Effect of increasing offer level of water spinach (*Ipomoea aquatica*) on intake, growth and digestibility coefficients of rabbits

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Abstract

Twelve New Zealand White rabbits with an initial live weight of 897 ± 95.2 g were allocated to a randomized block design to study the effect of different levels of water spinach (*Ipomoea aquatica)* (8, 10, 12, 14, 16 and 18% of live weight in DM). The water spinach was taken from the first and second harvests of plants established in CelAgrid-UTA Cambodia, after 30 days of first growth (or regrowth).

Increasing the offer level of water spinach from 8 to 18% of live weight (DM basis) increased the proportion of leaf consumed, the intake of crude protein and the digestibility of the DM and the crude protein. Digestibility of crude fiber decreased with increase in the proportion of leaves consumed. Live weight gain was depressed with increasing offer level apparently because of a decrease in the crude fiber content of the diet, as with increasing offer level the rabbits selected "low-fiber" leaves rather than "high-fiber" stems.

It is concluded that fresh water spinach as the sole feed of rabbits can support acceptable growth rates of 14 to 20g/day with DM feed conversion between 3.83 and 5.18. The crude fiber level in water spinach appears to be too low to support maximum performance and better results may be achieved by providing supplementary feed sources that are high in fiber.

Keywords: *Water spinach (Ipomoea aquatica), rabbits, digestibility, feed conversion, weight gain, feed offer level, selection.*

1. Introduction

The demand for human food from animal products (meat, egg and milk) is increasing year by year (Delgado *et al.*, 1999) but it is predicted and that there will be a world shortage of cereal grain due to the competing needs of expanding human and livestock populations (Leng, 2002). The potentially high cost of grain will make poultry meat expensive. There is therefore a need for research in order to develop systems of animal production based on locally available resources.

Rabbit meat is very nutritious. The meat is rich in protein content and low in fat and cholesterol. On the other hand, rabbits have the ability to consume directly forage proteins and convert this to animal protein, while swine and poultry rely mainly on cereal grains and high quality proteins such as fishmeal to meet their dietary protein needs. Hence, rabbit meat is often referred to as an inexpensive protein source (Lukefahr, 1992).

Water spinach is an herbaceous trailing vine that grows dwells in muddy stream banks, freshwater ponds, and marshes. This perennial aquatic vine is confined to the tropics and subtropics because it is susceptible to frosts and does not grow well when temperatures are below 23.9 ^{0}C. Water spinach can reproduce sexually by producing one to four seeds in fruiting capsules or vegetatively by stem fragmentation (Dressler, 1996). Some preliminary researches have been conducted on the use of water spinach as a basal diet for rabbit production (Miech Phalla, 2002, unpublished data; Honthong Phimmasan *et al.*, 2004; Vo Thi Tuyet Nga, 2004; Papers I and II) which has indicated its potential of this feed as an alternative to conventional diets, which usually consist of pelleted mixtures of concentrates and forages such as alfalfa (Lebas *et al.*, 1997).

The biomass yield of water spinach has been shown to respond dramatically to fertilization with biodigester effluent (Kean Sopphea and Preston, 2001; Ho Bunyeth, 2003; Ly Thi Luyen, 2003), with increasing concentration of crude protein in the dry matter.

The aim of this experiment was to measure the production response of water spinach to fertilization with biodigester effluent and to study the effect of different offer levels of water spinach on performance traits and digestibility coefficient of rabbits.

2. Materials and Methods

2. 1. Location and climate

The present investigation was carried out in the site of ecological farm of Center for Livestock and Agriculture Development (CelAgrid-UTA Cambodia), located in Rolous village, Rolous commune, Kandal Stoeung district, Kandal province, 26 km from Phnom Penh. During the conduct of this study (16 September to 15 November, 2004) average air temperature, as measured daily at 12:00, was 30.7 ± 0.89 ^{0} C.

