developing country, several internal and external factors may influence the sustainability of breeding farms, including:

- The quantity and quality of breeding stocks is not sufficient.
- Uniformity of livestock breeding stock has not yet been achieved.
- The business risks of breeding farms include low return rates, since it takes a long time before returns start coming in.

[1] Director of Livestock Breeding Development, Directorate General of Livestock Breeding, Jakarta, Indonesia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

- Upgrading of breeding stock is in progress in most species except for layers and broilers.
- Breeding programs in the country are still not yet ready to compete against free trade areas.

Characteristics of Bali cattle

Bali cattle, which have several local names such as Balinese, *Bibos banteng*, *Bibos (Bos) banteng* and *Bos sondaicus*, are native Indonesian cattle used mainly for meat and draught power. They are an important part of the society and culture of many regions.

The growth rate of the Bali cattle population has been steady. In 1970 Bali cattle numbers were around 3 million, but by 1999 there was a total population of more than 4 million head, widely distributed in almost all provinces in Indonesia. Village breeding for Bali cattle is found particularly in South Sulawesi, East Nusa Tenggara, West Nusa Tenggara and Lampung but also in many other regions.

Nevertheless, in certain areas the quality of Bali cattle has declined. This has occurred due to such factors as inbreeding and negative selection. The disposal of very good stock could not be controlled and many were sent to slaughter. It is now difficult to find Bali cattle breeding stocks with a wither height of 102 cm for cows and 105 cm for bulls.

Morphology

The origin of Bali cattle is domesticated Banteng, a wild cattle species in Indonesia called *Bibos banteng* Wagner or *Bos sondaicus* Schegel and Muller. Adult liveweight for Bali males is 475 kg and for females 250 kg, while adult wither heights are 120 cm and 110 cm for males and females respectively.

Males are reddish-brown in colour, turning black with increasing age with white patches on the hindquarters, while females are yellow reddish-brown with white patches on the hindquarters and legs. Both males and females are horned, and the horns form a sharp U-shape.

Bali cattle cope well even on poor pastures or fodders, and show high heat tolerance. They also have a high degree of disease resistance, but are susceptible to malignant catharal fever (MCF), carried by sheep and Jembrana disease. Other advantages are that they are very prolific, possibly due to their long heat period, and that their meat is very tender and lean.

Performance

Management conditions are referred to as extensive (low input/non-backyard) and backyard/farmyard production. Commonly, Bali cattle are kept in backyards for a few months of the year; otherwise they are kept on pasture. Adults held at farmhouses are fed farm by-products and fodder as well as being allowed to graze.

Data on the average performances of Bali cattle are:

- birth weight — male 17 kg, female 14 kg;
- average age at sexual maturity — male 16 months, female 16 months;
- age at first parturition — between 22 and 26 months;
- parturition — 380 days;
- length of production life — 8 years;
- milk yield per lactation — 600–900 kg;
- lactation length — 90–150 days;
- milk yield — per year 500–1000 kg, per day 4 litres;
- lean meat yield — 38–44%;
- daily weight gain — 200–600 g;
- carcass weight — 200 kg;
- dressing percentage — 56%.

There are still some questions as to what is the genetic composition of pure Bali cattle, and we do not yet know whether we can find purebred animals or not. Bali cattle in Sulawesi are more resistant to Jembrana disease than similar cattle in Bali, while in Bali (desa Taro) we also find white Bali cattle.

Conservation and use

Bali cattle conservation in situ will be implemented in Nusa Panida island. Cryo-preservation of semen is done at the Signosari AI Centre, though no cryo-conservation of embryos has been done so far. It is noted that in Bali, a major objective has been to maintain and conserve the species. Besides maintaining the pure breed of Bali cattle, efforts will be undertaken to enhance the rate of improvement of Bali cattle breeding stock, in quantity as well as in quality.

National Livestock Breeding Policies

Change is under way in Indonesia since the declaration in January 2001 of National Policies UU No. 22 1999 and PP No. 25 in 2000. Conservation from now on will not be driven or implemented by the central government, but by the provincial governments. A consensus between national and provincial governments on how to use animal genetic resources is now being developed. Whether breeding policies for a species are formulated partly at national level or partly at provincial level will depend on the importance of the animals involved in terms of their economic value, and how much they can contribute to better incomes and other social conditions. Breeding policy will be at provincial level if the animals' genetic resources are of little value and their contribution to national welfare is small. Relevant factors include their suitability for local environments and their importance in the local society and culture.

