Target feeding for improved smallholder beef production in the Mekong region: lessons from Cambodia and Lao PDR

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Abstract. Increased demand for red meat throughout the Greater Mekong Subregion (GMS) presents smallholder cattle and buffalo farmers with an opportunity to supply better quality animals to expanding regional markets. Cattle were target-fed in Cambodia with introduced forages to achieve gains of 0.19 kg/day over a 104-day period and this practice was compared with traditional cut-and-carry feeding practices where animals lost on average 0.04 kg/day. Target-fed animals were predicted to gain, on average, 25.9 kg more weight than animals fed in a traditional manner ($P = 0.057$), and to improve their estimated value by more than US$60. These outcomes were similar to outcomes in Lao PDR, where cattle and buffalo in fattening stalls gained 0.32 and 0.22 kg/day, respectively, over a 4-month period, and 0.04 and 0.09 kg/day when free-grazing. Greater weight gains are possible if farmers feed forages at the recommended 15% of bodyweight on a fresh-weight basis per day. Lack of knowledge of animal weights by farmers and traders was addressed by the creation of an accurate weight tape to provide a cheap and easy tool to monitor animal production and health, and to assist in negotiating a fair sale value. However, increased knowledge of appropriate forage plot size and feeding requirements of animals to be target-fed is required for farmers to change from being livestock keepers to livestock producers. To increase supply for the growing demand for red meat, an ongoing, multi-disciplinary extension program should be a priority for livestock improvement programs in the GMS.

Additional keywords: buffalo, cattle, forages, marketing, weight tape.

Introduction

Smallholder livestock production in the Greater Mekong Subregion (GMS) is semi-subsistence (Ngo and Mund 2006), with >70% of the population living in rural areas and agriculture accounting for 43% of total employment (ADB 2013). Smallholder farmers generally own <2 ha of land, with productivity dependent on labour, skill, finance and technology resources (Conway 2011). In Cambodia, smallholder large-ruminant farmers typically own fewer than five head of cattle (Young et al. 2014), whereas farmers in northern Lao Peoples Democratic Republic (PDR) own six or seven head (Rast et al. 2013). Inadequate provision of feed quality and quantity is a major constraint to beef production in Cambodia and Lao PDR. In Cambodia, the feed deficit is almost year-round because of distinct wet and dry seasons and an agricultural focus on rice production. Cattle and buffalo are typically tethered close to the household and fed native grasses daily by a cut-and-carry method, or communally grazed on rice stubble post-harvest (Nampanya et al. 2012). Conversely, in northern Lao PDR, an upland grazing system allows animals to be grazed on native grasses during the day and to be housed overnight (Nampanya et al. 2010). Hence, in the wet season there is not the same severity of malnutrition, because pastures are actively growing and of higher nutritional quality. In both countries, rice straw provides roughage but is of limited nutritional value. These feeding regimes are low in protein (3–4%) and high in crude fibre (35–48%), resulting in low body condition score (BCS) and limited weight gain (Devendra and Leng 2011).

Rural poverty remains a major problem, with 23% of people in Cambodia and 34% in Lao PDR living below the international poverty line of US$1.25 per day (UNDP 2013). Smallholder agricultural development is effective in reducing hunger and malnutrition through improving incomes (FAO, IFAD WFP 2012). The size and wealth of the middle class of many developing countries is increasing (Rask and Rask 2011), and this increases the demand for animal protein (FAO 2008). China’s per-person meat consumption is projected to increase by 68%
by 2023 (Quirke et al. 2003). Therefore, it is opportunistic for smallholder cattle and buffalo farmers in Cambodia and Lao PDR to increase production and capitalise on this export demand for beef.

To take advantage of an emerging beef market across the GMS, smallholder farmers need to change from being livestock keepers to livestock producers. Accurate assessment of animal value through determining liveweight and possession of the skills to target-feed animals with forages of improved quantity and quality to improve liveweight, BCS and marketability will assist smallholder farmers to achieve this change. The aims of this research were to determine the effect on beef production of target feeding cattle with improved forages, and to assess cattle and buffalo liveweight and value with the aid of a weight tape developed specifically for local animals.

