SHRUBS AND TREE FODDERS FOR FARM ANIMALS

PROCEEDINGS OF A WORKSHOP IN DENPASAR, INDONESIA, 24 – 29 JULY 1989

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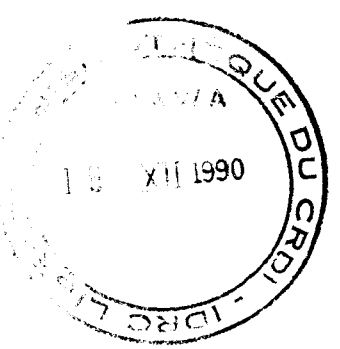

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Abstract

This publication presents the results of an international meeting held in Denpasar, Bali, Indonesia, 24–29 July 1989, that focused on the use of shrubs and tree fodders by farm animals. Through 26 papers, the workshop addressed feed-resource availability, use by ruminants and nonruminants, processing methodology, economics, and development issues. These aspects and the current knowledge on shrubs and tree fodders were further highlighted by country case studies detailing prevailing situations and policy matters. A special session was held to discuss the successful development and results achieved in the three-strata forage system in Indonesia. The workshop concluded with important working group discussions on the priorities for further research and development, and on the potential for the wider use of shrubs and tree fodders in the developing world.

Résumé

Cette publication présente les résultats d'une rencontre internationale tenue à Denpasar, Bali, Indonésie, du 24 au 29 juillet 1989 et qui a porté sur l'utilisation des arbustes et fourrages végétaux par les animaux d'élevage. Les 26 communications qui y ont été présentées traitaient de la disponibilité des ressources alimentaires pour les animaux, de leur utilisation par les ruminants et les non-ruminants, des méthodes de transformation, des aspects économiques et des questions du développement. Ces sujets et les connaissances actuelles sur les arbustes et les fourrages végétaux ont ensuite été étudiés plus à fond dans le cadre d'études de cas de divers pays exposant les circonstances particulières de chacun et les questions liées aux politiques. Une séance spéciale a porté sur la mise en place et les résultats des systèmes de production de fourrages végétaux en trois strates en Indonésie. L'atelier s'est terminé par d'importantes discussions des groupes de travail sur les priorités de recherche et de développement pour l'avenir et sur les possibilités d'utilisation élargie des arbustes et des fourrages végétaux dans les pays en développement.

Resumen

Esta publicación presenta los resultados de una reunión internacional celebrada en Denpasar, Bali, Indonesia, del 24 al 29 de julio de 1989, y la cual centró su atención en la utilización de forrajes elaborados a partir de arbustos y árboles para alimentar a animales de granjas. En 26 trabajos presentados al seminario, los participantes abordaron temas tales como la disponibilidad de recursos alimentarios y la utilización de los mismos por rumiantes y no rumiantes, metodologías de procesamiento y cuestiones de economía y desarrollo. Estos aspectos y el conocimiento que se tiene actualmente sobre los forrajes de arbustos y árboles se vieron subrayados aún más por estudios de casos por países en los que se detallaron situaciones existentes y cuestiones de políticas. Se celebró una sesión especial para discutir el desarrollo y resultados exitosos alcanzados en Indonesia con el sistema de forraje de tres niveles. El taller concluyó con importantes discusiones de los grupos de trabajo sobre las prioridades existentes en el campo de la investigación y el desarrollo y sobre el potencial que encierra la amplia utilización de arbustos y árboles en el mundo en desarrollo.

