Media Peternakan, Agustus 2008, hlm. 146-154 Vol. 31 No. 2
ISSN 0126-0472
Terakreditasi B SK Dikti No: 43/DIKTI/Kep/2008

Forage Resources in Livestock-Cropping Smallholder Systems. A Case Study of Farmers at Transmigration Areas of Dompu, West Nusa Tenggara

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(*Diterima 25-02-2008; disetujui 11-06-2008*)

ABSTRACT

A study aimed to identify the farmer practice in providing feed for their Bali cattle was undertaken at Satuan Pemukiman A (SPA) sub-village, Manggalewa sub district, Dompu, West Nusa Tenggara, a region of highly variable rainfall patterns and lengthy dry seasons. A critical aspect of this study was the detailed characterization of the availability, quality and usage patterns for existing forage resource within the SPA mixed crop-livestock farming system. The study found that SPA farmers used varying mixtures of free or tethered grazing and cut and carry to supply the forage needs of their cattle. The available grazing was of good quality and supply in the wet season but declined rapidly by early dry season. From mid-dry season on, the vast majority of farmers relied increasingly on cut and carry forage from a range of sources including volunteer pastures, crop residues, shrub legumes and finally other sources such as banana and papaya stem, cashew apple and native tree leaves in the late dry season. Despite some use of high quality shrub legumes such as *Leucaena leucocephala* and *Gliricidia sepium* the quantity and quality of available forage was often below maintenance, especially for lactating cows. The study also revealed that existing forage sources such as the shrub legumes *L. leucocephala* and *G. sepium* maintained high levels of crude protein and digestibility year round. Greater use of shrub legumes (especially *G. sepium*) and conserved forages have the potential to significantly reduce the feed gap in the second half of the dry season at SPA.

Key words: Bali cattle, smallholder, cut and carry, pasture, shrub legume

INTRODUCTION

Demand for beef and other livestock products is increasing pressure on cattle production throughout south-east Asia (Delgado *et al.,* 1999). The province of West Nusa Tenggara is one of main regions for cattle production in Indonesia, with production being mainly based on Bali cattle (*Bos sondaicus, or Bos/Bibos banteng*). The average household keeps between 2-4 Bali cattle, usually a mixture of cows, weaned males or females and calves.

A major constraint to livestock production in this area is the unreliable or lack of supply of high-quality forage, especially in the mid to the late dry season, when both native

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pasture and standing crop residues are in short supply. Access to adequate supplies of high quality forage, particularly in the late dry season is essential to improve cattle performance and production to meet the growing demand for beef and to raise small holder income. Farmers have embraced shrub legumes such as lamtoro (*Leucaena leucocephala)* and gamal (*Gliricidia sepium*). However, widespread use of new forages and feeding strategies has been constrained to date by poor understanding of the need to properly integrate these new forage technologies into existing mixed crop/livestock farming systems, especially in respect of competing labour and land demands. For such technologies to be effectively targeted and adopted, the underlying village level farming systems need to be well understood, to identify existing constraints and opportunities for improved forage and livestock production and the likely impact of introducing such new technologies on other aspects of the crop-livestock system.

A study undertaken at Satuan Pemukiman A (SPA) sub-village, one of the transmigration areas in Dompu district, West Nusa Tenggara, between September 2001 and October 2003, applied such a farming system modelling approach and aimed to understand the complex village agro-ecosystems and identifying options for improving small holder cattle production in that region. A critical aspect of this study was the detailed characterization of the availability, quality and usage patterns for existing forage resource within SPA mixed crop-livestock farming system. This paper reports the results of two years of forage monitoring on a representative sub set of SPA small holder farms and examines the implications for existing livestock production and opportunities for targeted improvement.

MATERIALS AND METHODS

Data on seasonal trends in forage source, type, quantity, composition and quality were collected at roughly 3-month intervals from a sub-set of nine livestock-owning farmers selected from a representative group of SPA village farmers involved in village benchmarking studies. One-third of the monitoring group were farmers who traditionally sourced their forage primarily from grazing (rarely use cut and carry); one-third were farmers who rarely grazed (primarily cut and carried) and one-third were farmers who traditionally used a combination of both.

