SHRUBS AND TREE FODDERS FOR FARM ANIMALS

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

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Proceedings of a workshop in Denpasar, Indonesia, 24–29 July 1989

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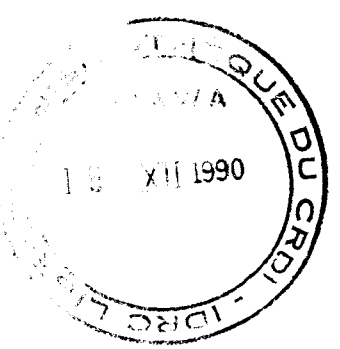

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Abstract

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.

Contents

Foreword vii

Acknowledgments ix

Introduction xi

Session I: The Resources

The diversity and potential value of shrubs and tree fodders
G.J. Blair 2

Shrubs and tree fodders in farming systems in Asia
A. Topark-Ngarm 12

Major characteristics, agronomic features, and nutritional value of shrubs and tree fodders
D.A. Ivory 22

Discussion 39

Session II: Use by Farm Animals

The use of shrubs and tree fodders by ruminants
C. Devendra 42

The use of shrubs and tree fodders by nonruminants
P.D. Limcangco-Lopez 61

Toxic factors and problems: methods of alleviating them in animals
J.B. Lowry 76

Discussion 89

Session III: The Three-Strata Forage System

The concept and development of the three-strata forage system
I.M. Nitis, K. Lana, W. Sukanten, M. Suarna, and S. Putra 92

Research protocols appropriate to the development of methodology for the three-strata forage system
K. Lana, I.M. Nitis, M. Suarna, S. Putra, and W. Sukanten 103

Socioeconomic aspects of the three-strata forage system in Bali
I.W. Arga 118

Communication aspects and research extension linkages of the three-strata forage system in Bali
N.K. Nuraini 130

Discussion 136

Session IV: Country Case Studies

Availability and use of fodder shrubs and trees in tropical Africa
A.N. Atta-Krah 140

Potential of legume tree fodders as animal feed in Central America
D. Pezo, M. Kass, J. Benavides, F. Romero, and C. Chaves 163

Availability and use of shrubs and tree fodders in Pakistan
M. Akram, S.H. Hanjra, M.A. Qazi, and J.A. Bhatti 176

Agrosilvipasture systems in India
P. Singh 183

Availability and use of shrubs and tree fodders in India
G.V. Raghavan 196

Availability and use of shrubs and tree fodders in Nepal
N.P. Joshi and S.B. Singh 211

Availability and use of shrubs and tree fodders in Bangladesh
M. Saadullah 221

Availability and use of shrubs and tree fodders in Sri Lanka
A.S.B. Rajaguru 237

Availability and use of shrubs and tree fodders in Thailand
M. Wanapat 244

Availability and use of shrubs and tree fodders in Malaysia
Wong C.C. 255

Availability and use of shrubs and tree fodders in Indonesia
M. Rangkuti, M.E. Siregar, and A. Roesyat 266

Availability and use of shrubs and tree fodders in the Philippines
L.T. Trung 279

Availability and use of shrubs and tree fodders in China
Xu Zaichun 295

Discussion 303

Session V: Processing, Methodology, and Economics

Opportunities for processing and using shrubs and tree fodders
M.R. Reddy 308

Development and evaluation of agroforestry systems for fodder production
A.N. Abd. Ghani and K. Awang 319

Economic aspects of using shrubs and tree fodders to feed farm animals
P. Amir 331

Discussion 340

Conclusions and Recommendations 341

Participants 347

Availability and use of shrubs and tree fodders in Thailand

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Abstract *— Feed resources for livestock production in Thailand are becoming increasingly important because of rising costs and scarce supplies. It is, therefore, imperative to use fully the available feed resources, including unconventional supplies, to meet the rising demands of the rapidly increasing animal populations, especially during critical feed shortages. Crop residues, shrubs, and tree fodders are potentially important in small farms to alleviate shortages of feed and increase the efficiency of the production system. However, some of these feeds contain toxic elements that need to be reduced or removed before they can be fed to animals.*

