Cattle Production on Small Holder Farms in East Java, Indonesia: II. Feeds and Feeding Practices

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ABSTRACT : A survey on feeding practices was conducted with thirty-one cattle farmers belonging to three categories: households without land and no income from agricultural labour (Class 100;10 farms), households without land but deriving considerable income from agricultural labour (Class 101;10 farms), and households with land and without income from agricultural labour (Class 110;11 farms). Information on the types of feeds given to cattle, amounts of feed offered and refused, and chest girth measurements were recorded every two weeks for a period of one year. In addition, samples of the feeds offered and refused were collected every two weeks and analysed for dry matter, organic matter (OM), crude protein (CP) and in vitro organic matter digestibility (OMD). Grass was usually cut at an early stage of growth, as such the CP (11.8%) and OMD (62%) were relatively high. All types of rice straw (whole, lower and upper part) and sugarcane forage (tops and leaves) were low in CP (<6 and <8.9%, respectively) and OMD (<45 and <47%, respectively). Rice bran and tofu waste was of much better quality than any other feed. The average number of different feeds in the rations (mean of all farms) was 1.98, with a lower value for class 101 (1.80), than for classes 100 and 110 (2.11 and 2.02, respectively). Of the total amount of OM consumed, 42% was rice straw, 21% grass, 19% maize forage, 10% sugarcane forage, <4% other forages (soya and groundnut straw), 1.3% rice bran and 2.9% tofu waste. The total amount of OM offered varied from <80 g/kg$^{0.75}$/d in August/September to 1.5 times as much in May ($p<0.01$). The intake of digestible organic matter (IDOM) for farm class 110 (37.7 g/kg$^{0.75}$/d) was significantly ($p<0.001$) lower than that for classes 100 and 101 (44.1 and 41.3 g/kg$^{0.75}$/d, respectively). The highest CP/IDOM ratio was recorded for farm class 101 (0.201 as compared to 0.181-0.184). (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 2 : 226-235*)

Key Words : Cattle Production, Feeding Practice, Indonesia

INTRODUCTION

Many studies on the feeding of livestock in South East Asia emphasise the availability of large amounts of crop residues, especially rice straw (Doyle et al., 1986; Devendra, 1993). Based on this, various options for solving problems of low ruminant production and seasonal feed supply have been considered and tested in the laboratory or in the field. These include the use of exotic forages, supplements or treatment of crop residues (Doyle et al., 1986; Schiere and Ibrahim, 1989; Schiere, 1995). However, experimental research on these technologies has had little impact on feeding practices and consequently on production at farm level in resource-poor agricultural production system in the tropics (Ibrahim, 1994). One reason for the poor adoption of new technologies is that past agricultural research focussed more on increasing the crop and livestock production capacity than adapting technologies to farmers' ecological and socio-economic production constraints (Fresco et al., 1990).

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A general household survey in the same village showed that there are large differences between households which rear cattle, in terms of access to land, and the level and composition of their income (Winarto et al., 1999). They concluded that the most prevalent type of livestock production in this area was a small scale cow-calf operation, either by landless households or those with <0.4 ha of land. Farmers in many areas not only use rice straw, but also other crop residues, green feeds and locally available supplements in various combinations, depending on the cropping pattern and the season. The hypothesis for the study reported in this paper was that these differences may cause considerable differences in access to feed resources and feeding of livestock in Sonoageng.

MATERIALS AND METHODS

The thirty-one cattle farms included in the survey were selected from the 164 households which had been included in the general household survey conducted in the area (Winarto et al., 1999). The households were divided into three groups: (a) households without land and no income from agricultural labour (Class 100;10 farms), (b) households without land but deriving considerable income from agricultural labour (Class 101;10 farms), and (c)

households with land and without income from agricultural labour (Class 110;11 farms).

In principle, all households were visited on three (in a few instances two) consecutive days at intervals of approximately two weeks during the period June 1994 to May 1995. Due to shortage of staff, this schedule could not always be maintained so that in some months (especially July and August 1994) most farms were visited only once instead of twice. In a few instances, farmers included in the survey, temporarily had no animals. As a result, the number of visits was only 44 and 33 in July and August, respectively, while it varied from 51 to 61 in the other months. The total number of 2-3 day visits was 639 (210, 199 and 230 for Farm Classes 100, 101 and 110, respectively), while the total number of single day visits was 1897 (623, 588 and 686, respectively).

For each daily visit, a record was made of the feeds given to the animals, including the amounts offered and refused (left overs). Samples were taken of both offered and refused feeds. Samples were analyzed for dry matter (DM), organic matter (OM) and crude protein (CP) by the method of AOAC (1980), and in vitro digestibility of OM (OMD) by the method of Tilley and Terry (1963). On each visit, the chest girth (CG) of the animals was also measured. CG data were used to estimate the liveweight (LW) of the animals using the formula LW (kg)=0.00051*CG $(cm)^{2.626}$.