A total of eight forage monitoring surveys were completed between February 2002 and October 2003, following a preliminary survey of village forage resources in September 2001. Each of these snapshot surveys was timed to capture major seasonal trends and critical transitions in forage quantity, composition, availability and quality. Forage use was monitored in November/December (early wet, 1-2 weeks after first significant rain; late January/early February (mid-wet season); March-April (late wet season); May-July (early/mid-dry and September-October; late dry season). Each monitoring session was conducted over a 24 hour period to capture a full grazing and/or cut and carry cycle.

Cut-and-carry forage use by each farmer was also monitored for type of forage offered; fresh weight, composition and percentage leaf of forage offered and left uneaten. Samples were also collected for determination of dry matter percentage, crude protein (AOAC, 1984) and *in-vitro* digestibility (Tilley & Terry, 1963) at the Nutrition Laboratory of the Faculty of Animal Science University of Mataram, Lombok. For most monitoring, forage quality samples were pooled into major categories such as grass, legume and forbs (weeds) for analysis. Specific cut-and-carry forages such as shrub legumes, banana stem, cashew apples, tree leaves fed in mid to late dry season were also sampled separately for quality determination. In addition, cattle belonging to farmers in the monitoring group were weighed on a roughly monthly basis as part of a general livestock monitoring activity associated with village benchmarking. All data collected were descriptively analyzed for mean value and standard errors.

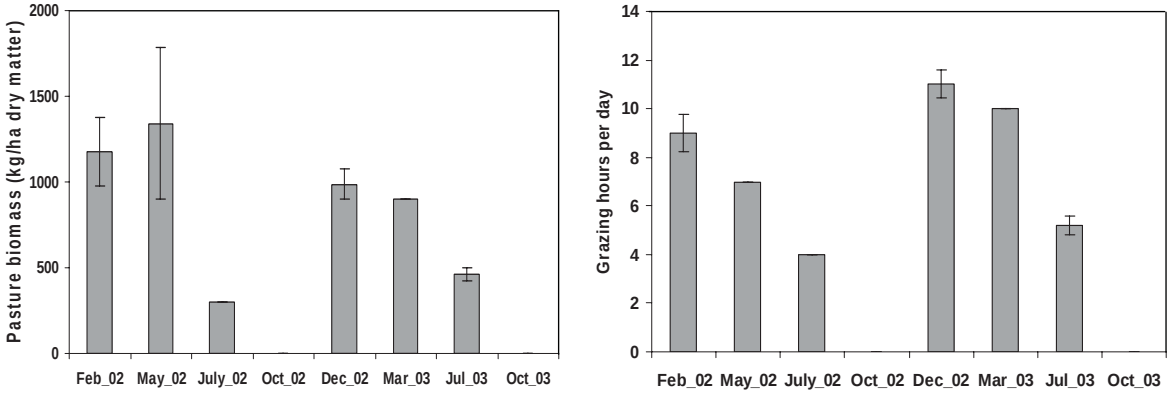
RESULTS AND DISCUSSION

The 2001-02 wet season was poor, limiting both pasture and crop growth. Whilst the 2002-03 wet seasons was better, the early finish and long dry season again limited forage availability and had a major impact on forage sourcing and livestock management strategies used by all SPA farmers surveyed. The available grazing resource consisted of mixed grass, legume and forbs, growing as volunteer pasture under cashew plantations, on fallow crop land or on under-utilized second land. The main cut-and-carry forage resource used included volunteer legume/grass mixes and shrub legumes (*L. leucocephala* and *G. sepium*) from living-fence hedgerows, with some small back-yard sown fodder banks of improved species such as elephant grass (*Pennisetum purpureum*), green panic (*Panicum maximum)* or stylo (*Stylosanthes* spp.) in the late dry season. During the early dry season, crop residues such as peanut or mungbean haulm and rice straw supplemented the cut-and-carry resource. When these resources became scarce toward the dry season, cut-and-carry forage was supplemented with banana and papaya stem, cashew apple and leaves of native trees such as sonokeling (*Dalbergia latifolia*) and kesambi (*Schleichera oleosa*). As the dry season progressed farmers were also forced to go further to secure both grazed and cut and carry forage. This labour cost had two related impacts. For farmers actively engaged in crop land preparation, there was insufficient time to expend sourcing sufficient forages from such distances. Conversely, those who were forced to expend such time and labour to keep their cattle alive had insufficient time for crop land preparation.