The national economic value of contributions from some locally exploited species is limited. Examples include Alabio ducks in Alabio Kalsel, spotted buffalo in Tanah Toraja Sulsel, and Kedu chickens in Kedu Central Java.

The development of systemic breeding stock

This aspect of national breeding policies comprises:

- sub-systems of breeding improvement, such as selection and crossing of replacement stock and genetic engineering;
- sub-system production and multiplication, with close relationships to VBCs, private breeders and a government breeding station;
- sub-system distribution, with close relationships to the market situation. To maintain equilibrium of supply and demand, the government when necessary will use a quota system;
- sub-system of quality control. In order to make sure that the quality of breeding stocks is guaranteed, mechanisms of standardisation, certification, and product labelling are to be used, supported by mechanisms of inspection. Government inspectors will be recruited and their skills will be developed through training courses.

The master plan of national breeding policy

The direction of breeding policy consists of dual approaches of conservation and the use of animal genetic resources simultaneously, as symbolised by two sides of a coin. Conservation itself refers to how we maintain genetic resources as they are, while the use of animal genetics is related to how we make efforts for breeding improvement based on crossing (breeding methods) and environmental considerations.

Conservation

Conservation can use either in situ or ex situ methods. In situ programs have been carried out for Madura cattle in Sapudi island, Bali cattle in Bali and Dompu West Nusan Tenggara, and Pelung chicken in Cianjur. Ex situ approaches have been used for Bali cattle at the Singosari AI centre.

Crossbreeding

The use of Dutch Friesian as the flagship for dairy cattle is questionable, since these animals in the Java environment and climate are restricted to the upland areas above 700 metres. Their numbers are steadily decreasing due to the development of infrastructure and the tourist industry. Therefore, for lowland areas, dual-purpose cattle will be raised and developed such as the Fresian × Ongole cross and the Grati and Simmental × Ongole cross. The new dairy centre will be relocated outside Java. The same approach may be used for Bali cattle as well. The crossing of Bali cattle is needed to support self-sufficiency in beef.

Creating an Indonesian breed

This program is still going on, including Bali cattle crosses to Simmental in West Nusa Tenggara, and Brahman bull–Bali cow crosses.

Strategic development of the breeding industry in Indonesia

The strategic steps for improvement of the breeding industry are linked to the issues of national livestock development in Indonesia during the past 5 years, particularly since the economic and monetary crises. The main issues are:

- how to attain self-sufficiency in beef production by the year 2005;
- how to maintain self-sufficiency in egg production and to promote poultry meat (white meat) as a potential substitute for beef (red meat) in the near future;
- how to increase the domestic milk supply to meet national demand.

Challenges for the investor as a breeder

Capital investment is needed for all breeding stock except native chickens, and this includes Bali cattle. National markets and international markets are very promising.

Summary and Recommendations

Compiled by David Lindsay[1] and Keith Entwistle[2]

Present Status and Prospects

Quantity and quality

There are perceptions in Indonesia that both the quality and the number of Bali cattle in the country are falling. Evidence was given that numbers in some regions are falling rapidly and in others marginally, but it is difficult to draw conclusions from this information that relies upon extrapolation of regional surveys conducted 20 years apart. However, the export rate from some regions in recent years does appear to be unsustainable. There is evidence also that the weight of cattle at slaughter is lower than in previous years. On the other hand, evidence for a decline in the quality of meat from Bali cattle is only anecdotal and some figures presented at the workshop showed in fact that in taste panel testing, Bali cattle meat was preferred by consumers. It is not clear that any of the decline in quality or quantity, perceived or real is attributable to genetic causes.

The breeding system

The workshop agreed that there is little or no structure in the breeding system being used at present. The breeding is, in general terms, random with no objective selection and with only minimal subjective selection of breeding animals. There are no data available to support the perception held by many participants that there may be negative selection for major traits because the best animals phenotypically are often sold for slaughter at high prices or used for crossbreeding, while the poor and smaller animals are kept for breeding.