Data on the amounts of feed offered and consumed were expressed as g per unit metabolic weight (MW= $kg\ (LW)^{0.75}$) per day. Most farmers did not practice individual feeding, but fed their animals as a group. Therefore, the total amounts of OM and CP offered and consumed per farm as well as the estimated total intake of digestible organic matter (IDOM) were divided by the summed MW of the animals present on the farm. The composition of the rations (number of different feeds included) was analyzed on the basis of the daily rations (N=1,897). For the statistical analysis of data for OOM (amount of offered OM), IOM (intake of OM), OCP (amount of CP offered), ICP (intake of CP), OMD, IDOM and ICP/IDOM ratio, mean values of the 2-3 day visits were used (N= 639).

The data was analysed using the Dbstat package (Brouwer, 1992). The chemical composition, types and quantities of feed offered and refused, animal weight data were entered in the Dbstat data entry files and the Dbstat analysis package was used to extract mean values with standard errors, feeds used and their proportions, frequency distribution of rations, and intake of nutrients expressed in metabolic weight basis. Statistical comparison/significance between farm classes (100 versus 101; 100 versus 110; 101 versus 110), effect due to seasons on nutritive value of feeds and interactions were also tested.

RESULTS

Feeds used

Feeds used included grass, residues of major crops (rice, maize and sugar cane), residues of minor crops (soya and groundnut), two types of agro-industrial by-products (rice bran and tofu waste) and a number of other green forages.

Grass

Grass is collected from crop fields, field boundaries, banks of irrigation canals, roadsides, sporting fields and home gardens. During the wet season, most of the crop fields are used for sawah (irrigated rice). During that time, grass can only be collected at weeding. This activity is carried out at about three weeks, and at two months after planting. Yields of grass from crop fields are relatively low in the wet season because most fields are flooded then. However, the amount harvested from canal banks, roadsides and home gardens are higher during the wet season. In the dry season, maize and soya are the main crops from these fields. During that time, grass also grows in between the main crop, and again is harvested during the process of weeding. Hence, the amount of grass harvested from crop fields is larger in the dry season than in the rainy season. On the other hand, the amounts of grass harvested from the other areas mentioned are higher in the rainy season than in the dry season when yields are low due to comparative drought conditions. Thus, the location of harvest varies with the season. Farmers stated that more grass is available in the dry season than in the wet season, but some grass is available throughout the year.

Grass is considered to be a communal resource, i.e. it is freely accessible to everyone. Actual access is largely determined by labour. According to the farmers, it takes at least three to four hours to collect a full basket (20-25 kg) of fresh grass. In the case of crop fields, collection of grass is related to working as a labourer in weeding activities. Most farmers wash the grass before feeding. Especially when collection of grass is associated with weeding, it is mostly collected in the morning and fed in the afternoon after washing and drying.

Rice straw

Farmers distinguish three types of rice straw: whole rice straw (WRS), lower rice straw (LRS) and upper rice straw (URS). WRS is obtained when the paddy is threshed manually using a bamboo rack or man-powered threshing machine. For this, the paddy is

cut about 5-10 cm above the ground. This method of threshing is mostly done in the field when paddy is harvested in the dry season and the field is dry. Much of this straw is taken home by labourers who help with the harvest and threshing. URS is obtained when the paddy is threshed using the so-called dos machine. Most of the paddy is threshed this way, because it is faster and needs less labour. When the dos machine is used, the paddy is cut at about one-third of the crop's height, a little below the panicle, while the lower part of the straw is left standing in the field. URS consists therefore of the crushed upper stem and panicle and generally belongs to the owner of the crop. This type of rice straw is traded. It may be sold (for cash) to other farmers or bartered for other things. When sold for cash, the price is based on the size of the plot where the straw was harvested. The price ranges from US$ 4-6 per quarter bahu (0.18 ha), i.e., US$ 22-33 per ha. Alternatively, URS harvested from 0.5 ha can be bartered for manure produced by two adult cattle during a period of 6 months. When the dos method of threshing is used, the lower straw (LRS) is left standing in the field. It is freely accessible for other farmers who want to collect it for their cattle. Fields must be prepared quickly for planting of the next crop.

The above implies that both rice producers and landless farmers, have access to rice straw. Most farmers in Sonoageng store rice straw: URS from their own land or bought from other farmers, or WRS and LRS directly collected from the field. Generally, the straw is stored in the cattle shed close to the animals, on the veranda of the house or stacked outside. The straw is fed without any further treatment.