Grazed Forage Availability and Use

While the total land area available for grazing remained relatively constant throughout 2002 and 2003, available pasture biomass (Figure 1a), declined steadily from the wet season to the mid-dry season as farmers progressively exploited volunteer pastures under cashews in plantation land and crop residues in rice field. As a consequence, time spent grazing on first and second lands (Figure 1b) declined progressively through the dry season, but increased rapidly once rain fell in the following wet season.

The relatively poor rains during the 2001-02 wet season limited pasture growth, restricting the available grazing. By July 2002, only one farmer from the monitored group was still grazing and by October 2002 the available grazing resource was exhausted at SPA, forcing all farmers to rely on cut-and-carry.



(a) (b)

Figure 1. Seasonal trends in (an available) standing crop pasture biomass and (b) time spent grazing (means and standard errors)

A similar pattern was observed in 2003, with only two of the nine monitored farmers still grazing by July and none by October. Figure 4 indicates observed total standing dry biomass of grazed pastures at the time of each sampling (these biomass yields represent the available grazing resource at each sampling, and not total accumulated growth).

Grazed Pasture Composition

Legume content (mainly *Glycine wightii*) remained relatively constant in the pasture mix whereas the proportions of grasses and forbs varied between wet and dry season. Forbs dominated wet season pasture composition in both 2001-02 and 2002-03 wet seasons.

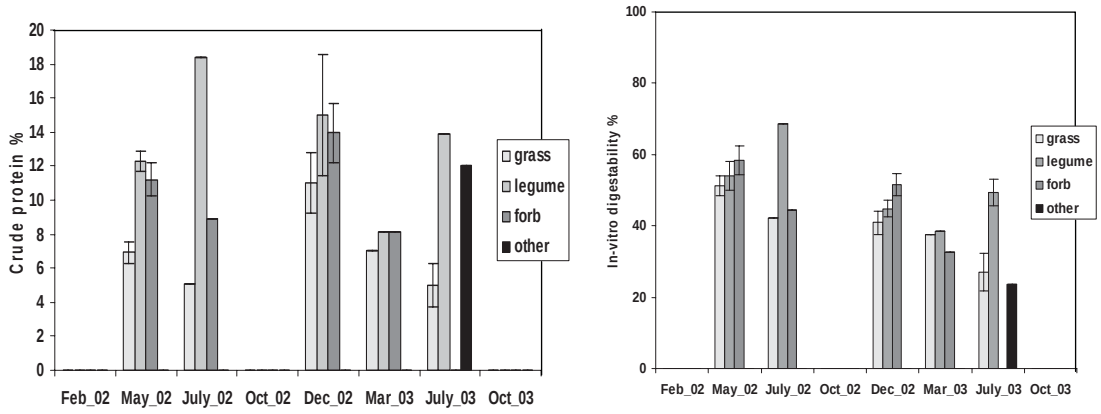
The pasture grass component was dominated by *Cynodon dactylon* and *Brachiaria* spp. with some *Imperata cylindrica* and *Digitaria* spp. The legume component was mostly *G. wightii* with some *Desmodium triflorum*. *Crotalaria* spp. were significant weeds in some areas, but not recorded separately in the data set for monitored sites. Dominant forbs included *Chromolaena odorata*, *Sida acuta* (both significant weeds), *Boerhavia* spp., *Cyperus rotundus* and *Portulaca oleracea.* Observed defoliation ratings for grazed pasture components indicated a strong selection preference for grasses such as *C. dactylon* and *Brachiaria* spp. during the wet and early dry seasons. Of the pasture legumes, *G. wightii* was favoured in the early to mid dry seasons when it often remains as a high quality standing hay crop under cashew trees in more distant second land areas at SPA which are accessed after closer grazing resources are progressively exhausted.