Agreement for implementing a breeding program

Regardless of the present status of breeding of Bali cattle, there are strong arguments for initiating a systematic genetic improvement program. Bali beef competes in the market with beef from other cattle breeds, local and imported, and many of these breeds now have effective improvement programs in place. The competitiveness of Bali cattle will decrease over time unless they too, are subjected to selection for improved productivity.

Most of the participants at the workshop agreed that, in some traits, Bali cattle have a strong inherent competitive advantage that should be preserved and developed. Evidence was presented that, given good nutrition and management, the breed is very hardy and probably more fecund than other cattle breeds under the same conditions, with lower maintenance costs for breeders. It was also claimed that the quality of the meat was better and that it fetched a premium price, at least in some markets.

Bali cattle also have some competitive disadvantage on which evidence was presented, and these traits could be improved genetically. In most cases where growth rates were measured, they were low compared with those of other breeds, suggesting that this would be a major selection trait in any organised breeding program. In addition Jembrana disease, a unique and lethal viral infection affecting Bali cattle, has proved to be relatively intractable to classic methods of control. A number of participants felt that this disease may be a candidate for marker-assisted genetic selection (MAS) in the future and, as such, a trait that could be included in a future breeding program.

There is an unacceptably high level of calf mortality, ranging from 2% to 40% with a mean that is probably around 15–20%. Most speakers related this to low milk production of the dam, but there is no unequivocal evidence for this or whether it is the root cause of the syndrome.

Conservation and maintenance of genetic diversity

Interest in the breeding of Bali cattle comes from two quarters. One is associated with maintaining and conserving this unique species, the other with producing an income for farmers. Given that there are

[1] University of Western Australia, Stirling Highway, Crawley, WA 6009 Australia

[2] University of New England, Armidale, NSW 2351, Australia

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

estimated to be about 4 million Bali cattle in the Indonesian cattle population of about 12 million, genetic diversity is not a problem and is unlikely to become one for some time, even under intensive selection for productive characteristics. So the twin goals of conservation and production can be achieved jointly, provided that selection for productivity can maintain the economic viability of the species and therefore the large population size.

Recommendation 1

The Indonesian Ministry of Agriculture, through AARD[1], should commence the planning and implementation of a systematic genetic improvement program for Bali cattle in the Eastern Islands of Indonesia, designed to improve the economic well-being of cattle-owning farmers in these regions, but at the same time ensuring that the unique genetic diversity of this species is preserved.

Breeding Objectives

What to breed for?

The first step in the preparation of any breeding plan is to set breeding objectives. To do this accurately it is necessary to have good information on the economic value of traits. Only economic models (i.e. profit models) are needed to determine values of traits, and these values change the breeding value of each trait by one unit. The genetic parameters of heritabilities and genetic and phenotypic correlations are needed not only to estimate breeding values but also to predict the genetic response for each trait.

At present, information on these parameters does not exist for Bali cattle and there are not even preliminary data for them. Data can be extrapolated from other breeds, but there are risks in setting up a breeding program on data that could be inaccurate for the breed, though in the absence of more accurate data it is a reasonable starting point. However, the workshop spent time debating in general terms the objectives that would be most important in a breeding plan for Bali cattle based mainly on economic considerations. Not surprisingly there was no clear consensus, reflecting the different objectives that exist across regions and husbandry systems. This is not an impediment to a national breeding plan. Different breeding objectives can be pursued in several breeding programs, possibly resulting in different sub-populations for different regions or environments.

Preliminary values for a number of possible traits were considered.

[1] Agency for Agricultural Research and Development

Growth rate and size

Most participants through that these related traits would have high economic values. However, some felt that the criteria for selection should be based not on body size but on animals' efficiency. Other related issues considered here were maximisation of the benefits of sexual dimorphism and the need to consult with farmers, particularly with regard to preferred mature size.

Temperament

This was given a medium priority because of the perception of a wide diversity of temperament in Bali cattle and a consensus that good temperament and easy handling of animals were traits valued by farmers.

Survival of calves

Because of the very high calf losses recorded in several surveys (mean 15–20%) this trait was given a medium priority. It was assumed by many that the high mortality is caused by low milk production and the separation of this trait may be desirable to achieve the maximum response, though evidence for this is unavailable at present. However, some research into better cow/calf management could help to improve this trait.