Maize

Maize is the second major crop after rice. It is planted either once or twice after the second rice crop. Maize is primarily grown for grain, but also yields considerable amounts of crop residues for feeding ruminants. Three types of maize forages may be distinguished: leaves, tops and husks. Leaves (mostly green) are obtained from pruning several weeks before harvest. Some farmers postpone removal of the leaves until the tops of the stems are also taken off, one to two weeks before harvest. After that, the lower part of the stem and cobs are left standing in the field to dry before harvesting. At harvest, the cobs are removed from the stem and carried home. Subsequently, the husks are taken off the cobs. Farmers who have no land themselves obtain considerable amounts of leaves and tops, in addition to their wages in cash, in return for working as a labourer during planting, weeding and harvest of the crop. Usually the same persons are involved in all of these activities. Similarly, they obtain husks in return for helping to take these off the cobs. The amount they can collect depends on their input of labour. Workers are entitled to have all the husks they remove from the cobs.

Sugar cane

The tops of sugar cane, available during the harvesting period from May to December, are regarded as communal property and are freely available to all farmers. Although the amount is very low compared to tops, some farmers also feed the leaves pruned off the cane during the growing period.

Soya

Feed generated from soya includes leaves and straw. Leaves fall off when the harvested soya is sun-dried before threshing. Threshing is by hand. The amount of leaves is small compared with straw. However, they are of much better quality. The straw consists of cracked stems and pods. Leaves are usually fed directly, while straw may be stored for later use.

Groundnut

Groundnut is a minor crop in Sonoageng and the residues, mainly straw and a very small amount of separated leaves, are usually fed directly rather than stored.

Industrial by-products

The industrial by-products fed to cattle include rice bran and tofu waste. Rice bran is sold by the village rice mills. The price ranges from US$ 0.10 to 0.12 per kg. Farmers who use the facilities to mill rice for home consumption, can take the bran free of charge, while they pay for the services of the mill with part of the milled rice. Not only rice from within the village is milled in Sonoageng, but also rice brought in by middle men from other villages. Although local farmers can buy rice bran from middle men operating at the mills, a large part of the rice bran is sold to other places, in particular feed mills in the Surabaya industrial area.

Tofu waste is produced by the tofu home-industry. This is a small-scale industry involving some 30 households in one of the Sonoageng sub-villages (Gading). Generally, the farmers buy tofu waste on the basis of monthly contracts. They pay US$ 3-4 monthly to have the daily waste of one cooking of tofu, which is approximately 8-10 kg fresh material or 0.8-1 kg DM. On a dry matter basis, the price of tofu waste (US$ 0.11-0.14) is comparable to that of rice bran. However, the amount available is limited and only farmers with a purchasing contract can obtain it.

Other green forages

Other feeds include leaves of various trees (kapok, leucaena, jak fruit, papaya), banana leaves, cowpea

leaves, sweet potato vines and spinach (Amaranthus) leaves. They are mostly harvested from their own home garden. Quantities are small.

Feeding practices

Animals are generally fed in the afternoon and evening. In the morning, the animals are usually tethered outside the stable to get sunshine with or without access to feed. In the afternoon, the animals are taken back to the stable to get salted drinking water and feed. If available, concentrates (rice bran) are usually given mixed in the drinking water. Drinking water, with or without concentrates, is usually offered again in the evening. Other feeds are fed twice or three times a day.

Nutritive value of feeds

The composition (% OM and CP in the DM) and digestibility of organic matter (OMD, measured in-vitro) of the feeds is shown in table 1. Grass is usually cut at an early stage of growth. As a result, CP and OMD values were relatively high. All types of rice straw were of low quality (OMD<45% and CP<6%). Farmers generally consider the upper rice straw to be of higher quality than the lower or whole rice straw, but this was not confirmed by the composition analysis. The nutritive value of maize leaves and tops was similar to that of grass, but the quality (especially the CP content) of maize husks was very low. Sugarcane leaves were also of low digestibility (<50%), while the CP content (8.9%) was intermediate. The values for tops were lower than those for leaves. Also soya straw was of low quality. Soya leaves had a fairly high digestibility. The digestibility of groundnut straw was not measured, but was assumed to be the same as that of soya straw. Groundnut leaves had a similar digestibility to soya leaves, but a higher % CP. Rice bran and tofu waste were of much better quality than any other feed. A wide range of values was found for tree leaves. Leucaena, cowpea and papaya all had high digestibilities, but only leucaena was outstanding as a

Table 1. Concentration of dry matter (DM), organic matter (OM) and crude protein (CP) in dry matter, and in-vitro digestibility of organic matter (OMD) of feeds

