Tropentag 2017, Bonn, Germany
September 20-22, 2017
Conference on International Research on Food Security, Natural Resource Management and Rural Development
organised by the University of Bonn, Bonn, Germany

Pen-Fed *versus* Grazing: The Potential of Forages for Cattle Production in North-Eastern Cambodia

Anna Seidel[a,*], Adrian Bolliger[b] and Uta Dickhöfer[a]

[a] University of Hohenheim, Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute), Germany
[b]International Center for Tropical Agriculture, Agrobiodiversity Research Area, Tropical Forages Program, Lao PDR

Abstract
Due to conversion of grassland and forest into cropland, rubber and oil palm plantations, smallholder cattle farmers in Ratanakiri Province, Northeast Cambodia, need to cope with decreasing grazing resources for their animals and with increasing land conflicts. The objective of this study was to evaluate the potential of cultivated forages contributing to cattle feeding in order to compensate the loss of grazing areas.
Above-ground biomass of cultivated forages (*Panicum maximum*, *Paspalum atratum*, *Brachiaria ruziziensis*, *B. ruziziensis* × *B. decumbens* × *B. brizantha*, *Stylosanthes guianensis*) in Pruok (13°57´N, 106°96´E) was determined destructively during the rainy season between June and September 2015. Samples of forages were analysed for their nutrient and energy concentrations. Furthermore, live weights of cattle either pen-fed on cultivated forages (n = 16) or grazing on native grasslands and in forests (n = 19) were recorded fortnightly for 14 weeks on five different smallholdings. Initial bodyweight of the local cattle was 122 ± 33 kg. Pen-fed animals consumed on average 3.9 ± 0.2 kg dry matter (DM) day^{-1}. Intake of the grazing cattle was not measured.
Above-ground biomass of cultivated forages ranged between 2 and 3 t DM ha^{-1} $month^{-1}$ with average crude protein, neutral detergent fiber and metabolisable energy concentrations of 84 ± 32 g kg^{-1} DM, 647 ± 48 g kg^{-1} DM, and 7.3 ± 0.4 MJ kg^{-1} DM, respectively. The average daily gain (ADG) was 79 and 241 g day^{-1} in pen-fed and grazing cattle, respectively ($P < 0.001$).
Sufficient forage amounts were supplied to pen-fed cattle. However, the predominant component was *P. atratum*, a grass of relatively low nutritional quality. Therefore, the differences in ADG were likely due to the overall lower nutrient quality of the cultivated forages compared to natural surroundings, where grazing cattle might have selected more nutritious plants in the rainy season. Thus, as management practice feeding cultivated forages was not an appropriate substitute to grazing during the rainy season. However, with decreasing access to grazing land, the use of cultivated forages to improve pastures or for conservation during the dry season merits further study.

Keywords: Cambodian smallholders, cultivated forages, grazing, cattle productivity

Contact Address: Anna Seidel, University of Hohenheim, Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute), Fruwirthstr. 31, 70599 Stuttgart, Germany, e-mail: AnnaSeidel1@gmx.de

Introduction
Over the past decade, smallholders in upland villages in north-eastern Cambodia have experienced new challenges in agricultural tenure and land use (Fox and Vogler, 2005), due to commercial and one-crop agriculture (Crews-Meyer and Walsh, 2002). In the past, smallholders grew their own

subsistence crops and grazed livestock on non-agricultural fields and on stubble or residues from agricultural fields in the off-season. Their main regular source of household income came from selling crops or from alternative on- and off-farm economic activities. Cattle, on the other hand, basically functioned as capital that could be made into cash in case of an emergency (White, 1996). However, the once vast grasslands and woodlands of Ratanakiri Province have shrunken, while the use of pesticides in plantations close to where animals graze has induced livestock poisoning and environmental damage (Bugalski and Thuon, 2015). Furthermore, some plantation owners maul or even kill livestock entering their plantations. This is aggravated by the fact that the majority of the local farmers do not purchase a deed of land ownership (Kirby, 1996). This requires a well-wrought adjustment in order to strengthen the position and livelihood of smallholders. Therefore, this research aimed to evaluate whether cut and carry from cultivated forages to feed penned cattle could improve cattle productivity compared to traditional, extensive livestock grazing systems. For this, the above-ground biomass and the nutrient concentration of farm-grown forages were estimated and the live weight gain of penned and grazing cattle was compared.