2. 2. Experimental design

Twelve New Zealand White rabbits with average live weight of 897 ± 95.2 g were used in this experiment to determine growth performance and digestibility coefficient, according to Randomized Block design (Table 1). The animals were weighed every five days. They were confined in cages constructed from wood and bamboo with dimensions of length 0.5 m, width 0.5 m and height 0.5 m.

The treatments were:

- WS8: Rabbits were offered water spinach [WS] at the rate of 8% of body weight (as DM)
- WS10: same as WS8 but with 10%
- WS12: same as WS8 but with 12%
- WS14: same as WS8 but with 14%
- WS16: same as WS8 but with 16%
- WS18: same as WS8 but with 18%

Table 1. Layout of experiment.

	WS8	**WS10**	**WS12**	**WS14**	**WS16**	**WS18**
Block 1 (cages 1 to 6)	4	7	8	3	11	6
Block 2 (cages 7 to 12)	9	2	1	10	5	12

2. 3. Feeds and feeding system

Water spinach was grown in soil plots, situated in the CeAgrid-UTA Cambodia station. Plot size for the water spinach was 3 m^2. Effluent from biodigesters charged with pig manure was used to fertilize the water spinach. Level of effluent N was 150 kg/ha during the monthly growth cycle of the water spinach. Water spinach was harvested at a level of 1 cm above soil level, to ensure good re-growth.

The water spinach (combined stems and leaves) was offered as bunches hanging from the side of the cage. It was fed to the rabbits three times per day in the morning at 8:00 am, middle day at 12:00 m and in the afternoon at 4:00 pm. Water was not supplied as earlier observations (Miech Phalla, personal communication) indicated that rabbits have the ability to consume water from the feed to their needs as water spinach has a moisture content of almost 90%.

2. 4. Data collection of growing water spinach

The fresh biomass yield of the water spinach was determined by weighing the fresh foliage at each of two harvests. Samples were separated into leaves and stems and these portions analysed for DM, N and organic matter. Samples of biodigester effluent were analysed for N.

2. 5. Digestibility studies

The acid insoluble ash content of feeds and faeces was estimated according to Van Keulen and Young (1977) in the days 30 and 60 of the feeding trial. Faeces were obtained in the morning before distribution of the feed. Feed refusals were collected every day and kept frozen in plastic bags until analysis. After thawing the samples, they were mixed thoroughly by hand and pooled, ground in a coffee grinder in the fresh state and, thereafter, representative samples were used for chemical analysis.

2. 6. Chemical analyses

Analysis of DM in feeds and faeces was determined by drying to constant weight by microwave radiation (Undersander *et al.*, 1993). The ash, crude fiber and N content of samples were assayed using AOAC (1990) procedures. The organic matter of feeds and faeces was calculated as 100 minus % ash.
The digestibility coefficients were calculated by standard procedures following the method of indirect digestibility (Crampton and Harris, 1969), using the acid insoluble ash as inert marker. The calculation of digestibility of DM was as follows:

DM digestibility (%) = (1- A/B)*100, where A and B are the acid insoluble ash concentrations in feed and faeces, respectively.

The digestibility of other nutrients (X) was calculated as follows:

Digestibility (X in %) = $(1- A/B*X_B/X_A)*100$, where X_A and X_B are the concentrations of X in feed and faeces, respectively.

2. 7. Statistical analyses

The data were subjected to analyse of variance according to the general linear model of the Minitab software (Minitab release 13.12; 2000). When the "F" test was significant (P<0.05), the means were separated using the Tukey comparison option in the Minitab software. The model used was the following:

$Yijk = \mu + Ti + Pj + Ak + eijk$

- Yijk = Dependent variable
- Tμ = overall mean
- Ti = treatment effect
- Pj = period effect
- Ak = animal effect
- eijk = random error

3. Results and discussion

3. 1. Mortality

One rabbit on the treatment WS8 developed digestive upset and died after 50 days on the experiment.