Disease resistance

This was given a low priority, with the reservation that should a MAS technique become available for resistance to Jembrana disease, it should be incorporated as rapidly as possible. However, experience in the field crossing Bali cattle with other breeds revealed significantly increased resistance to Jembrana disease in the offspring. Disease resistance to malignant catharal fever (MCF) could be important to the wide dissemination of Bali cattle since this disease is carried by sheep, which are found almost everywhere in Indonesia.

Fertility

Recorded estimates of fertility vary but are generally high compared with those of other tropical breeds in the region. This, and the relatively low heritability of fertility traits, suggested to participants that fertility should be accorded a low priority.

Adaptation to tropics

Bali cattle are already well adapted to, and will be selected in, a tropical environment so this trait was considered to have a low priority for improvement, as long as selection takes place in the environment that prevails under commercial conditions.

Survival as adult

The animal is hardy, surviving well under a low-input management system, and it was believed that no great emphasis was necessary to improve this trait.

Meat quality

The relative leanness of Bali cattle beef compared with other beef may prove of value for niche markets, but those markets hardly exist at present and will probably not develop until some time in the future. Therefore the workshop participants felt that without a clear definition of meat quality requirements needed in the market place, this was a trait of low priority.

Breed standards

This trait probably does not influence productivity greatly one way or the other but was given a medium priority for two reasons: first, the relatively strong emphasis on conservation of Bali cattle; and second, because any incorporation of this trait could link objectives of a breeding program with the subjective systems that are now in place. Breed standards may not be a complex trait (for example they might be represented as a score on a simple scale of 1 to 10), and several participants believed that colour was the overriding factor to be considered.

Recommendation 2

Values for several traits of economic importance for Bali cattle need to be established in order to set appropriate breeding objectives.

- ***A critical evaluation of published literature on the breed should be undertaken as a starting point to determining these values.***
- ***The outcomes and suggestions of this review should be agreed upon by Indonesian scientists before their adoption.***

Adopting priorities for a breeding program

Breeding objectives, once set, should be altered only for sound reasons, to ensure continuous progress toward them. However, the objectives do not need to be the same in all regions and all Bali cattle do not have to perform identically. In addition, the weighting given to the traits within the breeding objectives can also change from time to time as they become more accurate. This phase of a breeding program has great importance, and there needs to be a strong regional input so that characteristics that are considered important in one region but not in another region can be accommodated. Without good information on genetic parameters there will be inaccuracies in the selection process. However, as the program develops and the genetic database grows these parameters will become available and selection increasingly more accurate.

A mechanism also needs to be in place to ensure that the weightings of traits within the breeding objectives are updated as appropriate, and reviewed by geneticists competent to adjust them.

Recommendation 3

Priorities for the relative emphasis on traits of economic importance, as established at the workshop, are recommended as a starting point, and breeding objectives, once set, should be altered only for sound reasons, following a review of the relative weighting of traits by a panel of experienced animal breeding scientists.

Structure of the breeding program

While there are many sophisticated breeding programs around the world, many of these are unlikely to be relevant to the breeding of Bali cattle. The workshop agreed that for a plan to work effectively it should be simple and that it should involve farmers as early as possible in its development. Information was given to the workshop that few breeding programs in developing countries succeeded when they did not adopt this policy. One participant suggested that in workshop deliberations to design programs, participants should not think of the organisation that they represent or of Bali cattle, but rather think of the economic welfare of the farmer.

Such views influenced the later discussions of the workshop. After a presentation on how new technologies might help refine a national breeding plan, the workshop decided that an ideal plan for Bali cattle should not attempt to include techniques such as cloning, *in vitro* maturity and fertilisation, molecular aided selection (except in the special case of Jembrana disease if such a technique became available) and semen sexing. Each of these technologies was very expensive and added only a small increment, at best, to projected rates of genetic progress. The workshop suggested that there might be limited scope for MOET in a two-tier program (see later) when the national program had been in operation for some time. It also concluded that AI could have a place where practicable; however the national program should be developed largely on the basis of natural mating.

