STUDY ON THE POTENTIALITY OF DUCKWEEDS AS A FEED FOR CATTLE

K. S. Huque[1], S. A. Chowdhury and S. S. Kibria

Senior Scientific Officer, Bangladesh Livestock Research Institute, Savar Dhaka 1341, Bangladesh

Summary

Duckweed, an aquatic plant of the family Lemnaceae, is a rich source of protein and also contains cell wall materials. Spirodela, Lemna and Wolffia, the most available species of duckweeds were evaluated in terms of their chemical composition, the rate and extent of digestion of their dry matter (DM) and crude protein (CP) in the rumen and also their acceptability to the cattle.

The three species contained CP of 284, 399 and 299 g · kg^{-1} DM, respectively; NDF of 471, 574 and 476 g · kg^{-1} DM, respectively; ADF of 215, 203 and 227 g · kg^{-1} DM, respectively. The rumen digestibilities of DM of the three species for 24 h were 410, 570 and 731 g · kg^{-1} DM, respectively and of CP were 528, 740 and 778 g · kg^{-1}, DM respectively. The rates of digestion of DM of the three duckweeds were 2.22, 3.63 and 5.73 $\%h^{-1}$, respectively and of CP were 5.14, 4.22 and 6.05 $\%h^{-1}$, respectively. Similarly, the extent of digestion of DM were 853, 723 and 926 g · kg^{-1} DM, respectively and of CP were 801, 874 and 943 g · kg^{-1} DM, respectively. Mixed duckweeds as a component of a concentrate mixture were eaten by the cattle at the rate of 10% of their live weights.

It may be concluded that the dry matter and crude protein of the available duckweeds were highly degradable in the rumen and may be fed to cattle mixing with concentrates. For the effective utilization of duckweeds as cattle feed their effect on the rumen digestion kinetics of a roughage diet need to be studied carefully.

(**Key Words** : Duckweeds, Rumen Degradability, Intake)

Introduction

Feed shortage is the major constraint to cattle production in Bangladesh. About 96, 91 and 84% of the available dry matter (DM), metabolizable energy (ME) and crude protein (CP), respectively, come from poor quality fibrous feeds (Huque et al., 1992), of which 70% is rice straw (Rahman et al., 1990). Ruminant animals fed straws are generally deficient in readily available energy, protein and some minerals. They require supplementation with feeds containing both rumen degradable (Perdok, 1987) and undegradable proteins (Leng et al., 1990 and Huque, 1992) and readily fermentable carbohydrates of cell wall materials (Silva and Ørskov 1988).

Duckweed, a potential aquatic plant of annual dry amtter (DM) yield of 10 to 30 ton · h^{-1} containing up to 43% CP (Leng et al., 1994). It grows in waste waters emanating from sewage works, intensive animal industries on from intensive irrigated crop productions and is well accepted as a feed for the fish (Journey et al., 1991) or for the poultry (Haustein et al., 1990, Muztar et al., 1976). Leng et al. (1994) stated that the combination of fresh duckweeds and crop residues in a diet for ruminants appears to provide a balance of nutrients capable of optimizing rumen microbial fermentative capacity. Duckweeds are monocotyledons belonging to the family Lemnaceae. This family consists of four genera, *Lemna, Spirodela, Wolffia* and *Wolffiella* among which about 40 species have been identified so far (Journey et al., 1991). The former three genera are mostly available in Bangladesh. Dried duckweed meal which contains up to 400 g CP · kg^{-1} DM compares favorable with soybean as a source of plant protein (Porath et al., 1979).

They might be supplemented to cattle diets based on crop residues, mature grasses or pasture (Leng et al., 1994). Rusoff et al. (1978) found 900 g · hd^{-1} daily live weight (LW) gain of holstein heifers having initial LW of 250 to 300 kg. The animals were fed a diet of corn silage and duckweed, mixed at a ratio of 2:1. Rusoff et al. (1977) reported that the duckweed of Spirodela species obtained from a dairy waste lagoon contained crude protein, 350 to 400 g; fat, 20 to 50 g; fibre, 110 to 150 g;

[1]Address reprint requests to Dr. K. S. Huque, Senior Scientific Officer, Bangladesh Livestock Research Institute Savar Dhaka 1341, Bangladesh.