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Session IV: Country Case Studies

Session V: Processing, Methodology, and Economics

Availability and use of shrubs and tree fodders in Malaysia

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Abstract *— Only limited research has been undertaken on the availability, characterization, management, and use of indigenous fodder trees and shrubs in Malaysia for ruminant production. Some substantial studies have been undertaken on* Leucaena leucocephala *and* Cajanus cajan. *Feeding tree leaves to small ruminants, especially goats, as a supplement is a traditional practice of Malaysian livestock farmers. The various species used are usually found near the household, on vacant land, or in plantations. The intensity of using tree leaves and fodder shrubs is closely dependent on the type of management. The chemical composition of some common shrubs and fodder trees used by farmers in Malaysia is presented. The majority of fodder foliage is high in crude protein and crude fibre, and the minerals are adequate for livestock production. Information on productivity, intake, digestibility, and toxicity, however, is lacking. A farming-system approach for integrated fodder tree production in smallholdings is proposed.*

Résmué *— En Malaysie, trop peu de recherches ont été faites sur la disponibilité, la caractérisation, la gestion et l'utilisation d'arbustes et d'arbres fourragers indigènes dans la production de ruminants. Des études importantes ont porté sur* Leucaena leucocephala *et sur* Cajanus cajan. *Donner en complément de ration des feuilles d'arbre aux petits ruminants, surtout aux chèvres, est pratique traditionnelle chez les éleveurs de bétail malaisiens. Les espèces normalement employées se trouvent près de la ferme, sur des terrains vacants ou dans les plantations. Le degré d'utilisation des arbustes et des arbres fourragers dépend étroitement du type de gestion. L'auteur précise la composition chimique de certains arbustes et arbres fourragers dont se servent les paysans malaisiens. Presque toutes les feuilles de ces végétaux ont une haute teneur en protéines et en fibres brutes. Quant à leur teneur en minéraux, elle est suffisante pour la production animale. Manquent cependant des données sur la productivité, l'ingestion, la digestibilité et la toxicité. L'auteur propose une approche systémique pour intégrer la production d'arbres fourragers dans les petites exploitations agricoles.*

Resumen *— Solamente se ha emprendido una limitada investigación con respecto a la disponibilidad, caracterización, explotación y uso de árboles y arbustos forrajeros naturales de Malasia para la producción de rumiantes. Se efectuaron algunos estudios sobre* Leucaena leucocephala y Cajanus cajan. *Una práctica tradicional de los campesinos malasios es utilizar hojas de árboles como complemento alimenticio de rumiantes pequeños, especialmente cabras. Las diversas especies utilizadas se pueden encontrar comúnmente cerca de la casa, en terrenos vacíos o en plantaciones. La intensidad de uso de hojas de árboles y arbustos forrajeros depende en gran medida del tipo de explotación que se realice. Este trabajo presenta la composición química de algunos*

arbustos comunes y árboles forrajeros usados por los campesinos en Malasia. La mayor parte del follaje forrajero es rico en proteína y fibra en bruto y los minerales son adecuados para la producción de la ganadería. Sin embargo, se carece de información con respecto a la productividad, consumo, digestibilidad y toxicidad. Se propone un método de explotación agrícola para la producción integrada de árboles forrajeros en propiedades pequeñas.

Introduction

In Malaysia a low-input, ruminant-production system is used in smallholdings. The animals feed on wayside forages, tree leaves, fodder shrubs, and crop residues in the field or in communal land. The wide variety of plant species provides a versatile source of forage managed either by a cut-and-carry system or by grazing. In addition, the ground vegetation in plantations totaling over 3.8×10^6 ha (Table 1) has the potential for ruminant production along an integrated farming–livestock approach.

The new national livestock policy emphasizes integrating livestock into plantations to increase livestock development, particularly with sheep. The natural undergrowth in plantations is mainly indigenous grasses, plantation legumes, broad-leaved plants, ferns, and other weeds (Wan Mohamed et al. 1987). Over 70% of the undergrowth can be used for grazing as its nutritive value is comparable to that of improved grasses (Wan Mohamed 1977). Exploiting this vast natural resource is the current priority in the ruminant industry of Malaysia.

Because of the large area of plantations in Malaysia, the agro-by-products derived from the major plantation crops (oil palm, rubber, and cocoa) are also abundant (5×10^6 t estimated). However, the use of these agro-by-products is not discussed in this paper, only feeds and feed materials from wayside shrubs and fodder trees are highlighted.