Résumé *— Les espèces végétales utilisables comme fourrage dans la production animale deviennent, en Thaïlande, de plus en plus importantes en raison de la hausse des coûts et de la rareté des fourrages. Il s'impose donc d'utiliser pleinement ces espèces, y compris celles qui ne sont pas conventionnelles, pour répondre à la demande à la hausse attribuable aux populations animales en croissance rapide, surtout aux moments critiques de pénurie de fourrage. Les déchets agricoles, les arbustes et les arbres fourragers présentent un important potentiel, dans les petites exploitations agricoles, quant à la lutte contre les pénuries de fourrage et à l'accroissement de l'efficacité du système de production. Cependant, certains de ces fourrages contiennent des éléments toxiques qui doivent être réduits ou éliminés pour les rendre propres à la consommation animale.*

Resumen *— Los recursos alimenticios para la producción ganadera en Tailandia cobran cada vez mayor importancia debido al incremento de los costos y la escasez de oferta. En consecuencia, es imperativo usar completamente los recursos alimenticios, incluso los no convencionales, para satisfacer la creciente demanda, especialmente durante los períodos de escasez, de las poblaciones de animales que aumentan tan rápidamente. Los residuos de cultivos, los arbustos y los árboles forrajeros son potencialmente importantes en granjas pequeñas para mitigar la falta de alimento e incrementar la eficiencia y rendimiento del sistema de producción. Sin embargo, antes de dar al ganado estos alimentos, es necesario reducir o eliminar componentes tóxicos presentes en algunos de ellos.*

Agronomic characteristics and nutritive value

Several studies have been conducted to evaluate essential agronomic characteristics of potentially important shrubs and tree fodders. Because many parts

of Thailand experience a long drought period, it is essential that the chosen species are able to withstand and produce adequate feeds in harsh environments. Sampet and Pattaro (1987) found that total edible dry matter (EDM) yield over 2 years among *Leucaena leucocephala*, *Sesbania grandiflora*, and *Gliricidia maculata* were significantly different and influenced yields (Table 1).

During the dry season, *L. leucocephala* grew better than *Sesbania* or *Gliricidia*. The nutritive values were quite good, especially for *Sesbania* and *Gliricidia* (Table 2).

The amino acid contents of *Mimosa pigra*, *L. leucocephala*, and *G. maculata* are comparable. All species are high in both essential and nonessential amino acids (Table 3).

Table 1. Edible dry matter (EDM) yields of *Leucaena leucocephala*, *Sesbania grandiflora*, and *Gliricidia maculata* with different cutting heights over 2 years.

Cutting height (cm above ground)	EDM yield (t/ha)			Mean
	Leucaena	*Sesbania*	*Gliricidia*	
	Year 1			
25	5.27	7.75	4.79	5.94
50	6.75	6.38	4.67	5.93
Mean	6.01a	7.01a	4.73b	
	Year 2			
25	10.68	2.48	4.85	6.00
50	12.07	3.30	5.39	6.92
Mean	11.38a	2.89b	5.12c	
	Total EDM			
25	15.95	10.23	9.64	11.94
50	18.82	9.68	10.06	12.85
Mean	17.39a	9.96b	9.85b	

Note: Values in the same row followed by the same letter are not significantly different at the 5% level.
Source: Sampet and Pattaro (1987).

Table 2. Chemical composition (% dry matter) of *Leucaena leucocephala*, *Sesbania grandiflora*, and *Gliricidia maculata* forage.

Species	Season	CP[a]	CF	Ash	OMD
L. leucocephala	Wet	25.2a	12.0	7.8	64.9
S. grandiflora	Dry		11.9	8.7	64.2
	Wet	29.1b	11.9	8.6	70.8
G. maculata	Dry		12.2	8.8	70.6
	Wet	27.8b	11.8	8.3	73.6
	Dry		11.6	9.9	74.1

Note: Values followed by different letters differ at the 5% level. CP, crude protein; CF, crude fibre; OMD, organic matter digestibility.
Source: Sampet and Pattaro (1987).
[a] The crude protein content is for both wet and dry seasons.

Table 3. Amino acid content (g/16 g N) of *Mimosa pigra*, *Leucaena leucocephala*, and *Gliricidia maculata*.

