Forage growing as an incentive to improve smallholder beef production in Cambodia

R. D. Bush\textsuperscript{A,D}, J. R. Young\textsuperscript{A}, S. Suon\textsuperscript{B}, M. S. Ngim\textsuperscript{C} and P. A. Windsor\textsuperscript{A}

\textsuperscript{A}Faculty of Veterinary Science, University of Sydney, Camden, NSW 2570, Australia.  
\textsuperscript{B}Department of Animal Health and Production, Ministry of Agriculture Forestry and Fisheries, Phnom Penh, Cambodia.  
\textsuperscript{C}Royal Academy of Cambodia, Phnom Penh, Cambodia.  
\textsuperscript{D}Corresponding author. Email: russell.bush@sydney.edu.au

\textbf{Abstract.} A major challenge for large ruminant improvement projects in developing countries is smallholder farmer engagement that promotes the value of knowledge in informed decision making. Most large ruminant smallholder farmers in Cambodia are considered to be livestock keepers and will become livestock producers only if they recognise the production and financial benefits from improved health and management practices. The benefits of growing and feeding five introduced forage species was investigated as a potential entry point for smallholder farmer engagement in southern Cambodia. The mean chemical composition, digestibility and estimated metabolisable energy (ME; MJ/kg DM) of introduced forages at 30 days after first harvest were comparable to published values. An initial establishment of 52 fodder plots covering 2.6 ha in 2008 expanded to 1306 plots covering 45 ha, including non-project farmers from surrounding areas. The establishment of forage plots in high-intervention project villages provided an improvement in average daily liveweight gain of cattle and saved farmers up to 2 h labour per day. This strategy provided a platform for increased uptake and adoption of livestock health and production interventions.

\textbf{Additional keywords:} buffalo, cattle, nutrition, time saving, weight gain.

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\textbf{Introduction}

A major challenge for large ruminant improvement projects in developing countries is smallholder farmer engagement (Whitbread \textit{et al.} 2010; Young \textit{et al.} 2013a). When encouraging health and production intervention uptake and adoption by livestock-producing households, the aim is to promote the concept of valuing knowledge for informed decision making (Heffernan 2004) instead of seeking monetary handouts that lack longer-term sustainability. Knowledge itself is unlikely to be valued unless farmers perceive the message being delivered as credible (Kanter 2001; Young \textit{et al.} 2013a). Credibility is likely gained from a positive experience where the farmer benefits financially through increased income, or socially through increased time for other pursuits that would have otherwise been spent caring for or feeding animals (Young \textit{et al.} 2013a). Hence, it is important to identify an appropriate incentive that will motivate farmers to change the way they operate (Young \textit{et al.} 2013a). This provides an ‘entry point’ to achieve initial farmer engagement and a platform to promote additional interventions that will improve enterprise productivity and profitability.

In Cambodia, cattle and buffalo are in a constant state of undernourishment as they rely on poor-quality roadside grasses and rice straw as their primary source of nutrition in both wet and dry seasons (Pen \textit{et al.} 2010; Nampanya \textit{et al.} 2012). This has negative implications for health and production as animals are more susceptible to disease, have reduced draught power, and experience an extended intercalving interval in addition to reduced sale value due to low body condition and liveweight (Young \textit{et al.} 2013a, 2014). The challenge is to convince farmers of the benefits of investing in growing and feeding introduced forages when they traditionally feed readily available fodder resources at minimal or no monetary cost, but with a significant time investment by household members.

Given livestock in South-east Asia are an ‘asset bank’, as they act as a wealth store for these smallholder farmers (Thomas \textit{et al.} 2002), the likely appeal for providing improved forage quality and increased quantity to cattle and buffalo lies in promoting the resulting gains in liveweight and animal value. Additional likely benefits include time savings in not having to travel long distances to ‘cut and carry’ roadside grass or care for animals grazing rice stubble (Maxwell \textit{et al.} 2012), and also having additional household income to direct towards options such as increasing enterprise size and diversity or improve household members’ health and education (Young \textit{et al.} 2014).