3. 2. Water spinach yield

Fresh biomass yield was higher in the first than in the second cutting (Figure 1). The yield in the present study was higher than reported by Kean Sophea and Preston (2001) (23.6 and 16.3 tonnes/ha for first and second harvests, with fertilization from biodigester effluent at 140 kg N/ha.

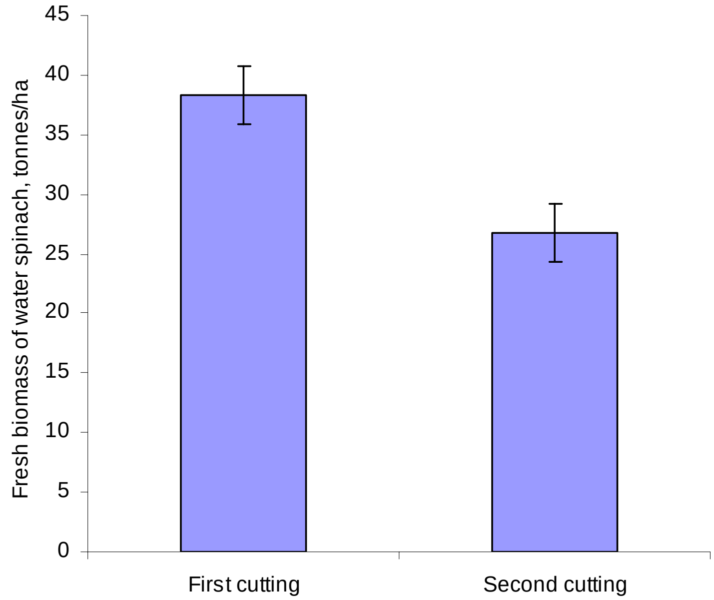

Figure 1. Fresh biomass of water spinach of 2 cutting interval.

3. 3. Feed characteristics

Water spinach leaves were higher in DM, crude protein and organic matter and lower in crude fiber than stems (Table 2). Compared with water spinach growing in water, the plants growing on soil in CelAgrid-UTA were higher in DM, but lower in crude protein (Papers I and II).

Table 2. Feed characteristics of water spinach (% in DM, except for DM which is on fresh basis).

	DM	**N**	**Crude protein**	**Ash**	**Organic matter**	**Crude fiber**	**Proportion**
Leaves	11.6	4.44	27.8	12.6	87.4	7.30	28.3
Stems	7.34	1.82	11.4	17.5	82.5	19.1	71.7

*Crude protein expressed by N*6.25*

3. 4. Feed intake

The experiment was designed as a production function with offer level as the independent variable. As the offer level increased, the proportion of the DM consumed as leaves increased (Figure 2), as did the proportion of DM consumed as crude protein (Figure 3). Rabbits are herbivores and very selective eaters (McNitt *et al.*, 1996). Thus, given the opportunity, they consumed more leaves than stems and the leaves are much higher in crude protein.

Table 3. Feed intake pattern (g/day) of rabbits offered different levels of water spinach.						
	WS8	**WS10**	**WS12**	**WS14**	**WS16**	**WS18**
DM						
Leaves	29.2	36.0	40.8	44.1	39.0	48.4
Stems	35.9	34.8	26.5	27.8	36.5	25.7
Total	65.1	70.8	67.3	71.9	75.5	74.1
Crude protein						
Leaves	8.14	10.4	11.6	12.5	11.0	13.7
Stems	4.11	3.98	2.97	3.15	3.96	2.90
Total	12.3	14.3	14.6	15.6	15.0	16.6
Crude fiber						
Leaves	2.13	2.61	2.99	3.24	2.81	3.56
Stems	6.89	6.69	5.04	5.33	6.68	4.87
Total	9.02	9.29	8.02	8.57	9.49	8.44