Amino acid	*M. pigra* leaves	*M. pigra* leaves and twigs	*L. leucocephala* leaves	*G. maculata* leaves
Essential				
Arginine	5.9	6.0	4.7	5.7
Histidine	2.8	2.8	1.9	2.4
Isoleucine	4.3	4.3	3.9	4.5
Leucine	8.0	8.3	6.7	7.9
Lysine	6.0	6.6	5.1	6.4
Methionine	1.8	1.8	1.2	1.5
Phenylalanine	7.7	5.5	4.3	5.6
Threonin	4.2	4.4	3.5	4.2
Valine	5.6	5.7	4.4	5.3
Nonessential				
Alanine	5.2	5.6	4.3	5.3
Asparagine	10.6	9.9	9.2	10.1
Cysteine	1.4	1.4	1.0	1.3
Glutamic acid	10.9	10.4	8.8	10.0
Glycine	4.7	5.0	3.9	4.7
Proline	4.9	5.2	4.9	5.0
Serine	4.5	4.3	3.7	4.2
Tyrosine	4.6	4.2	3.2	4.4

Source: Vearasilp et al. (1981).

Table 4. Dry matter yields (g/tree) of the edible fraction and woody stem, green leaf retention, and survival of forage trees at Khon Kaen, Thailand.

Species	Origin of seed	Yield of edible fraction (g/tree)	Yield of woody stem (g/tree)	Green leaf retention[a]	Survival (%)
Adenanthera pavonia	Western Samoa	399cd	64c	6.9	83
Albizia chinensis	Western Samoa	899c	1 180b	4.5	73
Albizia falcataria	Solomon Islands	1 960b	2 107ab	7.2	63
Albizia lebbek	Australia	781c	693bc	6.5	77
Calliandra calothyrsus	Western Samoa	320d	382c	3.2	13
	Indonesia	508cd	416c	2.6	30
Cassia siamea	Thailand	2751a	3304a	7.7	97
Enterolobium cyclocarpum	Indonesia	2821a	2727a	5.1	100
Gmelina arborea	Thailand	2223ab	2848a	2.0	83
Leucaena leucocephala cv. Cunningham	Australia	2027ab	3008a	5.6	100
Pithocellobium dulce	Thailand	244d	381c	6.7	90
Samanea saman	Solomon Islands	204d	46c	4.3	97
	Thailand	432cd	196c	6.7	100
Sesbania formosa	Australia	620cd	1399b	4.2	7
Sesbania grandiflora	Thailand	305d	292c	3.5	0
Sesbania sesban	Australia	1203bc	3345a	2.4	0
Sesbania sesban var. *nubica*	Australia	1417b	2260ab	2.0	0

Note: Values followed by the same letter within a column are not significantly different at $P < 0.05$.

Source: Akkasaeng et al. (1989).

[a] Means of rankings taken in February 1985 and March 1986.

Table 5. Chemical composition (% dry matter basis) of the leaves at November (dry, H1) and May (wet, H2) harvests of forage trees at Khon Kaen, Thailand.

Species	Origin of seed	Ash		CP		NDF		IVDMD	
		H1	H2	H1	H2	H1	H2	H1	H2
Adenanthera pavonia	Western Samoa	4.7	4.3	16.7	17.9	43.5	42.8	66.9	64.3
Albizia chinensis	Western Samoa	3.4	4.1	28.0	22.6	71.8	68.6	53.3	50.7
Albizia falcataria	Solomon Islands	5.3	7.2	19.5	18.6	51.5	40.7	61.5	64.3
Albizia lebbek	Australia	6.6	8.0	28.8	22.1	46.4	44.2	54.5	64.5
Calliandra calothyrsus	Western Samoa	4.9	5.1	17.5	17.7	52.5	46.7	51.5	49.5
	Indonesia	4.7	5.2	14.0	15.8	44.5	48.4	44.5	45.7
Cassia siamea	Thailand	5.2	7.2	18.8	12.9	53.5	45.1	65.5	62.1
Enterolobium cyclocarpum	Indonesia	4.6	3.2	21.7	16.8	40.3	42.1	68.6	64.7
Gmelina arborea	Thailand	5.2	5.5	13.3	14.0	45.8	40.9	60.7	62.9
Leucaena leucocephala cv. Cunningham	Australia	5.7	9.3	19.7	20.6	47.8	51.2	52.7	62.2
Pithocellobium dulce	Thailand	4.8	6.4	19.1	22.4	49.2	43.6	59.6	68.2
Samanea saman	Solomon Islands	4.2	5.5	24.1	27.3	52.7	43.8	58.4	62.6
	Thailand	4.1	5.5	22.8	24.2	45.4	47.1	61.3	61.2
Sesbania formosa	Australia	7.2	5.7	21.5	20.8	50.8	45.4	57.9	54.8
Sesbania grandiflora	Thailand	4.8	7.5	26.5	13.6	45.1	37.1	66.9	66.4
Sesbania sesban	Australia	6.8	9.9	26.4	24.2	38.7	29.5	69.1	79.0
Sesbania sesban var. *nubica*	Australia	8.8	8.8	21.3	21.5	36.9	39.2	67.8	65.8