	DM (%)	OM (%)	CP (%)	OMD (%)
Grass	97.2 (2.1)	82.4 (1.6)	11.8 (0.6)	62.0 (2.5)
Whole rice straw (n=54)	98.1 (2.2)	73.6 (4.2)	5.5 (0.5)	44 (1.8)
Lower rice straw (n=66)	97.4 (2.0)	74.9 (3.8)	4.8 (0.8)	40 (2.2)
Upper rice straw (n=45)	98.3 (2.1)	75.4 (3.6)	4.7 (0.7)	38 (2.5)
Maize forage:				
Leaves (n=37)	97.6 (2.2)	82.6 (2.7)	13.3 (0.7)	64 (1.9)
Tops (n=45)	98.3 (1.4)	84.9 (2.0)	10.3 (0.6)	56 (1.5)
Husks (n=66)	98.1 (2.4)	95.6 (2.1)	3.3 (0.6)	46 (2.2)
Cane forage:				
Tops (n=58)	97.3 (1.7)	91.4 (2.1)	6.1 (0.6)	43 (2.6)
Leaves (n=51)	98.1 (2.5)	86.7 (1.7)	8.9 (0.6)	47 (1.9)
Soya forage:				
Straw (n=32)	96.7 (1.3)	91.1 (0.9)	5.7 (0.9)	48 (2.6)
Leaves (n=27)	97.1 (2.1)	94.3 (1.6)	7.1 (0.7)	63 (2.1)
Groundnut forage:				
Straw (n=39)	96.9 (2.9)	88.4 (2.3)	10.8 (0.8)	48 (2.6)
Leaves (n=46)	98.6 (1.9)	91.3 (1.6)	13.0 (0.6)	65 (1.5)
Rice bran (n=23)	98.9 (1.4)	89.8 (4.5)	13.9 (0.4)	74 (2.4)
Tofu waste (n=7)	96.8 (2.9)	93.4 (1.9)	17.5 (0.4)	95 (0.9)
Kapok leaves (n=31)	97.9 (2.5)	86.9 (2.6)	11.8 (0.8)	49 (2.7)
Leucaena leaves (n=25)	98.7 (2.1)	91.4 (1.9)	24.6 (0.5)	63 (1.1)
Jak leaves (n=11)	98.3 (2.4)	93.4 (2.2)	7.6 (0.8)	44 (2.2)
Papaya leaves (n=9)	99.1 (1.9)	85.3 (1.9)	6.5 (0.4)	68 (1.5)
Banana leaves (n=12)	97.5 (2.1)	84.1 (2.6)	8.5 (0.5)	42 (1.8)
Cowpea leaves (n=21)	98.9 (2.6)	88.9 (2.2)	12.9 (0.9)	69 (1.2)
Sweet potato leaves (n=17)	97.6 (2.5)	87.1 (1.9)	11.8 (0.6)	56 (1.9)
Spinach leaves (n=9)	97.3 (2.8)	88.3 (2.1)	11.4 (0.7)	56 (2.1)

Figures in parentheses are standard errors.

source of CP.

Utilization of feeds by farm class

The amount of maize leaves available was small compared to the amount of tops (mass ratio leaves: tops=1:35, approximately). The same was true for the amount of sugarcane leaves compared to tops (mass ratio=1:7), groundnut leaves and straw (1:21), and soya leaves and straw (1:12). Therefore, no distinction was made between these components when counting the number of feeds in rations. However, maize husks were kept separate from leaves and tops. Due to the extremely small quantities of the individual green forages apart from grass, these eight feeds were treated as one category in the analysis of the data.

The average number of different feeds in the rations (mean of all farms) was 1.98, with a slightly lower value for Class 101 (1.80), than for Classes 100 and 110 (2.11 and 2.02, respectively). Most single-day rations consisted of two feeds (see table 2) but Class 101 farmers gave single feed rations more often (36%) than farmers of Class 110 (24%) and Class 100 (17%). The single feed most frequently offered was rice straw (11% of all diets), followed by maize forage (6%) and grass (5%). LRS and URS were more often fed alone (46% and 39% of all rice straw-only diets, respectively) than WRS (7%). Farmers of Class 101 and 110 fed only rice straw more often (13% of all diets at these farms) than Class 100 farmers (6%). Maize forage-only and grass-only diets were mostly given by farmers of Class 101.

Table 2. Frequency distribution of rations (% of total number, N) according to number of feeds included in households without land and no income from agricultural labour (class 100), households without land but deriving income from agricultural labour (class 101), and households with land and without income from agricultural labour (class 110)

Farm class	100	101	110	All
Number of rations	623	588	686	1,897
No. of feeds included:				
1*	16.8	35.9	24.3	25.5
2	58.6	49.1	53.2	53.7
3	21.7	14.1	19.0	18.3
4	2.6	0.9	2.8	2.1
5	0.3	-	0.6	0.3
6	-	-	0.1	0.1
* Rice straw only	5.6	13.1	12.8	10.6
Maize forage only	3.5	10.4	5.1	6.2
Grass only	3.5	9.7	3.3	5.4
Other single feed	4.2	2.7	3.1	3.3