Most large ruminant smallholder farmers in Cambodia are considered to be livestock keepers (Young \textit{et al.} 2014). Recognition of the production and financial benefits from improved health and management interventions is required to
encourage these farmers to become livestock producers. Hence, the aim of this paper is to identify appropriate entry points to engage farmers in adopting health and production improvements. This paper provides information on the nutritional quality of introduced forages, forage uptake by project farmers as well as liveweight gains from improved feeding regimes to improve beef production in the lowland regions of Cambodia.

Materials and methods

Project sites

Site selection and project design is described in detail by Young et al. (2013b). Briefly, six project sites (villages) from three provinces were selected to participate in the project, with two matched villages in each province. One village in each province was designated as high intervention (HI) and one as low intervention (LI). The villages and designated intervention type were Nor Mo (HI) and Dem Pdet (LI) from Takeo province, Preak Por (HI) and Koh Kor (LI) from Kandal province, and Senson Tbong (HI) and Veal (LI) from Kampong Cham province. Village selection criteria included: cattle population of at least 250 head (i.e. >100 adults, >50 weaners, and >50 calves); year-round road access; willingness of village authorities, farmers, and local government agency personnel to participate in the project; and, finally, a distance of at least 10 km between project villages in the same province to prevent cross communication between participants. Cattle in all villages received regular vaccinations for haemorrhagic septicaemia and foot and mouth disease, providing an incentive for farmers in the LI villages to be involved in the project. Knowledge interventions on forage production were only delivered in HI villages.

Farmer selection for forage growing

Farmer selection was based on commitment, having more than one animal, plus the potential capability to fence and irrigate at least 300 m² of land. Initially, five or six farmers were selected in each of the three HI villages to grow, maintain and harvest recommended forage species using supplied seed, seedlings or rooted tillers. It was anticipated that this number would increase by a further 10–15 farmers/village each year, based on farmer interest and demand.

Intervention delivery and farmer training

The forage growing and feeding interventions introduced to the HI villages are described in detail by Nampanya et al. (2012). Briefly, interventions providing knowledge and technology improvements were delivered using a series of 1–4-day workshops and on-farm training. Technology improvements included forage plot development with seeds and seedlings as well as silage making. Initially, seed was provided for sowing and later replaced by seedlings (due to better competition against weeds) grown at one of 15 Department of Animal Health and Production (DAHP) forage nursery plots. Once forage plots became established on each farm, training was provided on targeted feeding practices as well as fodder conservation using bag silage. Targeted feeding encourages farmers to identify animals to feed individually so as to improve draught power, reproductive performance and sale price following fattening, depending on their production aims. The introduced forage species were introduced on the basis of their suitability to specific growing environments and included grasses Panicum maximum cv. Simuang, Brachiaria hybrid cv. Mulato II, Brachiaria brizantha cv. Marandu, and Paspalum atratum cv. Terenos as well as a legume Stylosanthes guianensis cv. Stylo 184. On-farm training consisted of DAHP project staff working with small groups of farmers to provide instruction on forage cultivation, plot management (fertiliser application comprising primarily manure and irrigation if available) and harvesting to optimise quality and quantity of fodder produced as well as approaches to feeding to improve weight gains and animal productivity. Interventions and training in animal health were also provided to complement the forage messages.

Forage and weight data collection

Annual audits were used to determine the number of farmers growing forages and the area of the forage plot on each farm. For the period March 2008 until February 2011 (~34 months), data on weight gain of 63 mixed-sex Haryana cattle (>1–2 years old, 24 female and 39 male) in the LI and HI intervention groups were obtained from seven weighings at ~5-month intervals.

Nutritional quality of introduced forage species

Proximate analysis was used to establish the nutritional value and digestibility of forages. Forages were grown during the wet season. Fresh samples containing all above-ground biomass (stem and leaves) of all introduced forages were collected daily over a 5-day period 2 months after sowing, and divided into two parts. The first part was analysed for DM where ~5–10 g of sample was dried for 24 h in the oven at 100–105°C. The second part was kept and pooled for analysis of ash, crude protein (CP), crude fibre (CF) (AOAC1984), neutral detergent fibre (NDF), and acid detergent fibre (ADF) (Van Soest and Robertson 1985) as well as predicted digestible DM % (DDM%) (Oddy et al. 1983) where

\[
\text{DDM}\% = 83.58 - 0.824\text{ADF}\% + 2.626\text{N}\%.
\]

Metabolisable energy (ME) levels were then estimated using the empirical formula (NSW Agriculture 1983)

\[
\text{ME content MJ/kg DM} = 0.17\text{DDM}\% - 2.0.
\]

Chemical composition between species was analysed using one-way ANOVA in SPSS software (ver. 16.0, IBM SPSS Statistics, New York, USA).