Material and Methods

The study was conducted on five farms in the village Pruok (13°57´N, 106°96´E) in Lumphat district of Ratanakiri Province, Northeast Cambodia, in 2015. The climate is monsoonal with mean annual precipitations and temperatures of 2,326 mm and 26 °C, respectively (1997 - 2014, Banlung). The dominant soil types of the study area are Gleysols and Acrisols (Someth *et al*., 2013). The farms were selected on the basis of their forage plots, size of the herds, and the farmers' willingness to participate in trials on their land. The leguminous forage species *Stylosanthes guianensis* cv. Ubon and the following four forage grasses were considered: *Panicum maximum* cv. Mombasa, *Brachiaria ruziziensis* cv. Ruzi, *B. ruziziensis* × *B. decumbens* × *B. brizantha* (*B*. hybrid), *Paspalum atratum* cv. Ubon. Values given in this text are expressed as mean ± standard deviation. The biomass of these forages was estimated in the beginning of June, July, August, and September by cutting the grasses and the legume to 4 ± 3 cm and 12 ± 5 cm above ground level used in three representative areas of 1 m^2 each, respectively. The collected material of each species was weighed and dry matter (DM) concentrations were determined by drying the samples (n = 71) at 60 °C for 48 h. Pooled Samples (n = 15; 5 forage species x 3 cutting times) were analysed for crude ash concentration by the Weende Feed Analysis method (Bassler and Naumann, 1993). Determination of crude protein (CP) concentration was conducted by the Dumas combustion method using an Elementar Vario MAX CN Analyser (Elementar Analysensysteme GmbH, Hanau, Germany). Neutral and acid detergent fibre concentrations were estimated according to the methods of van Soest *et al*. (1991) using an ANKOM 2000 Fibre Analyser (ANKOM Technology Corp., Macedon, NY, USA). Digestible organic matter (DOM) and metabolizable energy (ME) concentrations were determined by the Hohenheim Feed Value Test (Close and Menke, 1986).

On each farm, cattle belonging to the local breed at the age of about two years were weighed on three consecutive days in the morning and were divided into pairs in terms of sex and initial live weight. Out of each pair, one animal was randomly allocated to the pen-fed system and one to the grazing system. On average, the initial live weight of penned and fed a mix of the farm-grown forages cattle (n = 16) was 121 ± 27 kg and that of cattle grazing on the naturally-occurring vegetation (n = 19) amounted to 121 ± 36 kg. After 35 cattle treated for internal parasites and diseases had been in the respective system for two weeks for adaptation, all individuals were fortnightly weighed on two consecutive days in the morning for 14 weeks. Pen-fed cattle consumed 3.9 ± 0.2 kg DM day^{-1}. Data were analysed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Least squares means and standard error of the means of live weight gain per cattle were calculated for each system using the Mixed Model procedure (Proc Mixed). The model consisted of the fixed factor system (grazing and pen-fed) and the random factor (farm I to farm V), while sex as a fixed factor and initial weight as a covariate were not significant. Multiple comparisons of least squares means were done by the Kenward-Roger method.

Results and Discussion

Forage yield and quality

Smallholders grew forages in small areas on non-cropped land close to the house. The available area per farm and the size of the forage plot per farm ranged from 3 to 25 ha and from 0.06 to 1.95 ha, respectively. Due to its flooding tolerance (Hare *et al*., 2004), *P. atratum* was dominantly cultivated during the rainy season, followed by *B. ruziziensis x B. decumbens x B. brizantha*. Maximum yields of cultivated forages were measured in *P. atratum* with 2.5 ± 0.4 t DM ha^{-1} $month^{-1}$ and in *P. maximum* with 2.4 ± 0.2 t DM ha^{-1} $month^{-1}$, whereas *S. guianensis* had the lowest yields with 1.8 ± 0.4 t DM ha^{-1} $month^{-1}$. Enhanced conditions of growth may increase yields, as reported by Ngim (2013). Maximum CP, DOM, and ME concentrations were found in *S. guianensis*, whereas lowest ones were determined in *B. ruziziensis* (Table 1). The mixture of farm-grown forages fed to the penned cattle consisted of 42% *P. atratum*, 26% *P. maximum*, 16% *B. ruziziensis x B. decumbens x B. brizantha*, 13% *S. guianensis*, and 4% *B. ruziziensis*.

