STRATEGIES TO IMPROVE BALI CATTLE IN EASTERN INDONESIA

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

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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.

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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.

Strategies to Improve Bali Cattle in Eastern Indonesia
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(printed version published in 2003)

- 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
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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.

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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.