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# Liveweight gain and feed intake of weaned Bali cattle fed a range of diets in Central Sulawesi, Indonesia

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**Abstract.** Three experiments were conducted to determine liveweight (W) gain and feed and water intake of weaned Bali cattle offered a range of feed types. In each experiment, 18 weaned entire male Bali cattle were allocated to three treatment groups in a completely randomised block design, with six replicates (animals) per treatment. The dietary treatments were: Experiment 1, native grass fed *ad libitum*, native grass supplemented with rice bran at 10 g dry matter (DM)/kg W.day and native grass supplemented with a mixture of rice bran and copra meal in equal proportions fed at 10 g DM/kg W.day; Experiment 2, elephant grass hay fed *ad libitum*, elephant grass supplemented with gliricidia at 10 g DM/kg W.day, and gliricidia fed *ad libitum*; and Experiment 3, corn stover fed *ad libitum*, corn stover supplemented with gliricidia at 10 g DM/kg W.day, and corn stover supplemented with rice bran/copra meal in equal amounts (w/w) at 10 g DM/kg W.day. Each experiment was 10 weeks in duration, consisting of a 2-week preliminary period for adaptation to diets and an 8-week experimental period for the measurement of W change, feed and water intake and digestibility of the diet. Growth rates of 6–12-month-old, entire male Bali cattle fed a range of local diets ranged from 0.10 and 0.40 kg/day. Lowest growth rates occurred when the cattle were given the basal diets of native grass (0.104 kg/day), elephant grass (0.174 kg/day) and corn stover (0.232 kg/day). With the addition of supplements such as rice bran, rice bran/copra meal or gliricidia to these basal diets liveweight gains increased to between 0.225 and 0.402 kg/day. Forage DM intake was reduced with these supplements by on average 22.6% while total DM intake was increased by an average of 10.5%. The growth rate on gliricidia alone was 0.269 kg/day and feed DM intake was 28.0 g/kg W.day. Water intake was not affected by supplement type or intake. In conclusion, inclusion of small quantities of locally available, high quality feed supplements provide small-holder farmers with the potential to increase growth rates of Bali calves from 0.1 to 0.2 kg/day, under prevailing feeding scenarios, to over 0.4 kg/day.

**Additional keywords:** digestibility, forage, growth, intake, supplement.

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## Introduction

Bali cattle (*Bos sondaicus*) are indigenous to Indonesia and account for ~30% of the total national cattle population (Directorate of Livestock 2008). Most Bali cattle are located in the eastern region of Indonesia and are an important component of the small-holder crop-livestock farming systems. They are typically managed under cut and carry systems (Talib *et al.* 2003). Weaning of Bali cattle under this system typically occurs at ~12 months of age, if practised at all. The prolonged lactation results in cows of low body condition with long inter-calving intervals. Managed weaning of the calf, at ~6 months of age, will reduce the nutrient demands of the cow and allow her to recover body condition for the subsequent lactation and facilitate a quick return to oestrus and reduced inter-calving interval.

Managed weaning of Bali calves will require an understanding of the nutrient requirements of this class of animal. There is limited information regarding the growth of young Bali calves under local feeding strategies which are likely to be adopted by farmers. The growth rates of Bali cattle fed native grass (NG) range from 0.02 to 0.76 kg/day across a range of locations, classes of cattle and with the provision of different supplements (Marsetyo *et al*. 2006). However, not all studies have investigated practical strategies which are likely to be implemented by small-holder farmers. While potential exists to increase growth rates of weaned Bali calves, strategies need to be developed that are likely to be adopted within the constraints of the existing small-holder farmer crop-livestock systems. This study examined a range of diets designed to increase the growth rate of young Bali cattle and to develop practical feeding strategies to complement weaning thereby improving cattle production systems of small-holder farmers in Central Sulawesi.