Note: CP, crude protein; NDF neutral-detergent fibre; IVDMD, in vitro dry matter digestibility.
Source: Akkasaeng et al. (1989).

Akkasaeng et al. (1989) studied the forage and fuelwood production of 17 provenances of predominantly leguminous shrubs and tree species (Table 4). When cut at 1 m height five times during a 30-month period, *Enterolobium cyclocarpum*, *Cassia siamea*, *Gmelina arborea*, and *L. leucocephala* gave the highest yields of edible material, with accumulated dry matter productions of over 2 kg/tree. *Sesbania* spp. and *Calliandra*, however, did not produce well in northeastern Thailand. The chemical composition of the leaves of all tested species was also reported (Table 5). Their crude protein (CP) and in vitro dry matter digestibility (IVDMD) percentages were relatively high, whereas the neutral-detergent fibre (NDF) contents were low, particularly for *Cassia siamea* and *Sesbania* spp. There appeared to be no differences between dry and wet seasons. In relation to potential importance and high nutritive values, more data is required on in vivo digestibility and intake by animals. The chemical composition of many other fodder tree species has been reported by Manidool (1985).

Use of shrubs and tree fodders

Some studies have reported on potentially important feeds with high nutritive values, summarizing their acceptance, intake, and use. Cow pea (*Vigna unguiculata*) crop residues at harvest are still fresh and contain an abundant proportion of green leaves. Both the leaves and stems are high in CP and easily digested in the rumen (Wanapat and Wachirapakorn 1986; Wanapat, Uriyapongson et al. 1989). When dried leaves were used to supplement rice straw for growing native cattle, a level of 300 g/head per day sustained body weight (Table 6). However, the residues can be used either green, dried, or as silage.

Table 6. Dry matter intake, digestible nutrient intake, and average daily weight change of native cattle fed rice straw supplemented with cowpea crop residue.

	Level of supplementation (g/day)				
	0	300	500	800	SE
Dry matter intake (kg/day)					
Rice straw	2.3	2.3	2.2	2.1	—
Cowpea residue	—	0.3	0.4	0.7	—
Total	2.3a	2.6a	2.6a	2.8a	0.1
Dry matter intake ($g/kg^{0.75}$)					
Rice straw	67.9	68.3	66.8	62.9	2.3
Cowpea residue	—	6.4	11.3	14.9	1.1
Total	67.9a	74.8ab	80.1b	77.8b	2.8
Digestible nutrient intake					
Dry matter (kg/day)	1.0	1.3	1.3	1.4	—
Crude protein (g/day)	—	48.6	60.2	124.4	—
Weight change (g/day)	−127.3a	11.2b	54.3b	24.9b	27.4

Note: Values in the same row followed by the same letter are not significantly different at $P < 0.05$. SE, standard error.
Source: Wanapat, Uriyapongson et al. (1989).

Another good forage supplement is cassava leaf. As reported by Bezkorowajnyj et al. (1986), the leaves can be collected from the bottom half to two-thirds of the plant, and as much as 469 kg fresh leaves or 156 kg dried leaves/ha can be produced without adversely affecting tuber yield. The leaves can also be collected every 60–75 days, and two collections can be made during the dry season, yielding 320 kg/ha of sun-dried leaves. Approximately 6 kg of fresh leaves (2 kg sun dried) can be collected in 1 h.