Tree leaves and shrubs in ruminant production

In Malaysia, fodder cultivation for livestock production is minimal because of the small livestock population and the year-round abundance of green feed. In other

Table 1. Projected dry matter (DM) productivity from native and cultivated forages in agricultural systems in Peninsular Malaysia.

Type of land	Area ($\times 10^3$ ha)	Average annual DM production (t/ha)	Total DM production[a] ($\times 10^3$ t)
Plantation land[b]	3 774.0	5	18 870.0 (79.1)
Grazing reserves	38.2	7	267.4 (1.1)
Cultivated forages[c]	25.0	20	500.0 (2.1)
Roadside pasture	6.3	7	44.1 (0.2)
Padi bunds	5.8	5	29.0 (0.1)
Marginal forests[d]	832.0	5	4 160.0 (17.4)
Total	4 681.3	—	23 870.5 (100.0)

[a] Percentages are shown in parentheses.
[b] Estimated one-third of land suitable for grazing.
[c] Government farms.
[d] Forest land for silviculture.

countries of Southeast Asia, fodder trees or shrubs are planted along roadsides, footpaths, the banks of rivers and canals, and rice field bunds to augment the poor-quality feeds available. Feeding tree leaves and fodder shrubs from nearby forest areas and marginal lands to ruminants is traditional in ruminant production, especially goats, in the humid tropics (Rahman 1981). Shrubs and tree fodders have an important nutritional role in village production systems as well as in areas where forage land is scarce. Usually, the fodder shrubs are fruit trees or legumes in the vicinity of the household, where they provide shade. However, there are few reported studies on the role of fodder trees and shrubs in production systems in Malaysia.

The use of tree leaves has several benefits:

- they provide variety to the diet;
- they serve as reserve foliage in times of drought;
- they meet energy, protein, and, possibly, mineral requirements;
- they maintain forage quality following maturity; and
- they reduce feeding costs.

The escalating price of feed ingredients, especially of preformed proteins, and the need to ensure that dietary proteins adequately supplement rumen microbial protein for production, have led to interest in the leaves of leguminous trees as a dietary nitrogen source (Devendra 1983).

Shrub and tree fodder species

Lim (1968) identified the types of fodders and feedstuffs used, determined their chemical composition, and assessed forage quality. Peters et al. (1979) conducted a survey in goat-production areas in Peninsular Malaysia and listed the tree species whose leaves have been fed to ruminants (Table 2). Besides the species listed in Table 2, *Flemingia congesta*, *Gliricidia sepium*, *Albizia falcataria*, and *Parkia speciosa* are grown as shade plants in cocoa plantations. Recently, *Calliandra calothyrsus* has been studied as a possible fodder supplier.

Proximate analysis of shrubs and tree leaves

In general, tree fodders and shrubs are high in crude protein and crude fibre (Table 3). Mineral levels are adequate in most cases for most classes of livestock. Also, the estimated metabolizable energy of the common fodder shrubs is as good as that of cultivated pasture if not better (Table 3).

Feeding fodder shrubs and tree leaves

The use of shrubs and tree leaves in Malaysia has not been adequately studied. Usually, it is the foliage that is eaten; sometimes, however, the stems or even the seeds are sought by the animals. Shrubs are used year-round in mixed grazing and

Table 2. Shrub and tree species used for fodder in Malaysia.

Fruit trees	Palm	Shrubs
Anacardium occidentale	*Cococ nucifera*	*Bridelia menoica*
Artocarpus heterophyllus	*Elaeis quianeensis*	*Carallia* spp.
Artocarpus integer		*Cinnamomum iners*
Averrhoa bilimbi	**Tall trees**	*Clausena excavaeta*
Averrhoa carambola		*Flemingia* spp.
Eugenia aquea	*Fragraea fragans*	*Gliricidia sepium*
Ficus spp.	*Callicarpa tomentosa*	*Greenea corymbosa*
Mangifera indica	*Grewia paniculata*	*Leucaena leucocephala*
Morinda citrifolia	*Hevea brasiliensis*	*Macaranga indica*
Musa sapientum	*Terminalia catappa*	*Manihot esculenta*
Nephelium lappaceum		*Moringa oleifera*
Sandoricum koetjape		*Sesbania grandiflora*
		Vitex pubescens

Source: Adapted from Peters et al. (1979).