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ash, 110 to 150 g; calcium, 7 to 13 g; phosphorus, 5 to 8 g; potassium, 18 to 30 g per kilo dry matter. The iron, magnesium and manganese contents were less than 5 $g \cdot kg^{-1}$ dry matter. The PRISM Bangladesh, an NGO, successfully established the aquatic plant as a feed for the fish but no systematic works had been carried out yet on the duckweeds feeding to the cattle in Bangladesh. The present work was undertaken jointly by the Bangladesh Livestock Research Institute, (BLRI) and the PRISM, Bangladesh to study the intake of sundried duckweeds as a complete mix with concentrate feeds by bulls and to determine the rate and the extent of dry matter and protein degradabilities of different types of duckweeds in the rumen.

Materials and Methods

The sundried and mixed cultures of duckweeds were supplied by the PRISM from its production center at Mirjapur. Three rumen cannulated bulls of 317.0 ± 15.0 kg average LW were fed a diet of straw and green grasses. The diet was supplemented with a concentrate mixture contained duckweed at a rate of 279 $g \cdot kg^{-1}$ (table 1). Initially, the animals were allowed to eat the concentrates freely and then the amount to be supplied was calculated from the pre-adjustment period. The other feed ingredients were wheat bran (279 $g \cdot kg^{-1}$), molasses (279 $g \cdot kg^{-1}$), fishmeal (25 $g \cdot kg^{-1}$) and common salt (10 $g \cdot kg^{-1}$). The major fraction of the supplied duckweed was Spirodela but a fraction of Lemna was also present.

The straw and green grasses were offered *ad libitum* at a ratio of 1:1 (dry matter basis) and the concentrate mixture was fed twice daily at the rate of 2.8 $kg \cdot hd^{-1}$. The animals were adjusted to the diet for three weeks. The concentrate mixture was prepared weekly by mixing the dry feed ingredients with molasses thoroughly. After the adjustment period, dacron bags containing different species of dried and milled duckweeds were incubated in the rumen according to the methods described by Ørskov et al. (1980). The bag work was followed by a total collection of faeces and urine for 7 days. After collection, urine samples were mixed with a few drops of concentrated sulfuric acid and faeces and urine samples were stored at −20°C. Feeds, refusals and faeces samples were analyzed for dry matter (DM), crude protein (CP), ash, acid detergent fibre (ADF) and lignin according to the methods described by AOAC (1975), while that of neutral detergent fibre (NDF) according to the method stated by van Soest et al. (1967). Hemicellulose contents were calculated from the difference between NDF and ADF. The data on the rumen degradabilities of duckweeds were mathematically evaluated by the exponential model described by McDonald (1981).

TABLE 1. COMPOSITON OF THE CONCENTRATE MIXTURE FED TO THE ANIMALS

Feed ingredients	Composition ($g \cdot kg^{-1}$ dry matter)
Duckweed	279
Wheat bran	279
Molasses	279
Fishmeal	25
Common salt	10
Water	128
Total	1,000

The chemical components and the rumen degradation characteristics of duckweeds were analyzed for significant differences among the three varieties in a completely randomized design. Treatment means were compared by least significant differences (LSD).

Results and Discussion

The chemical compositions of feed ingredients and the three types of duckweeds are presented in table 2. The CP contents of Spirodela, Lemna and Wolffia are 284, 339 & 299 $g \cdot kg^{-1}$ DM, respectively. The CP contents of the plants mainly depend on the nitrogen availability in water on which they grow (Haustein et al., 1990). The supplied duckweeds were grown and harvested regularly from the mini ponds, fed with light soils. Leng et al. (1994) stated that duckweeds grown under ideal conditions and harvested regularly contained CP of 350 to 430 $g \cdot kg^{-1}$ but on nutrient-poor waters contained 150 to 250 $g \cdot kg^{-1}$ DM.