Fresh cassava leaves, however, contain high levels of hydrocyanic acid (HCN), which is toxic to animals. Sun drying the leaf (Fig. 1) reduces HCN content from

Fig. 1. A farmer sun drying cassava leaves (*Manihot esculenta*) for buffalo feed in Thailand.

210 to 31 mg% (Wanapat, Uriyapongson et al. 1989). Supplementing a low-quality roughage such as rice straw with dried cassava leaves maintained the body weight of both cattle (Bezkorowajnyj et al. 1986) (Table 7) and buffaloes (Wanapat 1983). Under village conditions, Wanapat, Uriyapongson et al. (1989) reported that supplementing dried cassava leaves to draft buffaloes during the dry season significantly improved both body condition and draft capability.

Mimosa pigra has been used in the diets of broilers, Japanese quail, and pigs at 4, 6, and 8%, respectively (Vearasilp 1988). In sheep, supplementing with fresh leaves of *M. pigra* at 400 g/head per day increased body weight at a rate of 350 g/head per day (Vearasilp et al. 1981). *Mimosa pigra* contains no mimosine; therefore, it is appropriate for ruminants. The digestion coefficients of nutrients in sheep fed *M. pigra*, have been reported.

Table 7. Dry matter intake and average daily weight change of cattle fed rice straw supplemented with cassava leaf (CL) and cassava chip (CC).

	Level of supplementation (g/day)					
	0	300 CL	600 CL	600 CC	300 CL 600 CC	600 CL 600 CC
Rice straw dry matter intake						
kg/day	2.8ac	3.2b	2.8a	2.1d	2.6c	2.8ac
% body weight	2.1a	2.2a	2.1a	1.7b	1.8b	1.8b
$g/kg^{0.75}$	72a	76a	71a	57c	61bc	64b
Total dry matter intake						
kg/day	3.1	3.7	3.6	2.9	3.7	4.2
% body weight	2.4a	2.6b	2.7bc	2.4a	2.5ab	2.7c
Weight change						
(g/day)	−181a	−108a	58b	−184a	−83a	59b

Note: Values in the same row followed by the same letter do not differ significantly at $P < 0.05$.

Source: Bezkorowajnyj et al. (1986).

Table 8. Performance of cattle fed rice straw supplemented with *Samanea* pods fed intact, water soaked, sodium-hydroxide (NaOH) soaked, ground, or with urea.

	Intact *Samanea* pods	Water-soaked pods	1% NaOH-soaked pods	Ground pods	Urea-supplemented pods (100 g/day)
Dry matter intake (kg/day)					
Samanea pod	1.8	—	5.6	2.6	5.9
Rice straw	2.1	—	1.7	1.4	1.9
Total	3.9	—	7.3	4.0	7.8
Digestibility (%)[a]					
DM	46.4	63.1	53.3	62.5	—
CP	28.7	48.2	53.4	46.5	—
CF	25.4	49.0	51.9	42.9	—
NFE	72.4	79.9	67.3	81.5	—
EE	11.0	24.0	38.5	36.1	—
Weight gain (g/day)	100.0	—	230.0	139.0	185.7

Source: Seetakoses et al. (1988).

[a] DM, dry matter; CP, crude protein; CF, crude fibre; NFE, nitrogen-free extract; EE, ether extract.

Studies using *Samanea saman* as feed have been receiving much attention because of the multipurpose nature of this species. Recently, *Samanea* pods have been reported to contain 12–19% CP and 14–20% crude fibre (CF) on a dry-matter basis (Seetakoses et al. 1988). The authors also reported that adding 2 kg *Samanea* pods to the rice straw diet of buffaloes enabled body weight to be maintained throughout the dry season. *Samanea* pods are, therefore, a good source of protein and energy with a rice straw diet. *Samanea* pods have a hard shell, however, which may contribute to its low digestibility. Thus, grinding, water soaking, sodium hydroxide, and urea treatments increase digestibility (Table 8).