Grazed Forage Quality

In general, both crude protein (Figure 2a) and *in-vitro* digestibility (Figure 2b) were higher in the early-mid wet season, although pasture legumes (mostly *G. wightii*) retained their high quality into the mid-dry season - a situation confirmed by field observations. As grazing had ceased by October in both 2002 and 2003, no pasture quality data was available for these times. In general, both crude protein and *in-vitro* digestibility results appear lower than might be expected, especially for wet season growth, though relative seasonal differences were still apparent.

Cut-and-Carry Forage Availability and Use

The amount of fresh forage offered varied from 25-30 kg per adult animal equivalent (AAE) in the wet season to 10-15 kg/AAE in the dry season. Mixed grass-legume-forbs cut and carry varied in moisture content from over



(a) (b)

Figure 2. Seasonal trends in (a) crude protein and (b) in-vitro digestibility of main grazed pasture components (means and standard errors)

80% in the mid wet season to around 50% by early dry season and less than 20% by late dry season. Shrub legume leaf and fine stem remained around 60-70% moisture (30-30% dry matter throughout the year. Banana stem and cashew apples having around 80% moisture provided important additional water sources when fed in the late dry season.

When fresh weight of forage offered was converted to dry matter, it indicated that total dry matter offered per AAE (Figure 3) was in fact highest in mid dry season at around 9 kg/AAE and lowest during wet season months at around 3-5 kg/AAE. Such dry matter levels would be below maintenance for adult Bali cattle, especially lactating females if this was the sole source of wet season forage. Usually, wet season grazing would supplement the cut and carry material offered to ensure overall dry matter remained adequate for maintenance and growth. The exception to this is when cattle are tethered close to the croplands during weeding and rice harvest during the period of January-March, when farmers have limited time to gather cut and carry or engage in supervised grazing.

The percentage of leaf in forage offered was generally above 50% for cut-and-carry mixed pasture forage except in late dry season 2002 when this forage source was in short supply. Shrub legume leaf to stem percentages remained well over 50% throughout the year in both 2002 and 2003. Most of leaf in cut and carry forage were eaten, although leaf residue tended to be higher through the wet season, probably reflecting the predominance of mixed pasture based cut-and-carry forages fed at that time.

Cut-and-Carry Forage Composition

The proportions of grass, legume and forbs in monitored cut-and-carry forage remained relatively constant through the wet and early dry season of 2001-02 when the main forage source was mixed grass and legume pasture (Figure 4). By July 2002, the legume source began shifting to shrub legumes *L. leucocephala* and *G. sepium*, and by October 2002 most of the grass and forbs component had been replaced by the other forage sources. By December 2002, early wet season growth had restored the grass-legume-forb balance as farmers reverted to volunteer pasture-based cut-and-carry forage sources. The higher legume content in the 2002-03 wet seasons reflects increased *G. wightii* growth in response to the higher rainfall. In late dry season 2002 and again in 2003, shrub legume cut-and-carry was supplemented by a range of other cut and carry forage sources including cashew apples, banana and papaya stem, tree leaves and rice

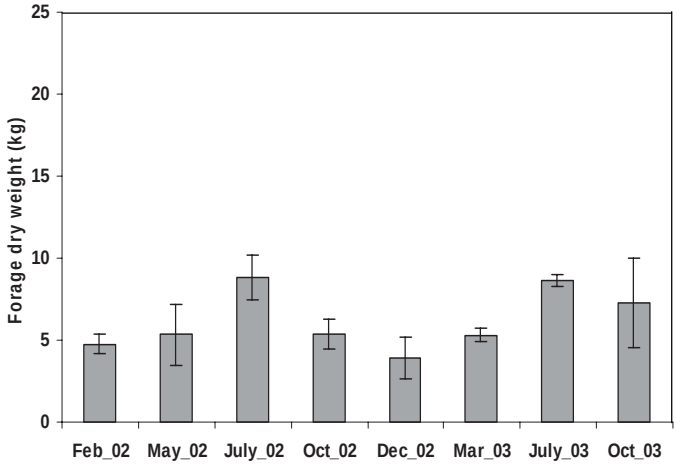


Figure 3. Seasonal trends in total cut and carry forage dry matter offered per adult animal equivalent (AAE), (means and standard errors)