Table 3. Proximate analysis (% dry matter basis) of some shrubs and tree leaves used in ruminant production.

Species	DM (%)	CP	CF	EE	Ash	Ca	P	ME (MJ/kg DM)
Anacardium occidentale	28.8	9.9	27.4	1.5	3.3	—	—	9.8
Artocarpus heterophyllus	36.6	19.1	17.4	4.1	8.3	1.38	0.16	13.2
Artocarpus integer	35.3	13.1	17.5	2.6	7.0	1.05	0.10	12.2
Averhoa carambola	32.6	15.3	14.4	3.9	7.0	1.46	0.16	13.2
Bridelia monoica[a]	38.5	7.5	28.9	3.3	4.4	0.83	0.10	9.1
Cajanus cajan	90.0	21.7	30.2	6.0	6.0	0.85	0.26	—
Carallia spp.	30.9	5.5	25.8	3.8	6.0	—	—	9.3
Cinnamomum iners	—	—	36.4	2.5	3.1	0.32	0.17	—
Cocos nucifera[b]	40.8	10.9	22.1	4.4	4.7	0.54	0.04	10.9
Elaeis guineensis[b]	39.0	16.4	23.0	5.0	8.1	0.44	0.03	11.7
Eugenia aquea	—	11.5	24.0	2.5	5.1	0.95	0.15	10.7
Ficus fistosa	19.6	14.0	15.1	1.9	11.7	2.47	0.24	12.8
Fagraea fragrans	35.3	11.4	25.5	4.3	2.9	0.03	0.04	10.4
Grewia paniculata	—	13.2	28.1	2.0	8.6	1.96	0.08	10.2
Macaranga indica[a]	35.8	11.1	25.2	3.2	8.4	0.88	0.06	10.4
Mangifera indica	46.3	10.4	21.0	6.0	6.3	1.63	0.12	11.1
Manihot esculenta	90.0	25.0	15.9	6.3	5.5	1.40	0.25	—
Nephelium lappaceum	30.6	15.0	24.5	2.6	4.9	0.99	0.24	11.2
Vitex pubescens[a]	38.6	15.0	28.5	1.5	4.4	0.52	0.13	10.5

Note: DM, dry matter; CP, crude protein; CF, crude fibre, EE, ether extract; ME, metabolizable energy.

[a] Source: Rahman and Khusahry (1984).

[b] Source: Devendra (1979a), Rahman et al. (1985).

the intensity of use of tree leaves and shrubs depends greatly on the system of ruminant management. There are four general systems of management adopted by smallholders:

Table 4. Management systems of farmers (%) using tree leaves.

Management system	Type of feed in the shed			
	Natural vegetation	Leaves	Salt	Concentrate
Intensive	100.0	69.7	72.7	9.1
Semi-intensive	5.4	41.9	73.0	8.1
Tethering	0.0	58.3	75.0	8.3
Estate semi-intensive	6.9	44.8	79.3	6.9
Total	28.3	49.3	74.3	8.1

Source: Adapted from Peters et al. (1979).

- *Intensive*: Animals are totally confined to a shed and cut-and-carry feeding is practiced.
- *Semi-intensive*: Animals are let out for grazing for a restricted period, usually in the afternoon, and confined to the shed at night and in the morning.
- *Tethering*: Animals are kept in the shed at night; during the day, they are tethered along the roadside, on public grounds, or in the vicinity of the houses.
- *Extensive*: Animals are kept on free range day and night.

