Nutrient Elements For Livestock In Aquatic Plants[1]

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ABSTRACT

Concentrations of 10 nutrient elements for livestock in six species of aquatic plants were studied over a period of 1 year. The plants were hydrilla (*Hydrilla verticillata* Royle, waterhyacinth (*Eichhornia crassipes* (Mart.) Solms), hornwort (*Ceratophyllum demersum* L.), pondweed (*Potamogeton pectinatus* L.), eelgrass (*Valisneria americana,* Michx.), and naiad (*Najas guadalupensis* (Spreng.) Magnus). On a dry weight basis, P, K, Mg, Cu, Zn and Mn were in the range of concentrations of land forages in the United States; Na was 10 to 100 times greater; and Fe exceeded the range by 4 to 19 times. Ca concentration was higher and P generally lower, except for waterhyacinth which contained approximately 2% Ca. The Ca:P ratio in this plant was suitable for cattle. Hydrilla, naiad, hornwort, pondweed and eelgrass had average Ca:P ratios of approximately 30 to 90 and 1 kg of the dry plant would provide at average levels 3 to 6 times the daily Ca. requirement of a cow on a maintenance ration.

INTRODUCTION

Public concern that aquatic plants be removed mechanically from water rather than killed by herbicides may cause them to become available in quantity as livestock feeds. Utilization as feedstuff is dependent upon knowledge of nutrient composition. Livestock feeders need composition data on feeds as guidelines in formulation of rations. Boyd (2, 3, 4) published information on protein and other nutrients in aquatic plants. Stephens et al. (10) demonstrated in studies with steers that nutrient elements were present and available in rations containing approximately one-third dry waterhyacinth or hydrilla. The present study was made to determine the range of concentrations of nutrient minerals in several aquatic plants throughout approximately 1 year of monthly or bimonthly sampling.

METHODS AND MATERIALS

Six species of aquatic plants were collected at monthly or bimonthly intervals starting in April 1971 and ending March 1972. Waterhyacinth was obtained from Lake Apopka; hydrilla from Kings Bay, Crystal River; hornwort, pondweed, eelgrass and naiad from Lake Panasoffkee, in Central Florida.

The plants were dried at 60 C and ground in a Wiley Mill using a 1 mm mesh screen. Samples were ashed at 550 C and the residues dissolved in hydrochloric acid prior to analysis. Phosphorous was determined spectrophotometrically by the method of Fiske and Subbarow (5). Calcium, potassium, magnesium, sodium, manganese, iron, zinc, copper and chromium were determined with the Perkin Elmer Atomic Absorption Spectrophotometer, Model 303.

RESULTS AND DISCUSSION

Concentrations of Ca, P, K, Mg, Na, Fe, Cu, Zn, Mn and Cr found in the aquatic plants are shown in Tables 1 and 2. Ca concentration in waterhyacinth was lowest and varied least throughout the year, even though Lake Apopka from which the waterhyacinths were obtained had a greater concentration of Ca in the water than the other water sources. The concentration of approximately 2% in waterhyacinth is similar to that in legumes (8). Hydrilla, hornwort, pondweed, eelgrass and naiad had average Ca concentrations ranging from 9 to 17%. The high Ca concentration and low P concentration (0.2 to 0.5%) could be unsuitable for animal feeding because of the wide Ca:P ratio. A ratio of approximately 2:1 is desirable but ratios to 7:1 may be satisfactory for cattle (7). The Ca concentrations were higher and more variable than usually found in land grasses which generally range from 0.3 to 0.6% and legumes that range from 1 to 1.8% (8). Some of the Ca of aquatic species may be encrusted on the plant.

Concentrations of P ranged from 0.12 to 0.66% which are similar to those in land forages (8). Although P contents of the waters from the four sources were similar throughout the year, waterhyacinths had an average percentage of P almost two times that of the other species each sampling.

The average values of K for the six species of aquatic plants varied from 1.4 to 4.1 and were in the range of land forages. Generally, land forages in the United States range in K content from approximately 1 to 3% (8).