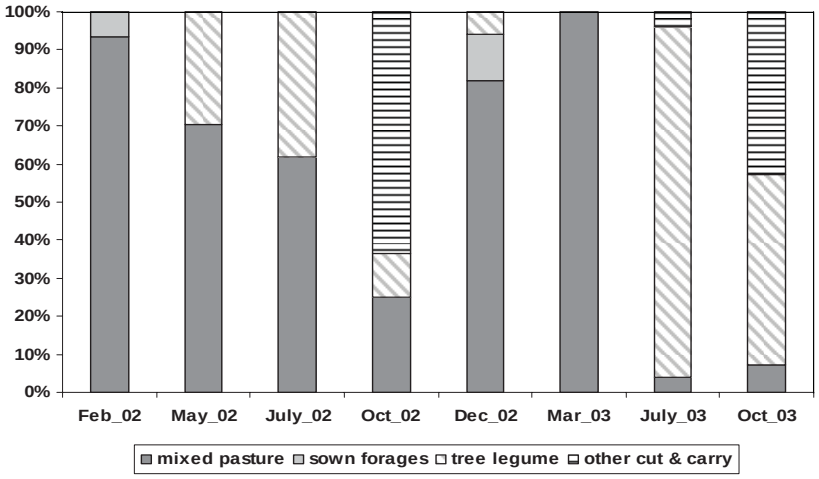


Figure 4. Seasonal trends in mean composition of cut-and-carry forage offered

straw in an effort to provide adequate stock feed from a rapidly diminishing supply, especially in 2002.

By 2003 there had been a significant shift to greater sourcing of tree legumes in the mid-late dry season (Figure 4), coinciding with increased plantings of *G. sepium* in particular. The number of monitored farmers using tree legumes in mid dry season increased from 60% in 2002 to 100% in 2003, while the number still feeding tree legume forage in the late dry season doubled from 30% in 2002 to nearly 60% in 2003.

Cut-and-Carry Forage Quality

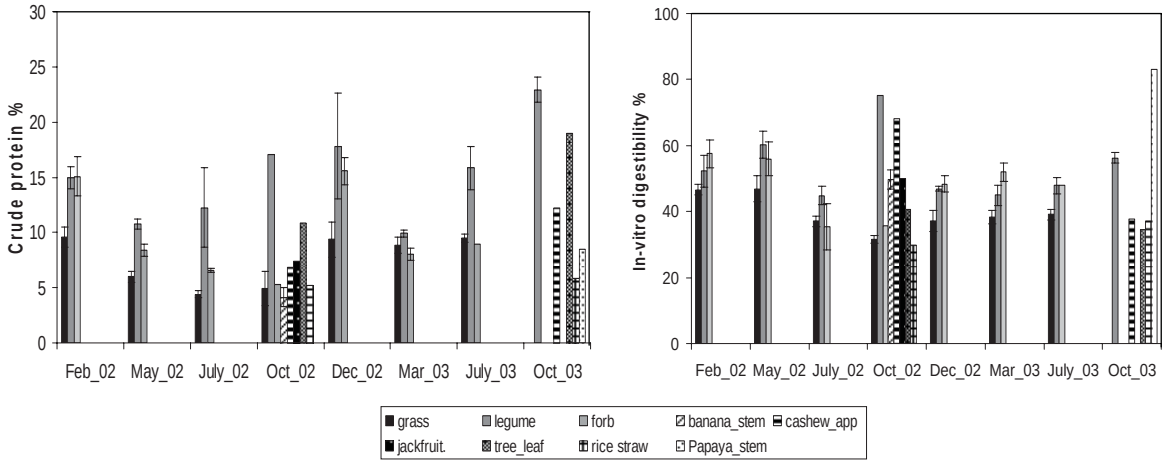
Crude protein and *in-vitro* digestibility levels for mixed pasture cut-and-carry were highest during the wet season, declining steadily during the dry season in both years (Figure 5a). By contrast, crude protein and digestibility levels in cut-and-carry tree legumes remained relatively constant throughout the year. As shrub legumes replaced mixed pasture as the main cut-and-carry source from the mid dry season, crude protein and digestibility percentage of cut-and-carry forage remained high. Although overall quantity of dry matter offered per animal in late dry season was often below maintenance requirements. Of other cut-and-carry forages offered, especially in the late dry season, banana stem, whilst highly digestible, was low in protein as was cashew apple. Again, both crude protein and *in-vitro* digestibility analysis figures appear lower than might be expected especially for wet season forages.