Nearly half (296, 48%) of the 623 single-day rations fed on farm Class 100 contained grass (see table 3). The proportion of rations in Class 101 containing grass was slightly higher (54%), while that in Class 110 was much lower (29%). The proportion of rations containing rice straw was high for all Classes. Nevertheless, the proportion for Class 110 (70%) was significantly higher than that for the other Classes (<60%). Farmers of Class 101 fed maize tops more often and maize husks less often than the other farmers, and used tofu waste much less frequently than other farmers: in 4% of the rations as compared to 29 and 39%. The large difference in feeding between Farm Classes is further illustrated in table 4. Farmers of Class 110 had, relatively speaking, a much larger herd than the other farmers (2.39 as compared to 1.80 and 1.35 Animal Units) ($p<0.001$). Nevertheless, as an average for the whole year, the amount of grass (expressed in kg/d) fed by them was 28% lower than that fed by the other farmers. As a result, the amount of grass fed per kg metabolic weight was less than half the average for the other farmers. Compared with Class 101, Class 110 farmers mainly fed their larger herd by using more rice straw, maize husks, and soya, i.e., low quality roughages, in combination with a larger amount of tofu waste. Class 100 farmers fed the largest amounts of sugarcane and soya forage.

Overall averages of the amounts of individual feeds given are shown in the last column of table 5. Of the total amount of OM offered, 43% was rice straw, 20% maize (7.6% husks and 12.5% tops), 18% grass and 10% sugarcane forage. Other forages, including soya and groundnut straw, together comprised <5% of the OM offered. Similarly, the OM matter offered included only 1.1% rice bran and 2.4% tofu waste. As observed above, Class 101 farmers used hardly any tofu waste at all. Due to differences in refusal rates (0% for rice bran and tofu waste, 4% for grass and 19% for rice straw and maize forage), the composition of the consumed OM differed slightly from that offered: 42% rice straw, 21% grass, 19% maize forage, 10% cane forage, <4% other forages, 1.3% rice bran and 2.9% tofu waste.

Seasonal utilization of feeds

The total amount of OM offered varied from <80 $g/kg^{0.75}/d$ in August and September, to 1.5 times as much in May ($p<0.01$). Compared to other forages, the amount of grass OM offered was relatively stable throughout the year. The largest amount (28.1 $g/kg^{0.75}/d$, mean for all farm types, see table 5), was fed in January when the quantities of the three major crop residues (rice straw, maize forage and cane forage) were low. On the other hand, the amount of grass offered was lowest (11.5 $g/kg^{0.75}/d$) in March, when peak amounts of rice straw were fed. Many

Table 3. Proportion (% of total number) of feed included in the rations of households without land and no income from agricultural labour (Class 100), households without land but deriving income from agricultural labour (Class 101), and households with land and without income from agricultural labour (Class 110)

Farm class:	100	101	110	Probability[1] of contrasts		
Number of rations	623	588	686	100-101	100-110	101-110
Grass	47.5	54.4	28.6	*	***	***
Whole rice straw	12.4	8.5	14.3	*	ns	**
Lower rice straw	22.2	26.2	28.0	ns	*	ns
Upper rice straw	24.2	20.2	27.8	ns	ns	**
Maize: tops/leaves	13.0	27.1	19.7	***	**	**
Maize: husks	13.2	8.3	13.7	**	ns	**
Cane forage	19.9	12.8	11.1	**	***	ns
Soya forage	6.3	2.4	4.5	**	ns	ns
Groundnut forage	1.8	0.9	1.9	ns	ns	ns
Rice bran	17.2	15.0	12.1	ns	*	ns
Tofu waste	28.9	3.6	39.1	***	***	***
Other green feeds	4.8	0.7	1.7	***	**	ns

[1] ***: p<0.001; **: p<0.01; *: p<0.05; ns: p>0.05.

Table 4. Amount of organic matter (OM) offered per animal and per farm in households without land and no income from agricultural labour (Class 100), households without land but deriving income from agricultural labour (Class 101), and households with land and without income from agricultural labour (Class 110)

	Per animal (g/kg$^{0.75}$/d)			Per farm (kg/farm/d)		
Farm class:	100	101	110	100	101	110
Feed:						
Grass	19.2 (0.9)	25.4 (1.9)	10.5 (1.1)	2.2 (0.4)	2.17 (0.1)	1.6 (0.1)
Whole rice straw	7.5 (0.6)	7.2 (1.0)	9.3 (0.9)	0.8 (0.1)	0.61 (0.1)	1.4 (0.1)
Lower rice straw	14.7 (0.8)	14.8 (1.4)	16.9 (1.3)	1.7 (0.2)	1.26 (0.1)	2.5 (0.2)
Upper rice straw	21.9 (1.1)	15.0 (1.1)	19.9 (1.5)	2.5 (0.2)	1.28 (0.1)	3.0 (0.2)
Maize: tops/leaves	7.3 (1.0)	18.6 (1.0)	11.3 (0.9)	0.8 (0.1)	1.59 (0.1)	1.7 (0.1)
Husks	10.3 (0.9)	5.7 (0.3)	6.8 (0.6)	1.2 (0.2)	0.49 (0.1)	1.0 (0.1)
Canetops & leaves	14.8 (1.1)	8.4 (0.9)	6.6 (0.5)	1.7 (0.1)	0.72 (0.1)	1.0 (0.0)
Soya straw	5.9 (0.4)	1.0 (0.1)	2.6 (0.2)	0.7 (0.1)	0.09 (0.0)	0.4 (0.0)
Groundnut straw	1.2 (0.1)	0.9 (0.1)	0.7 (0.1)	0.1 (0.0)	0.08 (0.0)	0.1 (0.0)
Rice bran	1.4 (0.1)	1.0 (0.1)	0.9 (0.1)	0.2 (0.0)	0.09 (0.0)	0.1 (0.0)
Tofu waste	3.5 (0.2)	0.3 (0.0)	3.3 (0.2)	0.4 (0.0)	0.03 (0.0)	0.5 (0.0)
Other green feeds	0.6 (0.1)	0.2 (0.0)	0.2 (0.0)	0.1 (0.0)	0.02 (0.0)	0.03 (0.0)
Total	108.3	98.5	89.0	12.2	8.4	13.4