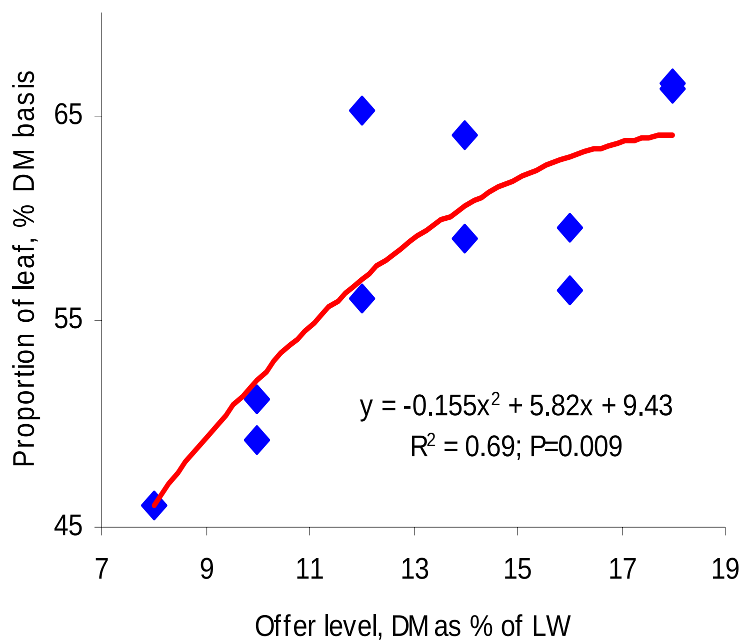

Figure 2. Proportion of water spinach leaves (%) in DM consumed, according to offer level.

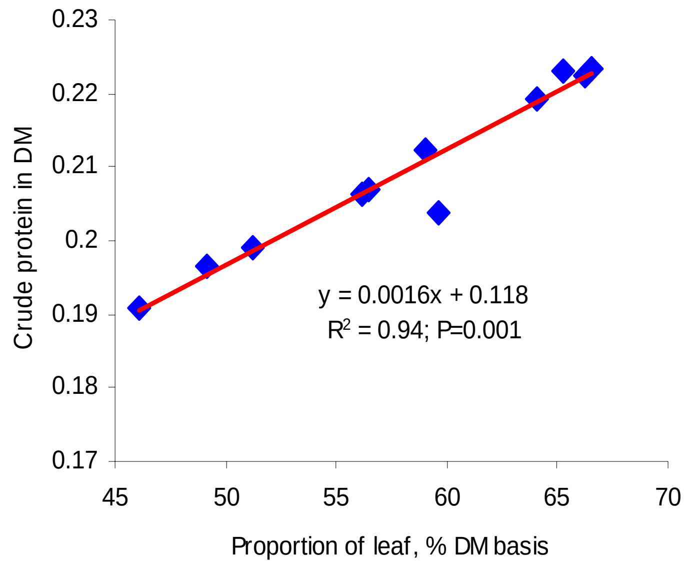

Figure 3. Relationship between proportion of leaves of water spinach consumed and proportion of crude protein in diet DM.

3. 5. Growth and feed conversion

The growth pattern of the rabbits on the different diets was linear, except in the last 10 to 15 days when it appeared to reach a plateau (Figure 4). This was especially evident on the treatments which previously had shown the supported the fastest growth rates. There is no obvious explanation for this result other than the suggestion that the rabbits had already reached their mature body size before the end of the experiment (Paper II). When the weight gain was plotted against the proportion of the DM consumed as leaves (Figure 5) or as protein (Figure 6), the relation was negative. More interesting is the relationship between the proportion of the DM consumed as crude fiber and the weight gain, which in this case was positive (Figure 7). Feed conversion was also improved as the proportion of crude fiber in the diet increased (Figure 8).

Table 4. Performance traits of rabbits fed different levels of water spinach as % of live weight in DM basis.