Data analysis

A systematic data analysis was conducted to check for errors and anomalies as well as to understand individual variable distribution. After the data were cleaned and manipulated in Microsoft Excel, descriptive and statistical analysis was conducted using both Excel and GENSTAT Ed. 13 (VSN International 2010). The average daily gain of cattle in the HI and LI groups was tested for statistical significance using a two-sample t-test.
**Results**

*Nutritional quality of introduced forage species*

The mean chemical composition (%DM), digestibility (%DM) and estimated ME (MJ/kg DM) of introduced forages at 30 days after first harvest are presented in Table 1. DM was similar among all species (range 19.8–23.5% DM), with CP highest for Stylo 184 (17.8% DM) and lowest for Simuang (11.7% DM). Of the introduced grasses, predicted digestible ME was highest for Simuang (53.6% DM) and lowest for Mulato II (51.9% DM), with Stylo 184 having the highest value at 54.3% DM. Estimated ME was highest for Stylo 184 (7.2 MJ/kg DM) and lowest for Mulato II (6.8 MJ/kg DM).

Forage plot establishment

An initial establishment of 52 fodder plots totalling 2.7 ha in 2008 grew to 1211 plots covering 41.7 ha in 2011 (Table 2). In addition, at the final data collection in February 2012, a further 95 plots had been established in Takeo covering 3.5 ha, bringing the grand total to 1306 plots covering 45 ha.

*Effect of forage feeding on liveweight gain*

The average daily weight gain of 1–2-year-old cattle in LI villages was 0.06 kg/head.day (range 0.05–0.06 kg/head.day) compared with 0.13 kg/head.day (0.11–0.15 kg/head.day) in HI villages ($P < 0.001$). This trend was typical for other age groups where weights were also recorded but not reported. There was no significant difference between average daily weight gain for male and female cattle. A comparison of weight gain in cattle (>1–2 years of age) between HI and LI villages over a ~34-month period in Cambodia is presented in Table 3.

**Discussion**

The success of introducing a forage-growing intervention is evident by the demand from smallholder beef farmers in three southern provinces of Cambodia. Although initial planning was for the selection of five or six farmers from the HI village in each province in 2008, the actual number of forage plots established was 52, totalling 2.7 ha. Within 4 years, the demand for forage growing had expanded to 1306 plots covering over 45 ha. Farmers from within the project villages as well as surrounding areas were introducing this new technology.

The nutritional values for the four introduced tropical grasses and one tropical legume provide a good indication of their ability to meet animal requirements for improved productivity, provided farmers feed the required quantity. These values are indicative of their nutritional value for multicut species at 30 days after the first harvest. The nutritional values for each species are comparable to published average values (Gohl 1981; Cook 2005; FAO 2009). However, it should be noted that many published figures present large ranges, reflecting the stage of maturity of the plant, which is often not stated, or fits within a developmental range such as young, intermediate or mature. For example, the CP for Stylo 184 of 17.8% is at the upper end of the range of CP values available on Feedipedia (FAO 2009; 6.2–21.7%) and Tropical Forages (Cook 2005; 12–20%).