Note: Average number of Animal Units per farm: 1.80, 1.35 and 2.39 for Farm Classes 100, 101 and 110, respectively.

farmers stored rice straw, but apparently not enough to avoid large seasonal variations in the amounts of rice straw offered: from 10.5 g OM/kg$^{0.75}$/d in December, when it comprised <10% of the total OM offered, to 85 g/kg$^{0.75}$/d in March, comprising 82% of the total OM offered. The amounts of maize residues (tops and leaves+husks) offered, was highest in October-December (40-73 g/kg$^{0.75}$/d), while amounts were very small in March-July (<5 g/kg$^{0.75}$/d). As expected, the amounts of tops and leaves available, increased earlier in the year than the husks. The amounts of cane forage were highest in May and June (>20 g/kg$^{0.75}$/d), intermediate in July-November (10-13 g/kg$^{0.75}$/d) and extremely low (<5 g/kg$^{0.75}$/d) in December-April. Soya forage was mainly fed (amount of OM offered >5 g/kg$^{0.75}$/d) in September-October and January-February. The amount of rice bran given, although low throughout the year, still showed a distinct seasonal pattern, similar to that of rice straw. It was very low (<0.1-1.1 g/kg$^{0.75}$/d) in August-March and higher (1.7-3.3) in April-July. The amount of tofu waste also tended to be higher in the period March-July (2.7-3.4), than in August-February (1.4-2.4 g/kg$^{0.75}$/d). The higher amounts in March-July are related to the celebration of 'Idel Fitr' (marking the end of the Muslim fasting period) and Nyadran (a traditional Javanese festivity which, in Sonoageng, is

Table 5. Amounts of individual feeds offered (g organic matter/kg$^{0.75}$/d) by month

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Mean
Grass	16.6	12.9	14.3	14.1	16.9	15.9	18.2	28.1	22.1	11.5	23.6	22.4	18.1
WRS[1]	2.7	17.6	11.4	12.1	2.9	6.3	0.9	6.9	15.7	0.0	8.6	9.3	7.9
LRS[1]	13.4	35.8	13.7	2.7	8.9	2.5	2.5	18.8	16.9	48.1	14.2	8.8	15.5
URS[1]	31.3	11.0	12.9	5.7	4.8	13.3	7.1	4.0	10.5	36.9	47.4	44.6	19.1
Maize tops/leaves	0.9	4.2	5.2	13.2	38.8	25.0	47.3	10.2	1.8	0.0	0.0	0.9	12.3
Maize husks	0.2	0.0	5.0	8.9	9.8	14.6	25.5	12.3	11.3	1.9	0.9	0.0	7.5
Cane forage	23.5	12.1	12.8	9.7	10.8	10.8	0.1	2.9	4.4	0.8	3.3	26.6	9.8
Soya forage	2.0	0.2	0.0	5.8	8.6	1.8	2.1	12.9	5.0	0.0	0.0	0.0	3.2
Groundnut forage	0.5	0.0	0.0	1.0	1.2	0.0	2.8	0.0	1.0	0.0	4.4	0.0	0.9
Rice bran	2.8	2.3	0.7	0.4	0.6	0.1	0.1	0.1	0.4	1.1	3.3	1.7	1.1
Tofu waste	2.7	3.2	1.4	2.4	1.9	2.4	1.7	2.4	1.7	2.9	2.7	3.4	2.4
Others	0.0	0.0	0.1	0.6	0.3	0.4	0.7	0.2	0.6	0.8	0.1	0.3	0.3
Total	96.5	99.3	77.5	76.7	105.4	93.1	109.0	98.8	91.4	104.0	108.5	118.0	98.1

[1] WRS: whole rice straw; LRS: lower rice straw; URS: upper rice straw.

celebrated in July), leading to a higher demand for tofu.