Materials and methods

Target-feeding trial

A 104-day feeding trial was conducted in Cambodia to assess the impact of targeted forage feeding under field conditions in terms of increasing cattle weights and improving animal values. Three villages were chosen in southern Cambodia that had established forage plots and farmers familiar with participatory research. Villages were close enough to Phnom Penh to facilitate regular visits by project staff. Seven farmers were recruited through consultation with the village chief on the basis that they had: two or more cattle, the facilities to feed trial animals individually, and literacy levels appropriate for data recording.

In June 2012, 22 Haryana-cross (Bos indicus) cattle with an average age of 3.6 years (median 3.0 years) were enrolled with 14 target-fed and eight (controls) fed under traditional practices during the wet season to facilitate forage growth. The cattle were selected by the participating farmers in accordance with their production goals, such as improved breeding, improved power for draught, or improved liveweight and BCS for sale. The number of animals each household selected was dependent on the amount of forage grown.

On the first day of the trial, all cattle were given an anthelmintic treatment containing levamisole hydrochloride 3.0% w/v and oxyclozanide 6.0% w/v (Levafas®; Norbrook Laboratories Ltd, Corby, UK), and vaccinated against foot-and-mouth-disease and haemorrhagic septicaemia. All farmers completed a pre-trial survey that captured baseline data including farmer name, number of cattle enrolled in the study, the amount of each feed type offered was weighed and recorded at each morning and afternoon feeding by the farmer. Once each month, all cattle (trial and control) were weighed using electronic scales. At the end of the trial, each farmer completed a survey capturing perceived change in cattle value and BCS, and the farmer’s attitude towards target feeding.

Development of a girth tape

In total, 6089 girth and liveweight measurements were collected during 2008–10 (Collection 1) and 1266 in 2011 (Collection 2) from cattle and buffalo in six villages in northern Lao PDR. Village selection and project design is described in detail by Nampanya et al. (2010).

The data collected were used to develop a model to predict liveweight from girth measurements. This was done separately for cattle and buffalo. Although a quadratic model of logeGirth was used initially to predict logeWeight, it was determined that a cubic spline method better described the relationship between liveweight and girth measurements. The specific form of the model fitted to each combined dataset was:

\[
\log e\text{Weight} = \beta_0 + \beta_1 \log e\text{Girth} + \text{Season} + \text{Sex} + s(\text{log eGirth}) + \text{Village} + \epsilon
\]

where Weight is weight of animal (kg), Girth is girth of animal (cm), Season is effect of season of data collection (first or second), Sex is effect of male versus female, Village is effect of village (random), and \( \epsilon \) is random error. Here, \( s(\cdot) \) represents a spline smoothing function, and the term \( s(\log e\text{Girth}) \) incorporates the nonlinear departures from the overall linear trend of \( \log e\text{Girth} \) (as specified by the \( \beta_1 \log e\text{Girth} \) term). Note that the log-transformation for both variables was included to satisfy approximate normality for \( \log e\text{Weight} \), the outcome variable, as well as approximate linearity between \( \log e\text{Weight} \) and \( \log e\text{Girth} \). The models were fitted to the data with ASReml-R (Butler et al. 2009).

Estimating animal value

Traders were surveyed in Cambodia \((n = 55)\) and northern Lao PDR \((n = 32)\) in 2009 to establish the importance of estimating liveweight and BCS when determining animal value. Survey questions related to the types and ages of cattle and buffalo purchased by the traders, the destination of these cattle (domestic or export), animal BCS (poor, medium or good), season (wet or dry), and the prices paid. Survey development followed a series of provincial meetings with traders and slaughterhouse managers.

Data analyses

Trader questionnaire responses were managed and analysed using Microsoft® Excel 2000 (Microsoft, Redmond, WA). A REML linear mixed model in Genstat Ed 13 (VSN International, Hemel Hempstead, UK) was used to analyse feeding trial data and predict weight gains of target-fed animals, with animal age, gender, treatment and time included as fixed effects, and village, farmer and animal as random effects.
Results

Target feeding trial

Over the 104-day trial, target-fed animals received, on average, 8% of their liveweight as fresh forage (range 5–14%), whereas control animals received 5% (range 2–10%). The final mean liveweight of target-fed animals that completed the study was 283.9 kg \((n = 14)\), compared with 243.0 kg for the control animals \((n = 6)\) (Table 1). Two of the control animals were sold prior to study completion. This equated to an average daily gain of 0.19 kg/day for target-fed animals, compared with a loss, on average, of 0.04 kg/day with traditional feeding practices. The linear mixed model indicated age as significant \((P < 0.001)\), with feeding regime marginally significant \((P = 0.057)\). The linear mixed model also predicted that the weight of target-fed animals would increase by 25.9 kg when accounting for age. The average BCS increased from 2.0 to 3.2 for target-fed and from 1.3 to 2.5 for traditionally fed cattle. The estimated value of target-fed cattle was US$61.29 higher than of traditionally fed animals at the end of the trial.