The nutritional quality of the introduced forages being promoted to smallholder farmers can be demonstrated by increased weight gains of the animals being fed. Average weight gains of 0.13 kg/head.day were more than double those experienced in villages relying solely on roadside grass and rice straw as their only source of nutrition, yet still below published gains of 0.25–0.6 kg/head.day for Stylo 184, 0.6 kg/head.day for Marandu and Terenos, and 0.81–0.91 kg/head.day for Simuang and Mulato II respectively (Cook 2005). This difference in weight gain may be attributed to farmers feeding less than recommended quantities as well as supplementing with rice straw, compared with feeding individual animals an entire ration of the respective forages. Other possible reasons for reduced appetite include growth constraints such as animal health, environmental stress and poor welfare and management. Associated publications report an increase in animal value due to improved body condition and weight also enabled farmers to expand their enterprise by increasing numbers

<table>
<thead>
<tr>
<th>Forage</th>
<th>DM</th>
<th>Ash</th>
<th>OM</th>
<th>CP</th>
<th>CF</th>
<th>ADF</th>
<th>NDF</th>
<th>DDM</th>
<th>ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simuang</td>
<td>21.5</td>
<td>7.1bc</td>
<td>93.0ab</td>
<td>11.7c</td>
<td>27.2b</td>
<td>42.4b</td>
<td>71.4a</td>
<td>53.6</td>
<td>7.1</td>
</tr>
<tr>
<td>s.d.</td>
<td>1.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>2.0</td>
<td>1.1</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mulato II</td>
<td>21.6</td>
<td>7.5b</td>
<td>92.6b</td>
<td>15.9b</td>
<td>27.2b</td>
<td>46.6a</td>
<td>68.8b</td>
<td>51.9</td>
<td>6.8</td>
</tr>
<tr>
<td>s.d.</td>
<td>4.5</td>
<td>0.2</td>
<td>0.2</td>
<td>1.3</td>
<td>0.7</td>
<td>1.9</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marandu</td>
<td>23.5</td>
<td>8.2a</td>
<td>91.8c</td>
<td>12.6c</td>
<td>26.4b</td>
<td>43.8b</td>
<td>66.7c</td>
<td>52.8</td>
<td>7.0</td>
</tr>
<tr>
<td>s.d.</td>
<td>3.6</td>
<td>0.3</td>
<td>0.3</td>
<td>0.23</td>
<td>2.7</td>
<td>1.3</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terenos</td>
<td>19.8</td>
<td>6.9c</td>
<td>93.6a</td>
<td>12.6c</td>
<td>27.6b</td>
<td>44.0b</td>
<td>67.7bc</td>
<td>52.6</td>
<td>6.9</td>
</tr>
<tr>
<td>s.d.</td>
<td>1.1</td>
<td>0.3</td>
<td>0.3</td>
<td>1.2</td>
<td>0.8</td>
<td>1.0</td>
<td>1.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stylo 184</td>
<td>20.4</td>
<td>7.2bc</td>
<td>92.8ab</td>
<td>17.8a</td>
<td>37.9a</td>
<td>44.6ab</td>
<td>69.5ab</td>
<td>54.3</td>
<td>7.2</td>
</tr>
<tr>
<td>s.d.</td>
<td>0.8</td>
<td>0.1</td>
<td>0.1</td>
<td>0.7</td>
<td>1.7</td>
<td>1.0</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Households growing forages and area grown (ha) in high-intervention (HI) villages in Cambodia 2008–11

<table>
<thead>
<tr>
<th>Year</th>
<th>Takeo (n)</th>
<th>Kampong Cham (n)</th>
<th>Kandal (n)</th>
<th>Total forage area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>34</td>
<td>12</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>2009</td>
<td>212</td>
<td>65</td>
<td>70</td>
<td>13.1</td>
</tr>
<tr>
<td>2010</td>
<td>263</td>
<td>148</td>
<td>85</td>
<td>19.6</td>
</tr>
<tr>
<td>2011</td>
<td>204</td>
<td>112</td>
<td>0</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Table 3. Comparison of weight gain in cattle (>1–2 years of age) in high-(HI) and low- (LI) intervention villages over a 34-month period in Cambodia