Recommendation 4

Any breeding program adopted

- ***must be simple in structure;***
- ***must involve farmers as key stakeholders in implementation;***
- ***must be based on economic values as a key driving factor;***

Strategies to Improve Bali Cattle in Eastern Indonesia
edited by K. Entwistle and D.R. Lindsay
ACIAR Proceedings No. 110
(printed version published in 2003)

- ***should not, with the exception of AI, involve expensive reproductive technologies;***
- ***should be based on natural mating as the major reproductive management strategy.***

Organisation of Breeding Programs

Breeding programs can have varying levels of complexity, but any breeding program for Bali cattle should be relatively simple yet able to achieve its objectives. As indicated, there needs to be a clear identification of the traits of interest, and a determination of their relative economic values. Furthermore, the breeding program structure needs to be clear to the key stakeholders, and the responsibilities of the different players need to be well defined and accepted. Such responsibilities include activities such as trait measurement, genetic evaluation, and the selection and dissemination of genetically superior animals.

Models for breeding programs

Most participants agreed that the Bali cattle improvement programs that have been in place have been of limited value either to smallholder farmers or in the development of genetic information. It was agreed that a review and evaluation of these breeding programs is warranted in order to identify — and so avoid in the future — past mistakes, as well as to capture any useful information from these programs for use in the preferred model.

There was considerable discussion on a preferred model for a breeding program. Most participants believed that the best approach was to use initially a one-tier model at a village/herd level in which replacements were generated from those herds. When this had been successfully implemented among several hundred village herds there could be a transition to a two-tier model with a controlled nucleus herd from which sires would be generated. In this case the nucleus herd might or might not be co-located, i.e. village cows could be identified as members of the nucleus and remain in situ. This approach of building up from the base by initiating simple breeding activities at the village level was favoured, as it provides opportunities for early involvement of farmers (and a sense of ownership), ensures relative uniformity across regions, enables herd improvement to become part of a more immediately beneficial herd management package, and overcomes many of the problems associated with 'top-down' models that have not been successful in the past.

Participants agreed that the adoption of new herd management arrangements is fundamental to the success of the preferred model, or in fact any other genetic improvement option. The minimal requirement will be the implementation of controlled natural mating on a seasonal basis, along with weaning. The establishment of such arrangements may well be the primary rationale for assemblage of village herds, given the potential for more rapid accrual of benefits to farmers from these changes than from genetic improvement programs.

There was also agreement on the need to develop a genetic evaluation/index tool to enable identification and selection of animals as replacement breeding stock at a young age so that they are not disposed of for sale or slaughter.

Recommendation 5

In order to increase the chances of success of any new breeding program, current programs need to be critically re-evaluated in order to identify their advantages and disadvantages, which need to be taken into account in planning new programs. Key aspects of this process are:

- ***After successful implementation, a new program could evolve into a two-tiered system with a controlled but distributed nucleus herd from which sires would be generated.***
- ***A review of current and previous breeding programs should be conducted to identify any useful information that can be utilised in the new program.***
- ***A selection index should be developed for the selection of replacement breeding stock.***

Animal identification systems

A feature of any successful breeding program is accurate and permanent animal identification. It was agreed that any identification system adopted must be secure, permanent, uniform across Indonesia, unique without duplication of IDs and capable of being fully computerised as early as possible in any program.

Measurements

A range of measurements were discussed as being essential, including information on production characteristics such as body weight (body size measurements may be more appropriate in some situations), growth rates pre- and post-weaning, and body weights (sizes) at defined ages or at a certain reproductive status (puberty, first and subsequent matings/ calvings). Additional information included carcass weights; information where appropriate on meat quality traits; and reproductive data including age/weight at puberty, conception rates, inter-calving intervals, fertility to AI and/or natural mating, cow and calf survival, and lifetime reproductive performance, and for males, information on age/weight at first mating, scrotal size and cow : bull ratios in those villages where natural mating is being used.

Organisational responsibilities

The workshop participants were in general agreement that, for a breeding program to succeed and continue, it should have both national and regional organisational components. There was consensus that at national level, overall responsibility should be assumed by the Ministry of Agriculture, with input from a range of government agencies and universities together with regional bodies such as Badan Penelitian dan Pengembangan Pertanian, or BPTPs. At this level, responsibilities would be for program design, development of a uniform national database, overall coordination of the program, and organisation and implementation of any identified future research requirements to support the program. As indicated elsewhere, there was a very strong view that implementation at the regional level must include substantial involvement of farmers, who would be the recipients of any benefit from the program and who must be given a sense of ownership of it.