At trial completion, all farmers indicated that they would continue target feeding and suggested that their target-fed animals had increased in estimated value compared with their traditionally fed animals. Farmers also indicated that target feeding of forages provided time-savings of ~2 h per day.

Development of a girth tape

No differences were obvious in the girth–liveweight relationships between male and female animals (data not shown), or between the two collections for cattle or buffalo (Fig. 1, plots of raw data).

Owing to the large number of outliers in the raw data, an iterative algorithm was used to reject observations with a standardised residual of >4 in absolute value. This value was selected because it is reasonable to assume that the most extreme standardised residual would be ~3.5 for ~7800 observations in normally distributed data.

The model was re-fitted by dropping the non-significant Sex and Season terms. The plots in Fig. 2 show the fitted model (mean weight for a given girth) along with the standard errors of the mean for cattle and buffalo. Note that predictions have been restricted to 60–225 cm girth for cattle and 75–225 cm girth for buffalo; outside this range, predictions are not reliable.

Estimating animal value

Traders were prepared to pay more for heavier animals but were concerned by the high prices that they paid compared with meat sales returns. They endorsed establishing domestic and export markets for live cattle and buffalo as well as for hides. Traders also wanted to prevent imports and illegal exports, and the introduction of tax discounts for slaughterhouses.

Table 1. Comparison of target feeding of forages over a 104-day period versus traditional cut-and-carry feeding of roadside grass on average daily feed intake, liveweight (mean ± s.e.), average daily gain and change in estimated value

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average daily feed intake (kg)</th>
<th>Initial average liveweight (kg)</th>
<th>Final average liveweight (kg)</th>
<th>Average daily gain (kg/day)</th>
<th>Change in estimated value (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forage</td>
<td>Rice straw</td>
<td>Rice bran</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target-fed ((n = 14))</td>
<td>22.2 ± 2.7</td>
<td>5.5 ± 1.7</td>
<td>0.46 ± 0.2</td>
<td>264.0 ± 32.0</td>
<td>283.9 ± 33.2</td>
</tr>
<tr>
<td>Traditionally fed ((n = 6))</td>
<td>9.8 ± 5.5</td>
<td>2.5 ± 0.6</td>
<td>0.08 ± 0.0</td>
<td>247.0 ± 33.4</td>
<td>243.0 ± 31.6</td>
</tr>
</tbody>
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\(^{A}\)Cattle values estimated by the owner at the start and conclusion of the trial.
majority of traders sourced their animals locally, with some purchasing from other districts. The different prices paid reflected specific target markets or the health and BCS of the animal.

During the survey, traders reported that they used BCS as a means of assessing animal weight, although they had difficulty in estimating the actual liveweight of animals. In response, a field visit in June 2010 provided an opportunity for farmers, traders and village or provincial staff to assess cattle visually at the Tameo Breeding Station, Cambodia, and Ban Nong, Xiengkhoun Province, Lao PDR, to estimate BCS, liveweight and animal value. Animals were then weighed on electronic scales and comparisons made between the estimated and actual weights, with differences discussed in relation to the impact on animal value. In both countries, traders were consistently either slightly overestimating (3–4% or +10 kg) or substantially underestimating (up to 24% or −50 kg) liveweight, which influenced their estimation of animal value accordingly. The lighter animals provided a higher variation in estimated weight and value. All animals had a low BCS (<1–1.5), and so were described as ‘skinny’ by traders.