Performance of Farmer's Cattle in Response to Quantity and Quality of Forage Offered

Figure 6 showed that cow live weight increased steadily from mid-late wet season to mid dry season in response to availability of adequate supplies of good quality forage. Live weight then starts to decline during the late dry season as both forage quantity and quality become limiting. The lack of live weight improvement during January to March wet season period coincides with periods of adequate diet quality but reduced dry matter availability during crop maintenance and harvesting times, when cattle are tethered close to the croplands.

Water Offered to Livestock

As provision of adequate water is critical to livestock performance, especially lactating females, this information was collected from each case study farmer at the time of each monitoring visit. The average of water provided per AAE remained relatively constant



(a) (b)

Figure 5. Seasonal trends in (a) crude protein and (b) *in-vitro* digestibility percentage of main cut-and-carry forage types offered (means and standard errors)

throughout the year at around 10-12 litres/head/day, rising to around 15 litres/head/day in the late dry season the hottest time of the year. Lactating Bali cows require around 20-25 litres of water per day for maintenance of milk production.

Direct recording of both available grazed pasture and fed cut-and-carry forage confirmed that, for much of the year, dry matter quantities available to livestock were rarely adequate for maintenance, especially in the second half of the dry season. The availability and quality of volunteer pastures declined steadily from wet season to dry season as pastures senesced. While the quality of shrub legumes remained high throughout the year, limitations on availability of this resource for cut-and-carry by late dry season significantly limited the total available dietary crude protein from cut-and-carry forage resource by late dry season.

This study confirmed that the annual late dry season nutritional gap is a significant impediment to increase livestock production. The combined impact of limitations to quantity

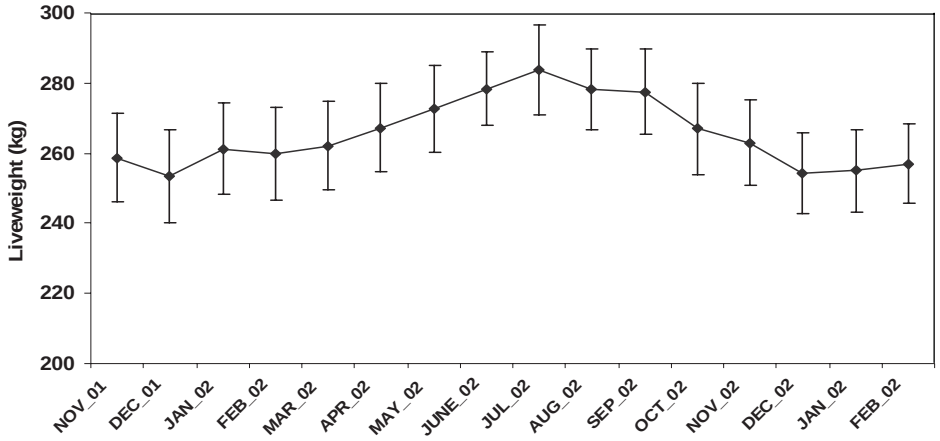


Figure 6. Seasonal live weight trends of Bali cows at Dompu between November 2001 and February 2002 (means and standard errors)

and quality of available forage in the second half of the dry season was reflected in a corresponding decline in animal condition during this period. This time, cows are usually in their first trimester of pregnancy, lactating and also used for draught land preparation activities (ploughing). Whilst it is expected, this study confirmed and quantified the nature and impacts of this annual nutritional gap, it had not expected to find another significant nutritional gap that of below maintenance dry matter availability during certain wet season months. This wet season nutritional limitation is caused by the inability of farmers to gather sufficient forage or spend time taking cattle to grazing lands during times of peak labour demand in the wet season cropping cycle (land preparation, planting, weeding, harvesting). Whilst the quality of forage offered is usually high at this time, the amount of dry matter offered is often significantly below maintenance requirement, especially for lactating cows.