 

## Materials and methods

### Experimental design, animals and diets

Three consecutive experiments were conducted at the experimental farm of the Department of Animal Science, Tadulako University, Palu, Central Sulawesi, Indonesia (0°41′0′ South, 119°44′0′ East). Experiment 1 was conducted between February and May, Experiment 2 was conducted between June and August and Experiment 3 was conducted between September and November. Annual rainfall at the experimental site is between 600 and 800 mm/year, with an even distribution across the year. All procedures used in these experiments were conducted under the guidelines of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes and were reviewed and approved by the University of Queensland Animal Ethics Committee.

Each of the three experiments was 10 weeks in duration, consisting of a 2-week preliminary period for adaptation to diets and an 8-week experimental period for the measurement of liveweight, feed and water intake and digestibility. Each experiment consisted of a completely randomised block design, with three treatments and six replicates (animals) per treatment. At the commencement of each experiment, animals were ranked and blocked on the basis of an unfasted liveweight. Within blocks animals were then randomly allocated to individual pens and treatments, and remained in the same individual pens throughout each experiment, with individual intake and digestibility determined. All cattle were injected with Ivomec (1 mL per 10 kg W; Merial Saude Animal Ltd, Fazenda Sao Francisco-Paulinia, Brazil) to control internal and external parasites at the beginning of the preliminary period of each experiment.

#### Experiment 1

Eighteen weaned, entire male Bali cattle ~6 months of age, and 91.8 ± 3.5 kg (mean ± s.e.) W and 953 ± 8 mm wither height, were allocated to treatments and individual pens as described above. The three experimental treatments were native grass [NG, 81 g crude protein (CP), 635 g ash-free neutral detergent fibre (NDF), 487 g ash-free acid-detergent fibre (ADF) and 13 g ether extract (EE)/kg DM, averaged over the experiment] fed *ad libitum*, NG supplemented with rice bran (RB; 120 g CP, 474 g NDF, 255 g ADF and 77 g EE/kg DM) at 10 g DM/kg W.day and NG supplemented with rice bran plus copra meal (RBCM; 166 g CP, 513 g NDF, 338 g ADF and 101 g EE/kg DM) at 10 g DM/kg W.day. The RBCM supplement was prepared by mixing RB and CM in equal proportions on an 'as-fed' basis, every morning before feeding. The supplements were provided once daily at 0700 hours and fed separately to the NG. The amount of supplement offered was adjusted regularly based on the most recent liveweight measurement. The supplements were gradually introduced over the first 7 days of the preliminary period. NG was cut locally (Palu, Central Sulawesi) each day and offered twice a day at 0800 and 1300 hours. NG refers to a mixture of grasses and forbs traditionally fed to cattle in Indonesia and consisted predominantly of *Brachiaria mutica*, *Eleusine indica* and *Paspalum conjugatum*. The grass was chopped to less than 10 cm in length before feeding. The amount of grass offered each day was set at 20% more than that consumed by the weaners on the previous day. Fresh drinking water was provided *ad libitum* to individual cattle in a separate bucket.

#### Experiment 2

The same 18 entire male Bali cattle used in Experiment 1 were used in Experiment 2. The cattle were ~9 months of age and 105.3 ± 4.8 kg W and 965 ± 10 mm wither height at the commencement of the experiment. The three experimental treatments were elephant grass (*Pennisetum purpureum*) hay (82 g CP, 664 g NDF, 464 g ADF and 28 g EE/kg DM) fed *ad libitum* (EGH), EGH supplemented with gliricidia (*Gliricidia sepium*; 211 g CP, 337 g NDF, 238 g ADF and 40 g EE/kg DM) at 10 g DM/kg W.day (EGHGLIR), and gliricidia fed *ad libitum* (GLIR). The EGH was harvested on three occasions, 30 days apart, dried, bulked and stored for a minimum of 2 weeks before the commencement of the experiment while the GLIR was harvested on the morning of feeding. EGH was chopped to less than 10 cm in length before feeding. GLIR and EGH were offered at 0800 and 1300 hours each day, at previous days' intake plus 20%. Animals offered the EGHGLIR treatment were offered EGH after their daily allocation of GLIR was consumed.