Discussion

This study demonstrated the challenges associated with increasing the supply of red meat in the GMS, and the results are applicable to the lowland rice-growing and upland grazing areas across the region. Although an area of 800–1000 m² of introduced forages per animal is required to fatten large ruminants over a 2–3-month period (Stür and Varney 2007), the size of forage plots in the feeding trial in Cambodia ranged from 150 to 909 m², with only one farmer having the recommended size. Despite this, target-fed cattle had higher average daily liveweight gains than cattle in the control group. The liveweight gains in this trial were similar to those from Lao PDR, where cattle and buffalo gained 0.32 and 0.22 kg/day, respectively, over a 4-month period compared with 0.04 and 0.09 kg/day for free-grazing animals (Nampanya et al. 2014). The estimated increase in value of US$61.29 is similar to gains of $78.00 for cattle target-fed for a similar time in Lao PDR (Nampanya et al. 2014). The weight gains in Cambodia would likely be greater if farmers supplied green fodder to the recommended 15% of liveweight per day (Stür and Varney 2007) instead of feeding, on average, 8% of liveweight forages and roadside grass. Control cattle fed forages or roadside grass at 5% liveweight lost weight, indicating that forages need to be fed in sufficient quantity to lead to improved liveweight gain. This is an important message for extension workers to enable successful results from target feeding.

A lack of knowledge of animal liveweights by farmers and traders was also identified. There are numerous production, health and financial benefits of providing smallholder cattle and buffalo producers with the capability of accurately estimating liveweight. Livestock sale value is usually based on a combination of BCS and liveweight (Millar and Photakoun 2008), so accurate estimation of liveweight is essential when negotiating a fair sale price. This is especially pertinent considering the benefits to livelihoods resulting from the sale of one animal.

Livestock extension workers in Cambodia and Lao PDR have reported that a girth weight tape developed for cattle and buffalo can enhance the ability of traders and farmers to determine animal value accurately in the absence of electronic scales. Hence, this weight tape has the potential to empower smallholder producers to be better negotiators when trading beef animals, while reducing trader risk of lost margin. Although commercially available weight tapes are common for Bos indicus and Bos taurus beef breeds in developed countries, they have proven unreliable in estimating the weight of local animals because of differences in body size and shape, especially around the girth.

When implementing a feeding regime, it is important to observe weight gain, so as to measure growth, development and productive performance as well as monitor ration efficiency. In addition to increasing animal weight, farmers need to increase the number of calves being born. Target feeding of forages to heifers to attain a critical mating weight and BCS for conception has a direct effect on the age at which

Fig. 2. Fitted model of association (solid line) between girth (cm) and liveweight (kg) for cattle and buffalo with standard errors of the mean (dashed lines).
heifers will first calve, as well as influencing the inter-calving interval of all females (McConochie 2007). After calving, cows in better body condition will produce a higher volume and quality of milk, promoting earlier puberty and lengthening a calf’s productive life. In addition, anthelmintic and other drug administrations are often based on an animal’s liveweight. Hence, producer knowledge of liveweight will promote the administration of appropriate doses and assist in reducing anthelmintic resistance (Mejia et al. 2003).

With rising incomes and an increase in consumption of red meat in Southeast Asia (Pingali 2007), smallholder producers are well placed to capitalise on this increased demand. For this to be achieved, an ongoing, multi-disciplinary extension program is required to assist smallholders to produce a consistent supply of better quality animals.

Conclusions
Increased demand for red meat throughout the GMS presents smallholder cattle and buffalo farmers in Cambodia and Lao PDR with an opportunity to provide better quality animals to meet expanding regional markets. Lack of knowledge of animal liveweights by farmers and traders was addressed through creation of an accurate weight tape to provide a cheap and easy tool to monitor animal production and health, and to assist in negotiating a fair sale value with traders. The introduction of target feeding provides a strategy for production of a more consistent supply of better quality and higher value animals, resulting in improved livelihoods for smallholder farmers in the GMS. However, increased farmer knowledge of forage plot size and feeding requirements of animals to be target-fed is needed and should be a priority for livestock extension programs in the GMS.

Acknowledgements
This study received financial support from the Australian Centre for International Agricultural Research (ACIAR AH/2006/159 and AH/2005/086). We acknowledge collaborators including the Department of Animal Health and Production in Phnom Penh, Cambodia, and the Department of Livestock and Fisheries in Luang Prabang, Lao PDR. The willingness of the Cambodian and Lao PDR farmers to provide the information presented in this paper is also appreciated.

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doi:10.3763/ijas.2007.0335

www.publish.csiro.au/journals/an