In the intensive system, cut forage is given once or twice a day ad libitum. In the semi-intensive system, the animals are let out to graze for 3–6 h and cut forage including fodder shrubs or tree leaves is given in the evening for night feeding.

Leaves of different trees, shrubs, and other plants are fed to the goats by 49.3% of goat farmers (Table 4). This practice is mainly found in intensive management (69.7%). Leaves are mainly supplied to does after kidding to boost milk production. Leaves of cassava (*Manihot esculenta*) are given by 42.5%, leaves of jackfruit (*Artocarpus heterophyllus*) by 30.1%, and leaves of mengkudu (*Morinda citrifolia*) by 15.1% of goat keepers. Other species are given in small amounts. Leaves are given either daily or at intervals of several days. However, the quantity and quality of the tree leaves fed to the goats are unknown. Concentrates generally fed to goats also contain tree leaves.

Information on the productivity of lesser known shrub species is largely lacking. Quantitative data is limited partly because of the lack of adequate techniques in browse yield estimation and partly because of the diversity of plant species and the arbitrary and subjective quantities used in feeding. Nevertheless, agronomic studies on some commonly known fodder shrubs, such as *L. leucocephala*, *Cajanus cajan*, and *Gliricidia sepium*, have been undertaken (Wong et al. 1984; Wong and Sharudin 1986; Wan Mohamed and Ravoof 1987).

Agronomic research

Some research has been done assessing and comparing the performance of tree species in Malaysia. Normally, the selected species are based on recommendations or published work in other countries.

Table 5. Nutritive value of leucaena (*Leucaena leucocephala*) and pigeon pea (*Cajanus cajan*) for sheep and goat.

	Leucaena		Pigeon pea	
	Goat	Sheep	Goat	Sheep
Digestible crude protein (%)	10.2	9.6	11.9	9.1
Total digestible nutrients (%)	57.4	50.5	52.9	40.7
Digestible energy (MJ/kg)	10.6	9.3	13.4	9.8
Metabolizable energy (MJ/kg)	8.8	8.0	11.0	8.0

Source: Devendra (1982).

Leucaena leucocephala

Leucaena is either planted or grown naturally in the countryside. The plant had been cultivated to provide shade for coffee in the early 1930s, but had not been extensively adopted. Interest in leucaena as a source of high protein feed was renewed after the problems of establishment were overcome through proper liming and inoculation of seed with effective *Rhizobium* strains (Tham et al. 1977). Leucaena has been a source of dietary protein to ruminants (Table 5) and xanthophyll pigment for poultry feed (Devendra 1982; Vadiveloo 1985).

Wong et al. (1984) obtained a dry matter yield of 13–22 t/ha per year from selected varieties at 8-week cutting intervals and at 50–100 cm cutting height. Grazed cattle in a grass–leucaena mixture gave daily live weight gains of over 400 g/head (Wong and Devendra 1983). When indigenous goats were supplemented with leucaena to varying levels of dried palm oil mill effluent, the quality of the total diet improved, resulting in higher intakes and live weight gains (Vadiveloo 1985).

Leucaena can be supplemented up to 30 g/kg live weight with goats fed dried palm oil effluent with no detrimental effects. Successful cultivation of leucaena as a high-protein crop has made leucaena leaf meal production in Malaysia a possibility. Malaysia annually imports over 48 000 t of leaf meal, at an estimated cost of over 8×10^6 USD, for pigs and poultry feeds. In various commercial feeds, imported leaf meal ranges from 2 to 5%. The importance of substituting leucaena leaf meal for imported leaf meal is illustrated in Table 6. The importance of producing leucaena leaf meal locally has been stressed (Mustaffa 1987).

The milk productions of Sahiwal-Friesian cows under stall feeding and rotational grazing on leucaena–*B. decumbens* pasture were 7 090 and 8 580 kg/ha per lactation, respectively (Wong et al. 1987). No nitrogen fertilizer was used in the pasture mixture.