#### Experiment 3

Fourteen of the cattle used in Experiment 2 were used in Experiment 3. The four largest cattle from Experiment 2 were replaced with four entire male Bali cattle of similar age and W to the remaining cattle for Experiment 3. The entire male Bali cattle were ~12 months of age and 108.9 ± 4.7 kg in liveweight and 972 ± 10 mm wither height at the commencement of the experiment. The three experimental treatments were corn stover (CS, 83 g CP, 696 g NDF, 476 g ADF and 21 g EE/kg DM) fed *ad libitum*, CS supplemented with GLIR (224 g CP, 379 g NDF, 331 g ADF and 30 g EE/kg DM) at 10 g DM/kg W.day (CSGLIR), and CS supplemented with RBCM (188 g CP, 518 g NDF, 347 g ADF and 95 g EE/kg DM) at 10 g DM/kg W.day (CSRBCM). CS was harvested, dried and stored for an average of 2 weeks before feeding. The same feed processing and feeding procedures as outlined in Experiment 2 were followed.

### Measurements and calculations

Basal diet and supplement intake of animals in individual pens were measured daily throughout the experimental period by recording the amount of feed offered and refused. Subsamples of feed offered were collected each day and subsamples of feed residues collected each week. Digestibility was measured by total faecal collection over 7 consecutive days on three separate occasions, during weeks 2, 5 and 8 of the experimental period. Faeces of individual animals were collected from the concrete floor of the pen at 0800 hours each day, weighed and a 10% subsample was stored at −20°C and then bulked for each animal over the 7-day period. Water offered and water refused was measured at the same time each day and adjusted for evaporation rates in the pens over the same time period. Liveweight was measured 2 times each week, except during the faecal collection periods when it was measured at the start and end.

Metabolisable energy (ME) intake was estimated from Freer *et al.* (2007) where ME content (MJ/kg DM) = 0.0157 × digestible organic matter in DM (g/kg). Total water intake was estimated from water imbibed (drinking water intake) plus an estimate of water consumed in the feed.

### *Chemical analyses*

DM content of feeds, refusals and faeces were determined by drying representative samples to a constant weight at 60°C. Samples of feeds, refusals and faeces were ground using a blender before passing through a 1-mm screen. Feed, refusals and faeces were analysed for DM (AOAC 1990; method 930.15), ash (AOAC 1990; method 942.05), NDF and ADF (Goering and Van Soest 1970). In addition, feeds were also analysed for N, using the Kjeldahl method (AOAC 1990; method 981.10), and EE (AOAC 1990; method 990.3).

### *Statistical analyses*

Liveweight gain, intake and digestibility were analysed as a randomised block design using a repeated-measures ANOVA in GENSTAT 11.1 statistical package (GENSTAT 2008) with block as the blocking effect and diet as the treatment effect. Differences between treatments were accepted as significantly different at $P = 0.05$. Differences in mean values between diet treatments were compared by Fisher's protected l.s.d.

## Results

### *Chemical composition of feed sources*

The CP contents of NG, EGH and CS were less than 100 g CP/kg DM, while RB and RBCM supplement were between 100 and 200 g CP/kg DM and GLIR was above 200 g CP/kg DM (means over each experiment). GLIR had the lowest NDF content of all feedstuffs used in Experiments 1, 2 and 3. Within experiments, there was no significant change in the digestibility of any of the diets over time (i.e. on the three separate occasions it was measured).

### *Experiment 1*

Entire male Bali weaners fed NG supplemented with RB or RBCM grew faster than those fed NG alone (Table 1). Unsupplemented animals consumed more NG than animals supplemented in the RB or RBCM groups, with no difference in grass intake between the two supplementation treatment groups. All cattle receiving RB supplement consumed their total allocation, while those receiving the RBCM supplement consumed ~83% of their total allowance. Total DM intake, digestible organic matter intake (DOMI) and estimated ME intake were higher for cattle, which received RB and RBCM supplements relative to the unsupplemented group, with no difference between the two supplemented groups. The DM digestibility was greatest for the RBCM-supplemented group. There was no difference in daily water intake or estimated total water intake (water imbibed plus water consumed in feed) between the treatment groups.