<table>
<thead>
<tr>
<th>Village</th>
<th>n</th>
<th>Initial weight (kg)</th>
<th>Mean</th>
<th>s.d.</th>
<th>Daily gain (kg/head.day)</th>
<th>Mean</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low intervention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veal</td>
<td>15</td>
<td>168.0</td>
<td>20.4</td>
<td></td>
<td>0.062</td>
<td>0.014</td>
<td></td>
</tr>
<tr>
<td>Dem Pdet</td>
<td>8</td>
<td>186.4</td>
<td>61.2</td>
<td></td>
<td>0.059</td>
<td>0.021</td>
<td></td>
</tr>
<tr>
<td>Koh Kor</td>
<td>7</td>
<td>257.4</td>
<td>37.0</td>
<td></td>
<td>0.045</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>–</td>
<td>193.8</td>
<td></td>
<td></td>
<td>0.057(^a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High intervention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensong Tbong</td>
<td>15</td>
<td>165.2</td>
<td>36.8</td>
<td></td>
<td>0.136</td>
<td>0.019</td>
<td></td>
</tr>
<tr>
<td>Nor Mo</td>
<td>11</td>
<td>167.9</td>
<td>32.8</td>
<td></td>
<td>0.109</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Preak Por</td>
<td>7</td>
<td>237.6</td>
<td>80.1</td>
<td></td>
<td>0.144</td>
<td>0.028</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>–</td>
<td>181.5</td>
<td></td>
<td></td>
<td>0.129(^a)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)HI and LI groups were statistically different using a two-sample t-test (P < 0.001).

of cattle, pigs and poultry or venturing into new livestock enterprises if not already established (Nampanya et al. 2012; Young et al. 2013).

Introduced forages are more appropriate for feeding large ruminants to improve production than is rice straw which contains between 4 and 6.5 MJ ME/kg DM and has a very low CP concentration ranging between 2% and 6% (Nour 2003). This is in part due to rice straw containing a large amount of silica (12–16%), which has no nutritional value, affects its palatability and reduces the amount ruminants will eat (Nour 2003). The digestibility of all forages was more than 50%, which is within the range of published figures (Cook et al. 2005), which is preferable to the common practice of farmers harvesting mature forages with higher yields and lower digestibility.

Farmers adopted growing forages at a faster rate than was initially expected. Farmer meetings identified time savings as a major motivational factor for uptake of this technology. The availability of forages at the household saved farmers, on average, 2 h/day as they or their children were no longer required to conduct the time-consuming activities of cut-and-carry or grazing animals on rice paddies (Millar and Phoutakhoun 2008; Pen et al. 2010; Maxwell et al. 2012; Nampanya et al. 2012; Young et al. 2014) as cut-and-carry forages were available adjacent to the cattle. This provided an opportunity for the farmer to seek outside employment and for children to spend more time at school.

Social incentives that can achieve a rapid ‘pay-back’ are likely to be useful in identifying ‘entry point’ interventions, particularly where financial benefits may require a longer time commitment to become overtly obvious or realised such as improved weight gain in large ruminants. A likely second reason for rapid forage technology uptake is that farmers are highly experienced in agrarian activities with livelihoods based on rice and vegetable growing. Therefore, the change to forage growing did not vary greatly from their current practices, making this change an easier process.

Severe widespread flooding occurred in Cambodia in 2011, affecting 18 of the 24 provinces. Over 350 000 households were affected and 10.7% of the nation’s rice crops were destroyed (United Nations Cambodia 2011). Kandal and Kampong Cham provinces were two of the most significantly affected, with project staff reporting that flooding had limited forage uptake. This is likely to be the primary reason why forage uptake slowed in 2011.

Seedlings are recommended for establishing forage plots compared with seeds as they are less susceptible to competition from weeds. This is important when convincing farmers to invest time and resources in establishing and managing a forage plot. The demand for forage seedlings exceeded supply and resulted in entrepreneurs establishing their own nurseries and selling to surrounding farmers.

The favourable experiences associated with growing and feeding forages encouraged farmers to be receptive to other health and production improvements such as vaccination against foot and mouth disease and haemorrhagic septicaemia, and improved husbandry practices. It is believed that increased adoption rates can be directly attributed to changes in the attitudes of smallholder farmers following this positive experience (Young et al. 2014).

Conclusions
Successful engagement of smallholder farmers is crucial when encouraging the uptake and adoption of animal health and production interventions. The growing of introduced forage species proved to be a credible entry point for farmers in southern Cambodia. The benefits of replacing roadside grass and rice straw with fodder of improved nutritional value more than doubled liveweights and saved time. This strategy provided a platform for uptake and adoption of health and production interventions.

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