The seasonal variation in the use of individual feeds was similar for all farm classes. The amount of tofu waste fed on Farm Class 101, for example, was lower for all months, than the amount fed on the other farms. Notable differences from this pattern are as follows. In the period June-August, the amount of rice straw fed by farmers of Class 101 was about 20 g/kg$^{0.75}$/d lower than the amount fed by other farmers, while the amount of maize residues fed by Class 101 farmers was higher. In the period January-February, the reverse was true. Also, while Class 110 farmers fed less grass than their counterparts in all other months, they fed as much or more in January (also when expressed in g/kg$^{0.75}$/d). As already mentioned, this occurred after the peak in feeding of maize forage (December), before large amounts of rice straw were available again. It is not clear whether Class 110 farmers fed more grass in these months because of greater availability, or because they are confronted with a shortage of other feeds. In any case, they did not use stored rice straw to fill the dip in availability of feeds between the harvests of maize and rice.

Ration quality per farm type and season

The calculated digestibility (OMD) of the rations was highest in the period September-January, i.e., the period when relatively large amounts of maize tops were fed and comparatively little rice straw (see table 6). The % CP showed a similar pattern. Intake of digestible organic matter (IDOM) was lowest in August-September (32.6 and 33.7 g/kg$^{0.75}$/d, respectively), i.e. when the amounts of rice straw fed had decreased sharply and maize forage was not yet available in large quantities. The overall average IDOM was 41.2 g/kg$^{0.75}$/d (1.28* maintenance). The distribution of values was skewed to the right (higher values). Therefore, the geometric mean (37.9 g/kg$^{0.75}$/d; 1.18*

Table 6. Intake of organic matter (IOM), organic matter digestibility (OMD), intake of digestible organic matter (IDOM), and ratio of crude protein intake/IDOM (ICP/IDOM) of rations (averages per month and farm class)

	N	IOM (g/kg$^{0.75}$/d)	OMD (%)	IDOM (g/kg$^{0.75}$/d)	ICP/ IDOM
Month:					
June	53	82.0	49.2	39.1	0.176
July	44	80.4	48.5	38.4	0.181
August	32	67.6	48.7	32.6	0.171
September	55	63.4	54.0	33.7	0.181
October	51	85.5	53.8	45.3	0.178
November	52	80.8	52.2	42.0	0.180
December	55	88.1	55.2	48.0	0.175
January	58	81.4	53.3	42.7	0.203
February	61	79.8	49.8	39.8	0.206
March	61	86.0	45.4	38.3	0.188
April	61	96.3	48.8	46.6	0.206
May	54	99.9	49.5	47.9	0.216
Farm class:					
100	209	88.2	51.1	44.1	0.185
101	199	82.3	51.7	41.8	0.201
110	229	77.4	49.3	37.7	0.181
Overall Mean:	637[a]	82.6	50.7	41.2	0.189
RSD[b]		36.5	6.89	17.2	0.035
Probability[c]					
Month		***	***	***	***
Farm class		**	***	***	***
Interaction		ns	ns	ns	ns

[a] 2 values (outliers) were excluded; [b] Residual standard deviation; [c] ***: p<0.001; **: p<0.01; ns: p>0.20.

maintenance) may be a more valid measure of the average feeding level. The monthly pattern differed somewhat between farm classes, but the interaction was not significant ($p>0.20$). IDOM on Farm Class 110 was significantly lower than that on Classes 100 and 101 ($p<0.001$). The highest CP/DOM ratio was recorded for farm Class 101, (0.201 as compared to 0.181-0.184).