The NDF contents of Spirodela and Wolffia were 471 and 476 $g \cdot kg^{-1}$, respectively and that of ADF contents were 215 and 227 $g \cdot kg^{-1}$, respectively. The NDF and ADF contents of Lemna were 574 and 203 $g \cdot kg^{-1}$ DM, respectively. It had a higher content of hemicellulose (371 $g \cdot kg^{-1}$) as compared to Spirodela and Wolffia (256 and 249 $g \cdot kg^{-1}$, respectively). The presence of long hairy roots in Lemna may have given a higher content of cell wall materials in it. The lignin content of Spirodela was 32.6 and Wolffia was 12.6 $g \cdot kg^{-1}$ DM. However, crude fibre content of duckweeds was reported to be ranged from 50 to 300 $g \cdot kg^{-1}$ DM depending on the nutrient status of water (Leng et al., 1994).

The diet fed to bulls had an average daily dry matter (DM) intake of 81.7 $g \cdot kg^{-0.75}$ (table 3). The average ratio of the DM eaten from roughage and concentrate

TABLE 2. CHEMICAL COMPOSITION OF THE DUCKWEEDS AND FEED INGREDIENTS USED TO FORMULATE THE DIET

Feed items	Composition ($g \cdot kg^{-1}$ dry matter)						
	Dry matter	Ash	Crude protein	Neutral detergent fibre	Acid detergent fibre	Hemi cellulose	Lignin
Spirodela	825	175	284	471	215	256	32.6
Lemna	883	176	339	574	203	371	–
Wolffia	865	156	299	476	227	249	12.6
Straw	881	116	64	717	439	278	–
Green grass	150	101	135	368	322	46	–
Conc. Mix.	690	303	195	245	123	122	–

TABLE 3. DAILY INTAKES ($g \cdot kg^{-0.75} \cdot d^{-1}$) AND DIGESTIBILITIES ($g \cdot kg^{-1}$) OF FEED NUTRIENTS, NITROGEN BALANCES (N_2-BALANCE) AND THE CALCULATED DAILY LIVE WEIGHT GAINS (LWG) OF THE EXPERIMENTAL BULLS

Feed nutrients	Experimental animals			
	Animal No. 1	Animal No. 2	Animal No. 3	Mean
DM intake	73.0	87.5	84.7	81.7
DM Digest.	650	704	598	650
OM Digest.	659	734	614	669
CP Digest.	591	623	563	592
N_2-Balance ($g \cdot kg^{-1}$)	35	33	40	36
Cal. LWG ($g \cdot kg^{-1}$)	1,103	1,040	1,261	1,135

mixtures was 70:30. On an average the animals ate duckweeds at the rate of 10% of their LWs. Table 3 also shows that the average total tract digestibilities of DM, organic matter (OM) and CP of the diet were 650 g and 592 $g \cdot kg^{-1}$, respectively. The bulls were in positive nitrogen balance (36 $g \cdot day^{-1}$ table 3). The calculated average daily weight gain of the bulls was 1,135 $g \cdot day^{-1}$ (assuming 20 g protein per kg LW gain). Rusoff et al. (1978) found LW gain of 900 $g \cdot hd^{-1}$, d^{-1} of holstein heifers fed a diet of corn silage and duckweed mixed at a ratio of 2:1. However, the LW gain of the bulls of the present experiment were estimated values from the nitrogen balance trial. To determine live weight gain we need more animlas to feed duckweeds for a longer period of time.

Table 4 and 5 show that degradabilities of dry matter

TABLE 4. DRY MATTER DEGRADABILITIES ($g \cdot kg^{-1}$) OF DUCKWEEDS AT DIFFERENT INCUBATION PERIODS

Hours	Duckweeds			Significance	
	Spirodela	Lemna	Wolffia	SED	Level
00 (washing loss)	125	292	386	125	$p < 0.01$
08	287	409	411	131	$p < 0.01$
16	359	475	581	364	$p < 0.05$
24	410	570	731	372	$p < 0.01$
48	614	610	875	360	$p < 0.01$
72	710	712	910	226	$p < 0.01$