	WS8	WS10	WS12	WS14	WS16	WS18
Live weight, g						
Initial	1060	870	900	910	945	875
30 days	1630	1363	1375	1398	1525	1410
60 days	2080	1830	1810	1765	1975	1745
Daily gain, g						
0-30 days	20.4	17.3	16.8	17.8	19.6	18.1
31-60 days	16.0	16.0	14.3	12.4	16.0	10.6
0-60 days	20.3	17.3	15.8	15.1	17.7	14.4
kg DM intake/kg gain						
0-30 days	4.06	4.30	4.21	4.28	4.25	4.36
31-60 days	4.52	4.24	4.52	5.50	4.37	6.55
0-60 days	3.83	4.10	4.28	4.76	4.41	5.18

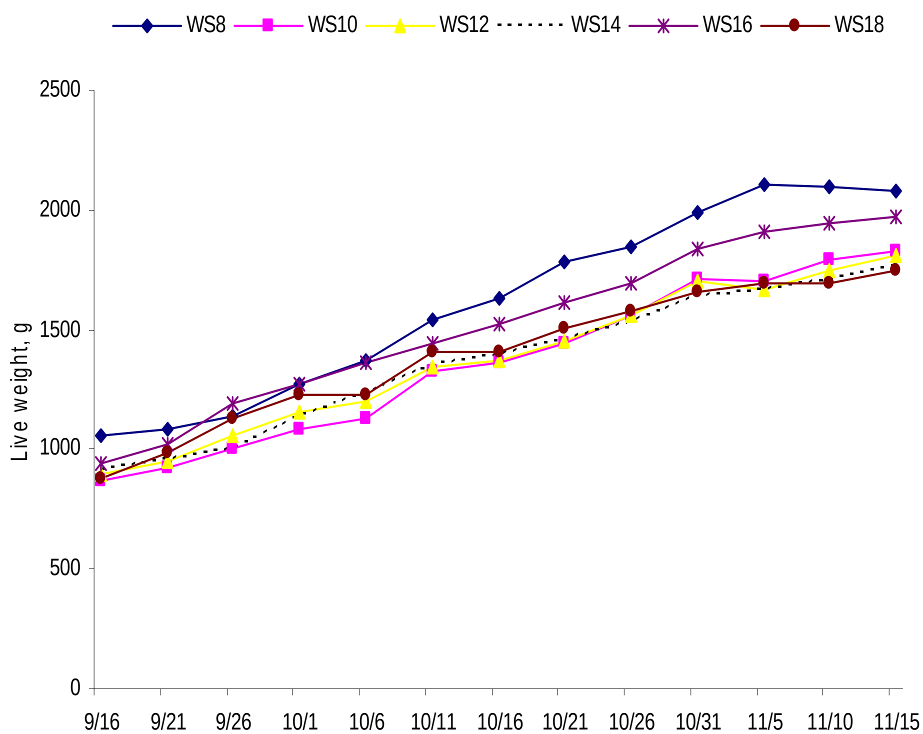

Figure 4. Growth curves of rabbits fed different levels of water spinach as % of live weight.

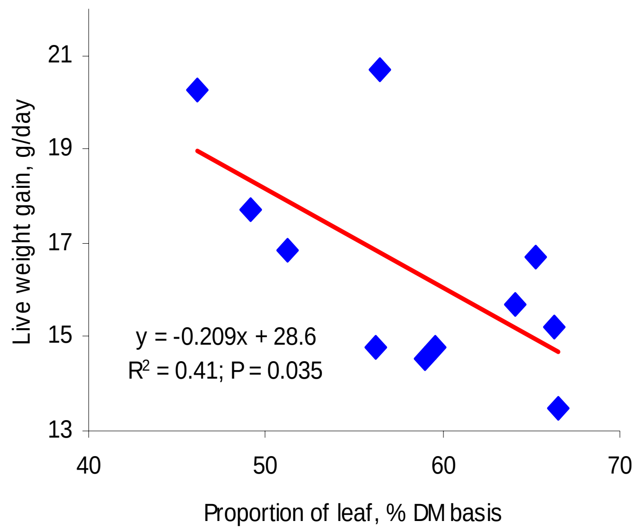

Figure 5. Relationship between proportion of leaves of water spinach consumed and daily weight gain.