Leucaena leucocephala leaves have been widely used in diets of all animal species. Cheva-Isarakul (1988) reviewed the use of leucaena as a feed. The available reports suggest that leucaena is degraded to some extent in the rumen and can by-pass it to the lower gut as a source of protein. Leucaena can produce ruminal NH_3 N coupled with volatile fatty acid (VFA) production (Wanapat et al. 1988). When used in diets, even at high levels, leucaena has had no serious detrimental effects (Snitwong et al. 1983). Leucaena can be fed fresh (Wongsrikeao and Wanapat 1986) or dried (Sarawish et al. 1988). Fresh leaves are more palatable and contain higher levels of protein, minerals, and vitamins, especially ß-carotene, compared with the sun-dried leaf. However, one important constraint of leucaena is its mimosine content, especially in the fresh leaves. Young leucaena leaves have a higher mimosine content than mature leaves (Table 9). Sarawish et al. (1988) demonstrated that supplementing the rice straw diet of growing native cattle with dried leucaena leaves produced good results; the results obtained with urea-treated rice straw were better. However, because of severe psyllid infestation, leucaena yield is insufficient, especially during the dry season. Therefore, other tree fodders must be investigated.

Tables 10 and 11 summarize results of nutritive studies and feeding trials in Thailand, respectively. It is evident that supplementing low-quality roughages such as rice straw with tree fodders and shrub leaves improves animal performance (Table 11). However, more research is needed to determine optimum supplementation levels, to obtain useful dose–performance responses, and to establish other feed mixtures that promote efficient utilization.

Table 9. Mimosine contents (%) of young and mature leucaena leaves collected from Pakchong and Roi-Et provinces in Thailand.

	Young leaves					Mature leaves				
Leucaena variety	**Feb.**	**Apr.**	**Jun.**	**Aug.**	**Mean**	**Feb.**	**Apr.**	**Jun.**	**Aug.**	**Mean**
Salvador type										
K-8 (Australian)	6.9	9.6	5.8	8.7	7.8	2.0	6.2	3.8	4.8	4.2
K-8 (Hawaiian)	11.2	8.7	7.8	9.1	9.2	2.6	3.8	4.2	6.7	4.3
K-28	3.7	9.3	7.0	7.7	6.9	1.6	5.6	4.1	4.4	3.9
K-67	9.3	6.3	8.0	6.7	7.6	4.9	4.0	4.6	4.5	4.5
K-156	3.4	5.0	5.8	6.7	5.2	1.9	3.5	4.0	4.3	3.4
cv. Peru	6.4	5.7	7.0	7.2	6.6	3.0	3.4	3.8	5.8	4.0
cv. Cunningham	2.5	7.8	8.7	8.0	6.8	1.3	1.3	5.1	4.5	3.0
Peruvian	5.5	6.8	7.8	7.7	6.9	1.8	3.3	4.8	4.8	3.7
Côte d'Ivoire	7.8	7.5	6.9	6.4	7.2	3.5	4.4	4.4	4.3	4.1
Mean	6.3	7.4	7.2	7.6	7.1	2.5	4.0	4.3	4.9	3.9

Source: Udom et al. (1982).

Table 10. Chemical composition and in vitro dry matter digestibility (IVDMD) (% dry matter basis) of selected tree fodders, shrub leaves, and crop residues in Thailand.

Feed	DM	CP	Ash	NDF	ADF	ADL	IVDMD
Samanea							
Leaves	89.5	22.4	3.3	37.0	32.1	16.1	—
Pods	89.0	16.7	3.3	—	—	—	—
Sesbania leaves	92.7	23.5	13.8	15.9	15.4	4.5	—
Cassava leaves	97.0	24.8	7.9	—	—	—	—
Sun hemp leaves	96.0	15.5	11.2	—	—	—	—
Water hyacinth							
Leaves	14.5	14.9	13.9	52.2	27.2	2.6	55.1
Leaves + stalks	8.9	9.2	14.8	51.6	31.0	2.9	52.8
Peanut residue							
Leaves	93.1	18.0	13.3	47.3	34.9	8.1	—
Stems	93.3	9.1	13.4	53.0	46.6	6.8	—
Cowpea residue							
Leaves	92.0	23.8	14.5	42.0	32.9	8.0	67.4
Stems	91.0	14.3	8.8	52.2	39.8	7.3	62.6

Note: DM, dry matter; CP, crude protein; NDF, neutral-detergent fibre; ADF, acid-detergent fibre; ADL, acid-detergent lignin.
Source: Wanapat (1986).