Table 1 Chemical composition (g kg^{-1} DM) and metabolizable energy (MJ kg^{-1} DM) of forages grown in Pruok during the rainy season from June to September 2015 (mean ± standard deviation).

	Forage species				
Parameter	1	2	3	4	5
Crude ash	94 ± 15	90 ± 9	73 ± 10	113 ± 18	100 ± 5
Crude protein	57 ± 3	75 ± 26	123 ± 14	71 ± 25	93 ± 44
Neutral detergent fibre	682 ± 52	656 ± 38	625 ± 93	625 ± 70	649 ± 35
Acid detergent fibre	460 ± 149	549 ± 154	424 ± 72	415 ± 129	442 ± 212
Digestibility of organic matter	520 ± 30	544 ± 24	559 ± 25	550 ± 60	539 ± 40
Metabolizable energy	7.0 ± 0.4[a]	7.4 ± 0.3[b]	7.8 ± 0.3[b]	7.3 ± 0.8[c]	7.2 ± 0.5[d]

DM, dry matter; n = 15, 5 forage species x 3 cutting times; 1, *Paspalum atratum*; 2, *Brachiaria ruziziensis*; 3, *Stylosanthes guianensis*; 4, *Panicum maximum*; 5, *B. ruziziensis x B. decumbens x B. brizantha*; [a, b, c] and [d] denote used ether extract concentrations were reported by Aganga and Tshwenyane (2004), Nasrullah *et al*. (2004), Luru *et al*., (2007), and Machogu (2013), respectively.

Live weight gains of pen-fed and grazing cattle

Smallholders raised between 9 and 30 cattle, mainly surviving by foraging wastelands, roadsides, and forests. During the dry season, animals were grazed freely day and night, whereas during the rainy season, they were tethered or herded. By-products from crops grown in Pruok principally included rice straw and rice bran were only used for feeding livestock during the dry season. In this study, pen-fed and grazing cattle gained 79 ± 76 g day^{-1} and 247 ± 124 g day^{-1}, respectively ($P < 0.001$). The significantly larger average daily gains of grazing cattle compared to penned cattle might be attributed to variations in nutrient composition between cultivated forages and natural pasture. Sufficient forage biomass was consumed by penned cattle. However, the predominant species in the forage mixture was *P. atratum*, a grass of relatively low nutritional quality. Inadequate protein concentrations of forages reduced the digestibility of energy (Campling *et al*., 1962). Hence, protein deficiencies might have reduced animal performance of pen-fed cattle, as has also been reported by Cecava and Perry (1995). On the other hand, grazing cattle might have been able to select more nutritious plants during the rainy season than the penned cattle. The increased deposition of protein relative to fat and the reduced maintenance requirements during the dry season might have contributed to compensatory growth in grazing cattle by increasing the energy available for growth, as described by Ryan *et al*. (1993).

Conclusions and Outlook

This research showed that feeding cultivated forages during the rainy season was not an appropriate substitute to grazing as management practice. However, with gradually decreasing access to grazing land, the use of cultivated forages may become more important. Therefore, the use of forage mixtures predominantly consisting of either leguminous forage species or forage grasses rich in CP merits further study. Future research may explore different pasture management strategies, planting leguminous shrubs and trees or over-sowing leguminous forages and improved forage grasses on fallow land to optimise the use of natural pastures by farmers during the rainy season. For this, land titles as a long time investment are crucial. Furthermore, research may assist to develop appropriate means of conserving well-adapted and high-quality forages for the dry season, a period when feed constraints become more acute. Therefore, it may be critical to investigate the threshold of compensatory growth in local cattle in order to ensure the ability of these animals during the rainy season to compensate dietary restrictions during the dry season.