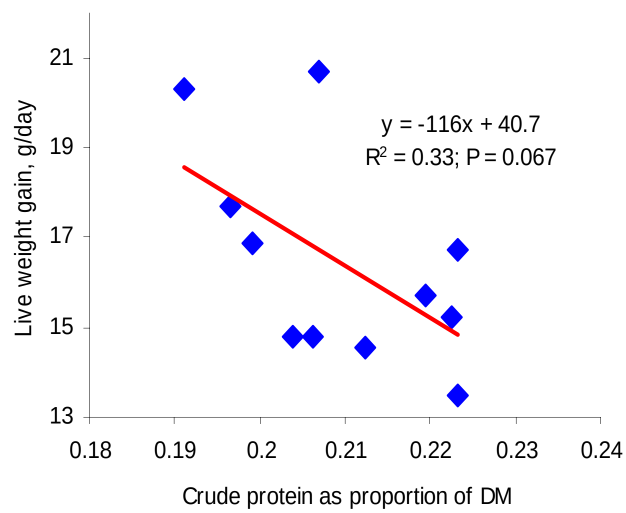

Figure 6. Relationship between proportion of DM of water spinach consumed as crude protein and daily weight gain.

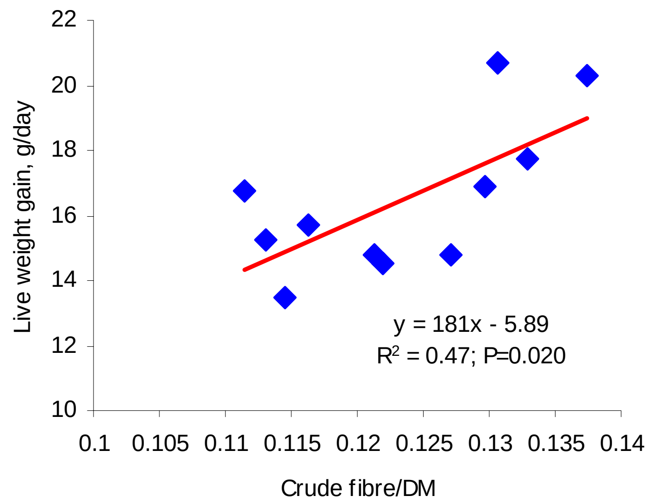

Figure 7. Relationship between proportions of DM water spinach consumed as crude fiber and daily weight gain.

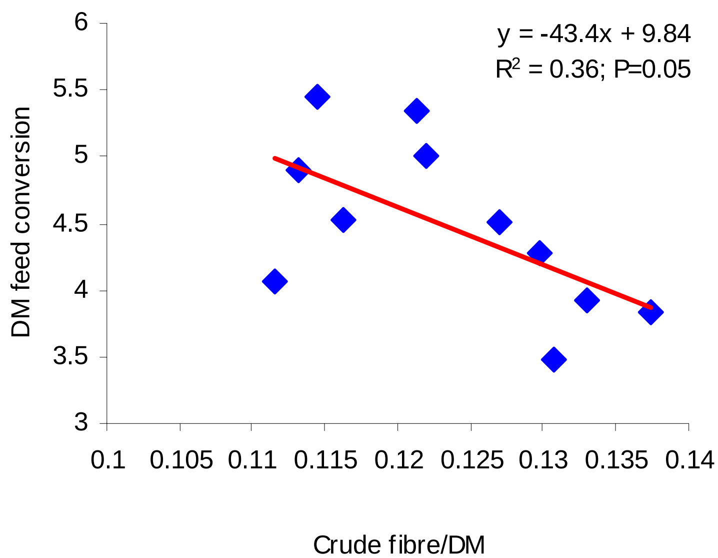

Figure 8. Relationship between proportion of DM water spinach consumed as crude fiber and DM feed conversion.