### *Experiment 2*

Entire male Bali cattle fed EGHGLIR or given GLIR grew faster than those fed EGH alone (Table 2), with no difference between treatments receiving GLIR. Total DM intake of EGH and GLIR groups were similar when fed as the sole component of the diet but inclusion of GLIR with the grass increased intake by cattle relative to both other groups. Inclusion of GLIR in the diet at both levels increased DM digestibility. Total DOMI and estimated ME intake were greater for cattle offered EGH supplemented with GLIR compared with groups receiving grass or legume alone. There was no difference in drinking water consumption but estimated total water intake increased in order of EGH, EGHGLIR and GLIR with differences between all groups ($P < 0.05$).

### *Experiment 3*

Entire male Bali cattle supplemented with RBCM grew faster than those supplemented with GLIR which in turn outgained those on CS alone (Table 3). CS intake was highest for unsupplemented cattle compared with other cattle, while there were no differences in CS, supplement or total DM intake between cattle supplemented with GLIR or RBCM. Dry matter digestibility, DOMI and estimated ME intake increased in order of CS, CSGLIR and CSRBCM ($P < 0.05$). There was no difference between treatments in drinking water consumption but estimated total water intake was greatest for animals supplemented with GLIR compared with other groups.

**Table 1. Liveweight gain, intake of basal diet, supplement, water, digestible organic matter (DOM) and ME (metabolic weight, $W^{0.75}$) intake, and apparent dry matter digestibility (DMD) of native grass (NG), native grass plus rice bran (NGRB) and native grass plus rice bran and copra meal (NGRBCM) fed to weaned entire male Bali cattle (Experiment 1)**

Values are means and standard error of the mean. Within rows, means followed by different letters are significantly different at $P = 0.05$. n.a., not applicable as no supplement offered

| | NG | NGRB | NGRBCM |
|---|---|---|---|
| Liveweight gain (kg/day) | 0.104 ± 0.05a | 0.225 ± 0.05b | 0.292 ± 0.05b |
| Basal diet intake (g DM/kg W.day) | 25.9 ± 1.1b | 20.4 ± 1.1a | 20.1 ± 1.1a |
| Supplement intake (g DM/kg W.day) | n.a. | 10.0 ± 0.5b | 8.3 ± 0.5a |
| Total intake (g DM/kg W.day) | 25.9 ± 1.2a | 30.4 ± 1.2b | 28.4 ± 1.2ab |
| DMD (g/kg) | 581.6 ± 11.9a | 581.9 ± 11.9a | 628.4 ± 11.9b |
| Total DOM intake (g/kg W.day) | 14.7 ± 0.8a | 17.5 ± 0.8b | 18.1 ± 0.8b |
| Estimated ME intake (MJ ME/kg $W^{0.75}$.day) | 0.72 ± 0.04a | 0.88 ± 0.04b | 0.91 ± 0.04b |
| Drinking water intake (kg/day) | 4.2 ± 0.8 | 5.9 ± 0.8 | 6.0 ± 0.8 |
| Estimated total water intake (g/kg W.day) | 99.5 ± 7.4 | 101.2 ± 7.4 | 99.5 ± 7.4 |

**Table 2. Liveweight gain, intake of basal diet, supplement, water, digestible organic matter (DOM) and ME (metabolic weight, $W^{0.75}$) intake, and apparent dry matter digestibility (DMD) of elephant grass hay (EGH), elephant grass hay plus gliricidia (EGHGLIR) and gliricidia (GLIR) fed to weaned entire male Bali cattle (Experiment 2)**

Values are means and standard error of the mean. Within rows, means followed by different letters are significantly different at $P$ = 0.05. n.a., not applicable as no supplement offered