The major constraint in promoting leucaena is its severe defoliation as a result of psyllid infestation. This is especially prevalent during dry periods. The Malaysian Agricultural Research and Development Institute (MARDI) is trying to develop new, superior, acid-tolerant leucaena hybrids with a high degree of psyllid resistance.

Gliricidia sepium

Gliricidia is a relatively fast-growing tree and is now common in plantations as a nurse tree. It is a deep-rooted perennial and provides a valuable, high-protein, green

Table 6. The effect on egg production and quality of different levels of leucaena leaf meal in the diet of poultry layers.

	Leucaena leaf meal (% dry matter)			
	0[a]	3[b]	6[b]	9[b]
Egg production	68.0	72.0	67.7	67.3
Avg egg weight (g)	60.9	61.4	60.3	61.9
Total egg mass (kg)	11.2	12.0	11.2	11.2
Total feed intake (kg)	29.8	30.2	29.9	29.2
Daily feed intake (g)	100.1	110.0	109.5	107.3
Feed: egg mass ratio	2.68	2.53	2.69	2.63
Albumin height (mm)	6.42	6.13	6.49	6.52
Haugh unit	77.9	75.6	78.4	29.0
Yolk colour index	6.9	7.8	9.8	11.6
Shell thickness (mm)	0.389	0.389	0.383	0.381

Source: Yeong (1988).
[a] Control diet containing 30% yellow maize.
[b] Treatment diets using broken rice to replace yellow maize.

feed supplement (25–30%), especially for small ruminants. In Malaysia, gliricidia is grown as a shade tree and as an ornamental in the house compound. It can withstand lopping up to 1–1.5 m cutting height without damaging regrowth. However, the tree tends to shed its leaves at the onset of a dry spell and at the blooming stage. The plant has not been exploited for fodder production, although information is abundant on its cultivation as a shade plant in cocoa plantation (Wills 1980).

Preliminary studies on gliricidia as a fodder plant by Wong and Sharudin (1986) have not been encouraging. Stem cuttings grew poorly and dry matter productivity was poor compared with the fast-growing leucaena and cassava. Annual dry matter yield of gliricidia is about 2 t/ha. Heavy infestation of an insect pest (*Brachyplatys* spp.) was observed at certain times of the year. In vitro dry matter digestibility, nitrogen content, and mineral concentrations of the foliage were comparable with those of cassava and leucaena. Because of its availability as a shade plant in cocoa plantation, it has forage potential in integrated systems. More research is needed on using existing gliricidia in cocoa plantations for small ruminant production. The germ plasm of gliricidia should be expanded to assess suitable foliage types for the humid tropics.

Cajanus cajan

The use of *Cajanus cajan* (pigeon pea) in Malaysia as a forage plant is a recent phenomenon. The plant is never cultivated on a commercial scale or at the smallholders' level. However, Wan Mohamed and Ravoof (1987) reported an annual dry matter production of 3.7–9.8 t/ha with an annual crude protein yield of 0.8–1.3 t/ha from 6- to 8-week cutting frequencies. The optimum planting distance was 30 × 61 cm and the nitrogen fertilizer rate was 55 kg N/ha per year. Crude protein content ranged from 25 to 28%; crude fibre, from 22 to 24%. More than 15% pigeon pea leaf meal in the feed of broiler chickens was detrimental (Table 7).

Beneficial use of pigeon pea foliage by sheep and goats was illustrated by Devendra and Chee (1980). The results consistently demonstrated the superiority of goats over sheep using pigeon pea fodder. An estimated 300 kg N/ha per year was

Table 7. Performance of broilers fed pigeon pea leaf meal.

Growth attribute	% pigeon pea leaf meal				
	0	7.5	15.0	22.5	30.0
Initial body weight (g)	361	435	439	440	427
Body weight at 9 weeks (g)	1 708	1 683	1 599	1 445	1 105
Total feed intake (g)	3 775	3 966	3 625	3 614	3 240
Feed/gain	3.0	3.0	3.1	3.6	4.8
Mortality (%)	31.6	25.6	21.8	21.0	10.4
Avg final weight (g)	1 710	2 260	1 600	1 430	1 120

fixed. More studies are needed to assess the potential of pigeon pea as a forage crop in humid environments because the plant is more adapted to semi-arid conditions.