The role of Dinas Peternakan (or other related Dinas) would be in the provision of advice and extension services in a range of areas, including technical and socio-economic issues such as AI, marketing and finances. Formation of farmer breeding groups (societies) would need to be encouraged to facilitate exchange of information at farmer level, as well as providing a mechanism for benchmarking changes in level of productivity.

Clearly, implementation of any breeding program is not a one-step procedure. There was a consensus that a staged program over 2–4 years was needed to take into account issues such as development of protocols, identification of sites, involvement of both farmers and Dinas staff, and development of infrastructure needs such as facilities for AI and for weighing.

A program to improve the genetic capabilities of Bali cattle would be less costly to implement than making significant changes in nutrition and management, but would nevertheless have significant resource implications.

Recommendation 6
Implementation of any new breeding policy for Bali cattle should be the responsibility of the Ministry of Agriculture and its constituent agencies, both national and regional.
- ***Implementation at the regional level must involve farmer stakeholders.***
- ***The program should be planned for implementation over a period of 2–4 years.***

Funding new breeding programs

Funding breeding programs was discussed at some length and there was considerable diversity of opinion on possible funding arrangements. However, the workshop concluded that there was a need for both national and regional government funding at high levels to support a range of activities, e.g. trait measurement, genetic evaluation, database management and information distribution, education programs relevant to improvement of Bali cattle, and possible market subsidies to encourage retention of valuable seedstock. It was also recognised that funding from farmers would be needed, one possible approach being a cattle transaction levy (this is currently the Australian model). Contributions from the commercial cattle industry sector and from foreign aid agencies were also identified as possible funding sources. However the workshop recognised the difficulties of attracting funds from the latter types of donors and the short-term nature of such funding. Changes over time in the proportional funding contribution from different sectors were also considered important by some participants.

Recommendation 7
It is recommended that funding for the new breeding program come from a number of sources:
- ***national and regional government funding to ensure that essential support functions, and perhaps subsidies, are provided;***
- ***consideration of a livestock transaction levy to support operations of the program;***
- ***other sources of potential funding, which need to be identified and sought.***

Supporting Research

As indicated earlier, there is an absence of information on genetic parameters for Bali cattle, and a need to establish heritability and repeatability estimates, and genotypic and phenotypic correlations for important economic traits.

This information needs to be collected from the breeding program as it is implemented, to enable refinements to be made, and to compare predicted genetic changes as a consequence of changes in selection for different traits. Genetic analysis and evaluation are ongoing activities, the responsibilities for which should be assigned to an institution with the capability for genetic research.

One speaker drew attention to the fact that many attempts to introduce breeding programs into livestock systems in developing countries had not been successful. However, it was pointed out that such failures had often been due to the introduction of new genotypes rather than the improvement of indigenous ones, or for a 'top-down' approach to genetic improvement programs.

Throughout the workshop mention was made of the negative impact of Jembrana disease and MCF on Bali cattle, which restricted the export of these animals from Bali as well as causing significant mortalities. As indicated above, MAS tools could be a useful approach to genetic control of Jembrana disease at some later date, though there is a need for an adequate, sensitive and reliable diagnostic test to indicate level of resistance.

The workshop participants also believed that market research on issues such as meat quality should be undertaken to provide guidance for future directions of the breeding program. While there has been concentration on quantitative aspects of Bali cattle meat production, there was a view from the workshop that qualitative aspects of meat production must also be examined in more detail, particularly the influence on meat quality of post-farm handling and processing of cattle.

The workshop noted the importance of environmental issues such as degradation of grazing land through overgrazing, and of social issues such as land tenure/land ownership. Although outside the brief of the workshop, they nevertheless needed to be recognised in the implementation of breeding programs.

The workshop also concluded that an essential component of any new program must be an evaluation process on at least a five year cycle to review the program's effectiveness, and that this review must concentrate on economic benefits to farmer participants as well as an evaluation of genetic benefits.

Recommendation 8

It is recommended that, concurrently with the introduction of new breeding programs for Bali cattle, additional research be implemented.

- ***to determine a range of important genetic parameters;***
- ***to develop a program of ongoing genetic analysis and evaluation;***
- ***to carry out additional research on Jembrana disease, MCF and aspects of meat quality of Bali cattle.***

Recommendation 9

That a five yearly cycle of program evaluation be put in place to review the effectiveness of the overall program, concentrating on determining economic benefits to farmers.