| | EGH | EGHGLIR | GLIR |
|---|---|---|---|
| Liveweight gain (kg/day) | 0.174 ± 0.03a | 0.280 ± 0.03b | 0.269 ± 0.03b |
| Basal diet intake (g DM/kg W.day) | 30.2 ± 1.3b | 23.8 ± 1.3a | 28.0 ± 1.3b |
| Supplement intake (g DM/kg W.day) | n.a. | 10.1 ± 0.01 | n.a. |
| Total intake (g DM/kg W.day) | 30.2 ± 1.3a | 33.8 ± 1.3b | 28.0 ± 1.3a |
| DMD (g/kg) | 547.6 ± 5.7a | 582.8 ± 5.7b | 588.3 ± 5.7b |
| Total DOM intake (g/kg W.day) | 15.1 ± 0.8a | 18.5 ± 0.8b | 16.3 ± 0.8a |
| Estimated ME intake (MJ ME/kg $W^{0.75}$.day) | 0.76 ± 0.04a | 0.97 ± 0.04b | 0.84 ± 0.04a |
| Drinking water intake (kg/day) | 8.6 ± 0.8 | 9.5 ± 0.8 | 8.9 ± 0.8 |
| Estimated total water intake (g/kg W.day) | 82.6 ± 6.4a | 102.5 ± 6.4b | 131.6 ± 6.4c |

**Table 3. Liveweight gain, intake of basal diet, supplement, water, digestible organic matter (DOM) and ME (metabolic weight, $W^{0.75}$) intake, and apparent dry matter digestibility (DMD) of corn stover (CS), corn stover plus gliricidia (CSGLIR) and corn stover plus rice bran/copra meal (CSRBCM) fed to weaned entire male Bali cattle (Experiment 3)**

Values are means and standard error of the mean. Within rows, means followed by different letters are significantly different at $P$ = 0.05. n.a., not applicable as no supplement offered

| | CS | CSGLIR | CSRBCM |
|---|---|---|---|
| Liveweight gain (kg/day) | 0.232 ± 0.03a | 0.311 ± 0.03b | 0.402 ± 0.03c |
| Basal diet intake (g DM/kg W.day) | 29.1 ± 0.6c | 21.2 ± 0.6a | 22.65 ± 0.6b |
| Supplement intake (g DM/kg W.day) | n.a. | 9.9 ± 0.5 | 8.4 ± 0.5 |
| Total intake (g DM/kg W.day) | 29.1 ± 0.5a | 31.1 ± 0.5b | 31.1 ± 0.5b |
| DMD (g/kg) | 554.2 ± 6.8a | 591.3 ± 6.8b | 612.9 ± 6.8c |
| Total DOM intake (g/kg W.day) | 13.9 ± 0.4a | 15.9 ± 0.4b | 17.1 ± 0.4c |
| Estimated ME intake (MJ ME/kg $W^{0.75}$.day) | 0.73 ± 0.02a | 0.84 ± 0.02b | 0.91 ± 0.02c |
| Drinking water intake (kg/day) | 10.1 ± 1.3 | 13.0 ± 1.3 | 10.5 ± 1.3 |
| Estimated total water intake (g/kg W.day) | 89.1 ± 9.5a | 124.5 ± 9.5b | 87.2 ± 9.5a |

## Discussion

Weaning calves at less than 6 months of age is one management strategy to improve reproduction rates of Bali cows within the crop-livestock systems of eastern Indonesia. Increasing the growth rates of weaned calves, through improved nutrition management, will potentially provide small-holder farmers with increased cash-flow, greater flexibility in marketing and better utilisation of scarce, high quality feed resources. The results of the three experiments described here indicate that the provision of small amounts of protein sources will result in modest increases in liveweight gain of weaned Bali cattle.