TABLE 5. CRUDE PROTEIN DEGRADABILITIES ($g \cdot kg^{-1}$) OF DUCKWEEDS AT DIFFERENT INCUBATION PERIODS

Hours	Duckweeds			Significance	
	Spirodela	Lemna	Wolffia	SED	Level
00	264	453	435	43.3	$p < 0.01$
08	432	578	478	26.6	$p < 0.01$
16	496	617	632	57.6	$p < 0.05$
24	528	740	778	45.9	$p < 0.01$
48	721	793	907	24.2	$p < 0.01$
72	797	863	926	18.4	$p < 0.01$

(DM) and crude protein of Lemna and Wolffia at different incubation periods (including zero hour) were significantly ($p < 0.01$, except $p < 0.05$ at 16 h) higher than that of Spirodela. The DM degradabilities of Wolffia, Lemna and Spirodela for 16 h were 581, 475 and 359 $g \cdot kg^{-1}$, respectively and for 24 h were 731, 570 and 410 $g \cdot kg^{-1}$, respectively. The CP degradabilities of the same species for 16 h were 632, 617 and 496 $g \cdot kg^{-1}$, respectively and

for 24 h were 778, 740 and 528 g · kg^{-1}, respectively. The DM degradabilities of Wolffia differed significantly ($p < 0.01$, except $p < 0.05$ at 16 h) at 16, 24, 48 and 72 h from that of Lemna. Similarly, the differences of CP degradabilities of the two duckweeds with Lemna were significant ($p < 0.01$) at 8, 48 and 72 h. As compared to Spirodela, the higher contents of soluble DM and CP in Lemna and Wolffia and their low or negligible contents of lignin (table 2) possibly resulted in higher DM and CP degradabilities of the later two.

Table 6 shows the calculated degradation characteristics of DM and CP of three weeds. It shows that the extraploted 'a' values (soluble fractions) of Wolffia are lower than the values found from washing of the control bags in tap water. The degradabilities of Spirodela and Lemna at different incubation hours including zero hour were fitted to the exponential model. But the data of Wolffia except zero hour were fitted, because the later data were not acceptable to the model. So, the extrapolation of a lower 'a' value by the model gave a big difference of it with that of washing loss in water.

TABLE 6. *IN SACCO* DEGRADATION CHARACTERISTICS OF DRY MATTER AND CRUDE PROTEIN OF DUCKWEED AT DIFFERENT INCUBATION PERIODS

Item	Dry matter			Crude protein		
	Spirodela	Lemna	Wolffia	Spirodela	Lemna	Wolffia
Soluble fraction (extraploted value, a, g · kg^{-1})	141	297	103	241	422	178
Potential digest. fraction (b, g · kg^{-1})	712	426	823	560	452	765
Degradation, C (%h^{-1})	2.22	3.63	5.73	5.14	4.22	6.05
Extent of degrad (a+b, g · kg^{-1}).	853	723	926	801	874	943
Effective degrad. at 0.05 passage rate.	–	–	–	524	629	516

The potential degradable fractions (b) of DM and CP of Wolffia were highest (823 and 765 g · kg^{-1}, respectively) followed by Spirodela (712 and 560 g · kg^{-1}, respectively) and Lemna (426 and 452 g · kg^{-1}, respectively). Similarly, the rate of degradation of DM and CP of Wolffia were also higher (5.73 and 6.05 %h^{-1}, respectively) than Lemna (3.63 and 4.22%h^{-1}, respectively) and Spirodela (2.22 and 5.14 %h^{-1}, respectively).

The calculation of CP degradabilities at a digest passage rate of 5.0 %h^{-1} shows that 516 to 629 g · kg^{-1} of duckweed protein may be degradable in the rumen. The rest of the potentially degradable fraction may have a chance to be degraded in the lower gut or could be voided in faeces.

From the above discussion it may be concluded that the dried duckweeds as a component of a concentrate mixture may be fed to cattle. Both dry matter and crude protein of the three duckweeds were highly degradable in the rumen. Their effect on the rumen digestion kinetics of a straw or a roughage based diet need to be studied carefully for the effective utilization of duckweeds as cattle feed. Further studies are required to evaluate supplementation levels of duckweeds for determining growth performances of cattle.

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