DISCUSSION

Livestock systems in South-East Asia are often referred to as crop-livestock systems, to indicate that rearing livestock is closely integrated with the production of food crops by smallholders and that crop residues are a major source of animal feed. The latter is clearly confirmed by the data from Sonoageng, where 78% of the feeds offered to cattle are crop residues. Also, the seasonal pattern of utilization of feeds is very closely related to the cropping pattern and harvest seasons, causing very sharp peaks in the utilization of individual feeds. The term crop-livestock system is, however, misleading if it is used to indicate that the area from which the animal feed is obtained, falls within the same boundaries as the crop production system. Research done in Sri Lanka, both in the mid-country (Zemmelink, 1996) and in the coconut triangle (Jayatileka *et al.*, 1998) clearly indicate that the feed resource base for dairy (cattle and buffaloes) farmers is outside the limits of land they own. In those studies, the feed resource base included public property (railway dikes, road sides, cemeteries), state owned farms, and neighbours/others tree plantations or rice fields. In the present study, the fact that there are many landless farmers who rear livestock, already indicates that these boundaries cannot be the same at the level of the individual farmer. By definition, landless farmers obtain their feed outside the boundaries of the own crop fields. It may be obtained from communal land such as roadsides and the banks of irrigation canals, or crop fields of other farms. The former are also used as a source of green feed by farmers who have their own fields. Thus, the boundaries of the crop and livestock sub-systems differ for both types of farms. While landless farmers depend entirely on communal land and the land of others, the importance of communal land for farmers with land should also not be under-estimated. Where most of the crop residues are of low quality, supplementation with green feed is essential to keep livestock in production, unless other supplements are available. In terms of quantities fed, livestock production in Sonoageng is mainly based on rice straw and maize forage. In terms of ration quality, however, grass plus small quantities of other green feeds and industrial by-products are very important. Access to feeds is partly related to ownership of land and crops, but for most feeds labour (related to cultivation and processing of the crop after harvest) is an important determining factor. Thus, while maize leaves and tops (cleared from the stalk before harvest) are more frequently used by landless agricultural labourers (Class 101), the husks (becoming available at the compound of the crop owner) are more frequently used by farmers with land (Class 110). Partly as a result of this, rations fed by landless labourers are actually of a higher quality than rations fed by the landowners. The effect of this division of maize residues is accentuated by the much higher frequency of feeding grass by landless labourers. Landowners feed more tofu waste, but not enough to compensate for the lower quality of roughage. After the first rapid appraisal of the situation in Sonoageng, it was thought that tofu waste was a quantitatively important supplement for livestock rearing in the village. However, a separate survey of the tofu industry had already indicated that the quantities of tofu waste were much lower than it appeared at first sight. The present study on feeding practices shows that it is mainly used by landowners, and those households which derive income from non-agricultural employment, and not by the agricultural labourers. Thus, higher quality feeds harvested from communal and private land, such as grass and maize tops, are more frequently used by landless agricultural labourers, while those which require payment in cash (tofu waste) are mostly used by landowners (Class 110), and others with a more favourable cash flow position (Class 100).

It is important to note the great importance of maize stover in the livestock feeding system of Sonoageng. Maize is mainly grown on land with a less secure water supply. If irrigation systems are further developed and more land is used for rice instead of maize, a higher quality crop residue will be replaced by one of lower quality. As a result, the average quality of feeds available in the village will probably decrease, while the overall feeding level in the village is already low. Most likely, especially the possibilities for landless labourers to rear livestock would be affected.

Of the non leguminous feeds used (table 1), maize husks had the lowest CP content (3.3%) and rice bran had the highest (13.9%). Of all feeds, the OMD of upper rice straw was lowest (38%) as compared to tofu waste which had the highest (95%). Comparable data for some of the feeds used in this study could be obtained only from the study of Ifar (1996). He

studied the quality of feeds used in two villages in the south Malang regency which is about 200 km from Sonoageng. He concluded that leguminous tree fodders and sugar leaves/tops are of good quality with OMD ranging from 64 to 69%; native grass and maize leaves are of medium quality with OMD ranging from 53 to 55%; and rice straw (whole plant) is low in both OMD (50%) and CP (4.5). For similar feeds in our study, the OMD values are lower than the figures reported by Ifar (1996), but the CP values are similar. It is often suggested that protein (nitrogen) deficiency of feeds is the major limitation for livestock production in areas such as Sonoageng (Egan, 1986). However, the present data shows that energy is as much a constraint as nitrogen. The crude protein/digestible organic matter ratio in the rations, although not high, seems adequate for the level of feeding in terms of energy.

A comparison of the observed feeding levels, combined with the estimated number of animals in the village on the one hand, and the total area of crop land on the other, suggests that the size of the village herd is in balance with the availability of feed, i.e. there are no indications that there are feeds left over. The only exception to this is lower rice straw. Only 19% of the rice straw fed was whole rice straw, 36% lower rice straw and 45% upper rice straw. Based on the harvesting technique, one would expect the amount of lower straw to be 2-3 times higher than the amount of upper straw. The ratio of amounts fed suggests that not more than half of the lower rice straw is used. As described above, lower rice straw not collected from the field in time, is ploughed into the soil. It may be questioned whether using more of this straw for feeding would help to increase livestock production in the village (Zemmelink et al., 1992; Ifar, 1996). The main effect would be that the average quality of the ration would decrease. This could be avoided by treating such straw with urea. Treating the straw already in use would also improve ration quality. As in other countries (Ibrahim, 1994), urea-treatment of straw has also been tried in Indonesia (Djajanegara et al., 1983). However, is has not found widespread application. This may partly be due to inadequate training of farmers causing many failures of the treatment process. However, considering the amount of work required and the risks involved, it could also be that the economic advantage is too small to make it attractive for farmers. This could also be the reason for the low quantity of rice bran used. The rapid rural appraisal survey conducted in 1993, gave the impression that farmers fed considerable amounts of rice bran in combination with straw (Soetanto, unpublished). The detailed data on a larger sample of randomly selected farmers show, however, that this is not a common feeding practice. The average amounts of rice bran fed are small, and show a distinct seasonal pattern, indicating that bran is mainly used immediately after the rice harvest, when larger amounts become available at the rice mills and prices are lower.

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