3. 6. Digestibility coefficients

The digestibility of DM, crude protein and organic matter increased as the proportion of the DM consumed as leaves increased (Table 5). Conversely, the digestibility of the crude fiber decreased as the proportion of the DM consumed as leaves increased (Figure 9).

Table 5. Mean values of digestibility coefficients (%) for rabbits offered different levels of water spinach.

	WS8	**WS10**	**WS12**	**WS14**	**WS16**	**WS18**
DM	74.6	73.5	77.3	76.9	77.6	78.3
Crude protein	60.3	59.9	67.5	66.3	68.9	70.9
Ash	74.2	70.2	74.8	73.4	76.4	77.6
Organic matter	74.6	74.0	77.7	77.4	77.7	78.4
Crude fiber	56.3	51.4	55.5	50.3	52.2	48.2

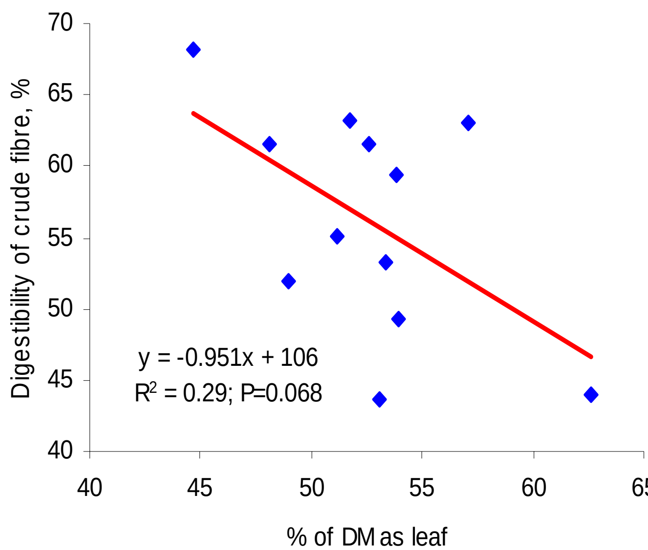

Figure 9. Relationship between proportion of leaves of water spinach

The decrease in fiber digestibility, as the proportion of DM consumed as leaves increased, indicates that the crude fiber in the leaves is less digestible than the crude fiber in the stems. This is the opposite of what occurs with most plant species where the cell wall component is less digestible in stems than in leaves (Van Soest, 1994). The reason for this difference could lie in the architecture of the water spinach plant (Photo 1). The stems (or stolons) of the water spinach rest on the soil (or in the water) and thus do not have to support the leaves. In contrast, in most plants the stems are upright and physically support the leaves (Rangnekar, 1991).

Photo 1. Architecture of water spinach plant.

Fiber plays an important role in the nutrition of the rabbit. According to Lebas *et al.* (1997), there is a minimum requirement for roughage in order to optimise the digestive processes, and the more digestible the fiber the higher is the requirement in order to satisfy the need for 10% of indigestible fiber in the diet.

The problem with water spinach would not appear to be one of too high digestibility of the fiber, but rather the too low concentration of fiber in the total plant (7.3% in leaf DM and 19.1% in stem DM). This hypothesis is supported by recent findings from an experiment in which two other sources of high-fiber feeds (grass and rice straw) were offered to rabbits in addition to the water spinach (Pok Samkol, Unpublished data). DM intake was increased by 50% when the rabbits had access to all three feed sources as compared with water spinach as the sole diet.

4. Conclusions

- Fresh water spinach as the sole of rabbits can support acceptable growth rates of 14 to 20g/day with DM feed conversion between 3.83 and 5.18.
- Increasing the offer level of water spinach from 8 to 18% of live weight (DM basis) increased the proportion of leaf consumed, the intake of crude protein and the digestibility of the DM and the crude protein. However, live weight gain was depressed with increasing offer level apparently because of a decrease in the crude fiber content of the diet, as with increasing offer level the rabbits selected “low-fiber” leaves rather than “high-fiber” stems.

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