References

1. AGANGA, A., TSHWENYANE, S., 2004. Potentials of Guinea Grass (*Panicum maximum*) as Forage Crop in Livestock Production. PJN 3 (1), 1–4.
2. BASSLER, R., NAUMANN, C., 1993. Methodenbuch: Die chemische Untersuchung von Futtermitteln. Ergänzungslieferung 3. VDLUFA-Verlag, Darmstadt.
3. BUGALSKI, N., THUON, R., 2015. A Human Rights Impact Assessment: Hoang Anh Gia Lai Economic Land Concessions in Ratanakiri Province, Cambodia. Conference Paper 28, Chiang Mai University, Thailand.
4. CAMPLING, R.C., FREER, M., BALCH, C.C., 1962. Factors Affecting the Voluntary Intake of Food by Cows 3. The Effect of Urea on the Voluntary Intake of Oat Straw. Br J Nutr 16, 115–124.
5. CECAVA, M.J., PERRY, T.W., 1995. Beef Cattle Feeding and Nutrition. Animal Feeding and Nutrition. Academic Press, San Diego.
6. CLOSE, W.H., MENKE, K.-H., 1986. Selected Topics in Animal Nutrition: A Manual Prepared for the 3rd Hohenheim Course on Animal Nutrition in the Tropics and Semi-Tropics, 2nd ed. Dt Stiftung f Internationale Entwicklung, Feldafing.
7. CREWS-MEYER, K.A., WALSH, S.J., 2002. Linking People, Place, and Policy. Springer US, Boston.
8. FOX, J., VOGLER, J.B., 2005. Land-Use and Land-Cover Change in Montane Mainland Southeast Asia. Environ Manage 36 (3), 394–403.
9. HARE, M.D., SAENGKHAM, M., TATSAPONG, P., TUDSRI, S., WONGPICHET, K., 2004. Waterlogging Tolerance of Some Tropical Pasture Grasses. Trop Grasslands, 227–233.
10. KIRBY, M., 1996. Report of the Special Representative of the Secretary-General for Human Rights in Cambodia. Commission on Human Rights. UN Doc E, CN 4, 1996/93, 84.
11. LƯU, H.M., NGUYỄN, M.N., NGUYỄN, N., 2007. Thành Phần Hóa Học Và Giá Trị Dinh Dưỡng Của Một Số Giống Cây Thức Ăn Gia Súc Họ Hòa Thảo. Tạp Chí Khoa Học, 183–192.
12. MACHOGU, C., 2013. A Comparative Study of the Productivity of *Brachiaria* Hybrid cv. Mulato ll and Native Pasture Species in Semi-Arid Rangelands of Kenya. Department of Land Resource Management and Agricultural Technology, University of Nairobi.
13. NASRULLAH, NIIMI, M., AKASHI, R., KAWAMURA, O., 2004. Nutritive Evaluation of Forage Plants Grown in South Sulawesi, Indonesia II. Mineral Composition. Asian Australas J Anim Sci 17 (1), 63–67.
14. NGIM, M.S., PHA, K., SAVOUTH, H., YOUNG, J.R., BUSH, R.D., 2013. Introduced Forage Productivity and Quality in the Smallholder Environment. In: YOUNG, J.R., RAST, L., SUON, S., WINDSOR, P.A. (Eds.), 2013, pp. 14-18.
15. RYAN, W.J., WILLIAMS, I.H., MOIR, R.J.,1993. Compensatory Growth in Sheep and Cattle II. Change in Body Composition and Tissue Weights. Aust J Agric Res, 1623–1633.
16. SOMETH, P., CHANTHY, S., PEN, C., SEAN, P., HANG, L., 2013. Basin Profile of the Lower Sekong, Sesan and Srepok (3S) Rivers in Cambodia: Project Report: Challenge Program on Water and Food Mekong Project MK3. Optimizing the Management of a Cascade of Reservoirs at the Catchment Level. ICEM, Hanoi, Vietnam.
17. VAN SOEST, P.J., ROBERTSON, J.B., LEWIS, B.A., 1991. Methods for Dietary Fiber, Neutral Detergent Fiber, and Non-Starch Polysaccharides in Relation to Animal Nutrition. J Dairy Sci, 3583–3597.
18. WHITE, J., 1996. Information and Research for the Planning Process in Ratanakiri Province: Current Situation and Future Needs. IDRC.