Other species

Little work has been done on the other shrubs and fodder trees listed in Table 2. Nevertheless, livestock farmers use them as fresh fodder supplements for their animals. These plants are generally not cultivated, they thrive as weeds near forest margins or in neglected, cleared areas.

Toxicity problems

Many shrubs and trees in Malaysia are not used in ruminant production both because of a lack of knowledge and because of the possible presence of toxic compounds. Causes of toxicity are poorly understood and vary from species to species. For example, cassava foliage can contain prussic acid, which, when consumed in large quantities, can kill the animal (Jaafar 1982). However, there is no clear evidence of such poisoning in certain districts of Malaysia, such as Banting Kuala Selangor and Sabah Bernam of Selangor Darul Ehsan (Rahman et al. 1985).

Similarly, leucaena contains mimosine, whose by-product, dihydroxypyridine (DHP), is toxic to monogastric animals and can cause enlarged thyroid glands and alopecia in ruminants if consumed in large quantities. In Malaysia, no obvious adverse effect of leucaena on ruminants had been recorded except at very high levels under experimental conditions (Devendra 1982). Nevertheless, cattle grazing on leucaena–signal grass mixture had slightly enlarged thyroid glands but no external symptoms of toxicity (Izham and Hassan 1984). Recent studies at MARDI showed, however, that goats in Malaysia were unable to degrade DHP because of the absence of the mimosine–DHP degrading bacteria in the rumen (Wong et al. 1989). The DHP in the urine of goats increased with increasing levels of leucaena in the diet.

In contrast, Vadiveloo (1985) observed no toxicity from mimosine when goats were fed 100% leucaena. Such a diversity of responses deserves investigation. Because little research has been done on local tree leaves and fodder shrubs as forage supplements in ruminant production, more research is needed to identify nontoxic or less toxic species for use in the future.

Research strategies

Currently, fodder shrubs are underused, partly because of the abundance of other natural feed resources. Also, little is known of their nutritional value. A systematic study of available shrubs and fodder tree leaves involving a nationwide survey is needed. Species must be characterized and their feeding value in raw and processed forms must be evaluated. Beneficiaries must be identified and existing farming systems and systems of economic production must be described. This is probably the most relevant strategy to promote the use of tree leaves and realize achievable, profitable levels of ruminant production.

In this respect, tree leaves and shrubs should be regarded as proteinaceous, mineral supplements, providing critical nutrients to deficient basal diets (Leng 1985). They will enhance efficient fermentative digestion and correct any nutrient imbalances in the animals, preparing them for demanding physiological states such as lactation. The criteria for using tree leaves as a supplement will be governed by the nutrients that are deficient in available feed resources.

Effective research to enhance nutritive value may follow. Physical, chemical, or biological treatments that are economically justifiable and applicable to small farms must be developed. Finally, appropriate environmental management and production systems should be developed (e.g., integrating fodder shrubs into cropping systems or intensive feed gardens).

Conclusions

Few trees or shrubs are used for livestock production in Malaysia. Despite the abundance and diversity of plant species in the country, their potential is poorly understood. Undoubtedly, many more species must be identified and studied before they are accepted as forage supplements.

In Malaysia, land and production inputs are the major constraints on forage development. The use of indigenous fodder shrubs and tree leaves, coupled with available, cheap, nonconventional feed resources, could be instrumental in fulfilling the forage and feed requirements of ruminants in the future.

The use of shrubs and tree fodders will eventually be linked to stimulating and expanding the country's ruminant livestock industry. Hence, the success of shrub and tree fodder research rests primarily in its applicability and potential to service the needs of the small-scale livestock producer.

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