Bali cattle consuming diets of NG, EGH or CS alone showed the lowest growth rates (0.104, 0.174 and 0.232 kg/day, respectively), across the three experiments conducted. These three basal diets are typical of those offered under village management systems across eastern Indonesia. CS fed in these experiments was of comparable quality to the two grasses as indicated by the comparable liveweight gain. In Central Sulawesi, corn is harvested at the milky dough stage for traditional 'corn on the cob' consumption as opposed to harvesting the corn as mature hard grain, resulting in a better quality of the stover when fed to cattle. Higher growth rates of calves were obtained when supplements (RB, RBCM and GLIR) of higher quality than the basal feeds were included in the diet. This suggests that for diets typically fed in villages, the first constraint on the liveweight gain of growing Bali cattle is probably protein, although the additional energy supplied by the various supplements will also have contributed to the measured increased liveweight gain. Within these three experiments a response to protein by the cattle was indicated through the supply of GLIR in Experiments 2 and 3 and RBCM in Experiments 1 and 3 but there appeared to be no advantage in offering higher amounts of protein in the form of GLIR (Experiment 2). It is likely that this result is due to some negative effect of GLIR on total feed intake rather than exceeding the maximum response to protein in the diet (Smith and van Houtert 1987). Despite this, GLIR is likely to be the most widely used protein source, of those evaluated within the present work, for many small-holder farmers. GLIR is abundant across much of eastern Indonesia, has a high CP content, is cheaper than many protein supplements and is less labour intensive to harvest than grasses. The use of GLIR as a supplement to available grasses at 10 g DM/kg W.day (or ~30% of the diet on a DM basis) is a more sustainable strategy for utilisation than feeding it as the sole component of the diet.

The low liveweight gain of weaned Bali calves that received NG in the present study (0.1 kg/day) is consistent with results reported in East Java, Lombok, West Timor and South-east Sulawesi [0.12, 0.03, 0.02 and 0.16 kg/day, respectively (Poppi *et al*. 2009; Saili *et al*. 2010)]. The current study demonstrated that Bali calves respond to increased dietary CP content (and energy), which is in agreement with other studies (Poppi *et al*. 2009; Marsetyo *et al*. 2010). Marsetyo *et al*. (2010) reported that the growth rate of Bali calves (9 months of age) fed Mulato (*Brachiaria mulato*) grass (104 g CP/kg DM) was 0.31 kg/day and increased with addition of GLIR and RBCM (both offered at 10 g DM/kg W.day) to 0.42 and 0.52 kg/day, respectively. In a separate study, a similar class of Bali cattle grew at 0.65 kg/day when fed a concentrate-based ration containing 188 g CP/kg DM (Poppi *et al*. 2009), which was the maximum growth rate recorded for this class of cattle across 14 separate experiments conducted under comparable conditions. Moran (1985) reported growth rates of 0.66 kg/day for Bali bulls (335 kg W) offered a 90% concentrate and 10% EGH diet with a CP content of 150 g/kg DM.

This study demonstrated that entire male Bali cattle receiving NG, EGH, CS and GLIR alone had intakes of 25.9, 30.2, 29.1 and 28 g DM/kg W.day, respectively, which are relatively high compared with values for *Bos indicus* cattle fed a range of forages (Panjaitan *et al*. 2010). The inclusion of supplements of RB, RBCM or GLIR to the basal diets resulted in a decrease in intake of the basal diet but an increase in total DM, and estimated energy, intake. This substitution effect of supplement for basal diet shown in our experiments ranged from 22 to 27% in agreement with previous findings with supplements added to low quality forage (Marsetyo 2004).

In cut and carry systems, small-holder farmers often carry water to their cattle as required. In each of our three experiments supplementation had no effect on the amount of water imbibed by the entire male Bali cattle and therefore on the volume the farmer would need to carry each day. Under the conditions of these experiments total water intake of growing Bali cattle ranged from ~80 to 130 g/kg W.day, equivalent on average to 3.5 (range 2.3–4.3) kg water/kg DM intake, varying with feed intake and type of diet consumed. This is less than the intake of 4.75 kg water/kg DM intake reported for older and heavier (248 kg W) Banteng cattle (Moran *et al*. 1979) and 4.5–6.0 kg water/kg DM intake estimated for weaned *Bos indicus* cattle at ambient temperatures of 25 and 30°C, respectively (Freer *et al*. 2007).

It was concluded that the growth rate of weaned Bali calves could be substantially increased from ~0.1–0.2 kg/day achieved on various forage sources in the region to in excess of 0.4 kg/day with the addition of locally available protein/energy concentrates or GLIR without depleting available feed resources. Increases of this order would likely have a major impact on the turnover of cattle and increase cash flows for small-holder operations across eastern Indonesia (Priyanti *et al.* 2010). It is pertinent that the feeding of these supplements did not increase the volume of water required by the calves and thus did not contribute to increased labour demands on farmers.

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