Table 11. Effects of supplementation of tree fodders and shrub leaf on rice straw intake and performance of ruminants in Thailand.

Ruminant species and diet[a]	Daily dry matter intake (head)[b]	Daily weight change (head)[b]
Crossbred Brahman cattle (91 days)		
RS + 1.5 kg dried kenaf leaf	2.5	248
RS + 2.13 kg cowpea hay	2.5	272
RS + 1.99 kg stylo hay	1.7	63
Grass silage	9.4	–204
Cattle (native) (120 days)[c]		
RS	2.9%	—
RS + sun hemp hay	2.7%	—
RS + sun hemp hay (3:1)	3.5%	—
RS + verano stylo hay (3:1)	3.3%	—
Sheep[d]		
RS + leucaena:gliricidia (1:0)	5.1	57.9%
RS + leucaena:gliricidia (1:1)	5.0	56.9%
RS + leucaena:gliricidia (1:2)	5.2	53.9%
RS + leucaena:gliricidia (1:3)	4.7	51.0%
Swamp buffaloes (30 days)		
RS + fresh leucaena	5.4	–440
UTS + fresh leucaena	6.3	444
Cattle (native) (133 days)[e]		
RS	63 g	–117
RS + 300 g DLL	70 g	–59
RS + 600 g DLL	79 g	41
UTS	80 g	–76
UTS + 300 g DLL	77 g	36
UTS + 600 g DLL	86 g	62

(continued)

Table 11. Concluded.

Ruminant species and diet[a]	Daily dry matter intake (head)[b]	Daily weight change (head)[b]
Cattle (native) (120 days)[e]		
RS	66.8 g	−114.6
RS + 300 g DCL	75.5 g	−56.6
RS + 600 g DCL	87.3 g	28.8
RS + 900 g DCL	94.1 g	63.4
UTS	69.9 g	3.4
UTS + 300 g DCL	78.7 g	52.6
UTS + 600 g DCL	85.9 g	84.0
UTS + 900 g DCL	91.9 g	146.4
Cattle (native) (113 days)		
RS	3.2	−60
RS + 1 kg *Acacia* pods	2.9	60
RS + 2 kg *Acacia* pods	3.9	100
RS + 3 kg *Acacia* pods	5.5	40
Cattle (native) (91 days)[c]		
RS	2.1%	−165
RS + 0.5 kg verano stylo hay	2.2%	11
RS + 1.0 kg verano stylo hay	2.2%	60
RS + 1.5 kg verano stylo hay	2.1%	104
Swamp buffaloes (123 days)[f]		
RS	5.1	−192, −375
RS + 1 kg dried *Mimosa* leaf	4.6	−103, −360
RS + 2 kg dried *Mimosa* leaf	3.7	−116, −326
RS + 3 kg dried *Mimosa* leaf	2.4	−9, −181
Swamp buffaloes (180 days)		
RS	—	64
RS + stylo	—	82
RS + sun hemp (2:1)	—	159

Source: Adapted from Wanapat (1986).

[a] RS, rice straw; UTS, urea-treated rice straw; DLL, dried leucaena leaves; DCL, dried cassava leaves.

[b] Except as noted.

[c] Daily dry matter intake is expressed as % body weight/head.

[d] Dry matter digestibility is listed instead of daily weight change.

[e] Daily dry matter intake is expressed as $g/kg^{0.75}$.

[f] Two values for daily weight change are given. The first is based on 2-year results; the second, 3-year results.

Recommendations

Given the potential importance of many shrubs and tree fodders as feeds, especially during the dry season, and in light of the current knowledge and rapid expansion and development of ruminant production in Thailand, particularly those of beef–dairy and buffalo production, the following recommendations are made concerning the more efficient use of shrubs and tree fodders.

- Potential species should be more widely planted in the farms to supply feeds throughout the year.

- These feed sources should be mainly used as supplements, especially with coarse roughages such as rice straw and other crop residues.
- Feeding strategies of available tree fodders and shrubs for relevant livestock-production systems and their production levels need to be identified.
- Potential varieties of shrubs and tree fodders need to be assessed regarding their values in the in vivo system.

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