Another significant constraint identified during this study was the water availability to livestock for most of the dry season due to lack of a reliable water supply at SPA. These limitations are especially important for lactating cows with the volume provided being generally below daily requirements in late dry season. Provision of better on-farm water storage and recycling of existing household water might help to overcome this deficit (Ash, 2004).

This study have identified both seasonal gaps in the quantity and quality of forage and possible options to redress these annual gaps, including expansion of shrub legume 'living fence' resources, in particular *G. sepium* and introduction of improved pasture species. On-farm trials evaluating suitable pasture legumes for SPA indicated that *Arachis pintoi* and *Stylosanthes* species have potential for use in second land cashew plantations (Sutaryono, 2005). It was reported that the supplementation of *A. pintoi* also increased the quality of diet in dry and wet season (Lascano & Thomas, 1988). There was also considerable scope for conservation of existing crop residue resources such as ammoniated rice straw, peanut, soybean, mungbean and cowpea crop residue for feeding in the late dry season. With increasing legume proportion in the diet, more organic matter and protein were degraded (Hess *et al*., 2003). Hence, the use of legume crop residues and shrub legume could increase the quality of feed offer to the cattle, especially in the dry season when the diet contains high number of low quality forages.

At SPA sub-village, the highly variable wet season rainfall environment and prolonged dry season has encouraged farmers to exploit whatever forage resources are available, especially at the end of dry season, when both volunteer pasture and shrub legume for cut-and-carry resources were exhausted. Increase in the use of shrub legume, such as *G. sepium* and *L. leucocephala* as both dry season fodder banks and "living fences", had great potential to overcome the shortage of quality forage in the dry season identified in this study. *L. leucocephala* was also used widely by smallholders in Amarasi Timor, East Nusa Tenggara (Piggin & Nullik, 2005). Other shrub legume species, *Sesbania grandiflora,* was reported also as a valuable and sustainable technology that fits well into smallholders farms (Dahlanuddin *et al.*, 2005). Introduction of improved legume pasture species, such as *A. pintoi* and *Stylosanthes* spp. that could be grown under cashew plantations, also had the potential to provide a significant additional fodder bank for both grazing and cut and carry use. There was also considerable scope for conservation of existing crop residue resources, such as ammoniated rice straw, peanut, soybean, mungbean, cowpea and even the volunteer legume *G. wightii* for feeding out in the late dry season as a protein and energy dietary supplement (McDonald *et al.*, 2004).

CONCLUSION

Farmers used mixtures of free or tethered grazing and cut and carry to supply the forage needs of their cattle. The available grazing resource which were mostly volunteer grasses,

legumes and weeds under tree crops on upland areas was of good quality and supply in the wet season, but both quantity and quality declined rapidly by early dry season. From mid-dry season on, the majority of farmers relied increasingly on cut and carry feed from a range of sources including volunteer pastures, crop residues, shrub legumes and finally other sources such as banana and papaya stem, cashew apple and native tree leaves in the late dry season. Despite some use of high quality shrub legumes such as *L. leucocephala* and *G. sepium,* the quantity and quality of available forage were often below maintenance, especially for lactating cows. Even in the wet season, when forage was abundant, forage dry matter supply per adult animal was often limited at critical times especially when the time for land preparation and rice harvesting, due to labour constraints for forage gathering or supervised grazing. Increase in the use of shrub legume such as *G. sepium* and *L. leucocephala* as both dry season fodder banks and "living fences" has great potential to overcome the shortage of quality forage in the dry season. The study also identified provision of adequate water supply, especially for lactating cows, as a likely major constraint to maximizing growth of young calves.

ACKNOWLEDGEMENT

The author greatly appreciates Mr. Jeff Corfield for his continuing support in preparation of this paper, and for ACIAR (Australian Centre for International Agricultural Research) for funding the research.

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