The lowest (0.26%) and highest (0.97%) average percentages of Mg were observed in pondweed and hornwort, respectively, from Lake Panasoffkee. Differences in capacity of aquatic species to retain Mg is apparent as reported for land grasses (12). The concentration of Mg in the water in which the waterhyacinth grew was approximately three

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TABLE 1. MACRO NUTRIENT ELEMENT CONCENTRATION IN SIX SPECIES OF AQUATIC PLANTS FROM THREE LOCATIONS IN FLORIDA, COLLECTED THROUGHOUT THE YEAR

		Calcium (%)[a]				Phosphorus (%)				Potassium (%)			
	Source[b]	No Samples[c]	Min	Max	Avg	No Samples	Min	Max	Avg	No Samples	Min	Max	Avg
Hydrilla	1	9	5.2	14.3	10.8	9	.12	.48	.32	9	.3	4.6	2.7
Waterhyacinth	2	6	2.0	2.7	2.2	6	.17	.66	.50	6	1.0	6.4	4.1
Hornwort	3	8	4.3	14.6	9.4	8	.23	.38	.33	8	1.4	3.8	2.5
Pondweed	3	7	4.3	22.3	17.1	8	.13	.30	.19	7	.6	3.8	1.4
Eelgrass	3	8	8.7	22.5	15.5	7	.16	.28	.21	8	.8	4.1	2.3
Naiad	3	4	8.9	13.5	11.2	4	.22	.27	.25	4	2.1	3.9	2.6

[a]Results expressed on dry weight basis.
[b]1. Crystal River
2. Lake Apopka
3. Lake Panasoffkee
[c]Collected at monthly or bimonthly intervals.

TABLE 1. CONTINUED

		Magnesium (%)				Sodium (%)			
	Source	Samples	Min	Max	Avg.	Samples	Min.	Max	Avg
Hydrilla	1	9	.03	.94	.59	6	.57	2.20	1.17
Waterhyacinth	2	6	.52	.64	.59	5	.62	1.20	.94
Hornwort	3	8	.14	1.58	.97	6	.45	2.41	1.19
Pondweed	3	7	.15	.68	.26	6	.44	1.10	.71
Eelgrass	3	8	.22	.78	.46	4	.74	1.30	1.03
Naiad	3	4	.23	.32	.28	3	1.21	1.63	1.46

[a]Results expressed on dry weight basis.
[b]1. Crystal River
2. Lake Apopka
3. Lake Panasoffkee
[c]Collected at monthly or bimonthly intervals.

TABLE 2. MICRO NUTRIENT ELEMENT CONCENTRATION IN SIX SPECIES OF AQUATIC PLANTS FROM THREE LOCATIONS IN FLORIDA, COLLECTED THROUGHOUT THE YEAR.

		Iron mg/kg[a]				Copper mg/kg				Zinc mg/kg			
	Source[b]	No Samples[c]	Min	Max	Avg	No Samples	Min	Max	Avg	No Samples	Min	Max	Avg
Hydrilla	1	9	457	3766	1438	8	0.3	204	36	9	19	82	50
Waterhyacinth	2	6	522	3183	1701	6	7	30	12	6	30	71	43
Hornwort	3	8	482	1274	1007	8	1	9	6	8	8	15	13
Pondweed	3	7	238	2432	676	5	1	8	3	7	10	36	19
Eelgrass	3	8	186	3374	1436	6	1	12	5	8	12	65	25
Naiad	3	4	337	2607	1132	3	4	11	8	4	11	16	14

[a]Results expressed on dry weight basis.
[b]1. Crystal River
2. Lake Apopka
3. Lake Panasoffkee
[c]Collected at monthly or bimonthly intervals.

TABLE 2. CONTINUED

		Manganese mg/kg				Chromium mg/kg			
	Source[b]	No Samples[c]	Min	Max	Avg	No Samples	Min	Max	Avg
Hydrilla	1	9	29	346	158	9	1.6	25.6	9.5
Waterhyacinth	2	6	106	227	142	6	0	10.6	3.2
Hornwort	3	8	465	802	640	8	0	9.1	2.4
Pondweed	3	7	33	226	114	7	0	8.1	2.3
Eelgrass	3	8	77	244	157	8	0	8.6	2.3
Naiad	3	4	162	271	213	4	0	4.9	2.9

[a]Results expressed on dry weight basis.
[b]1. Crystal River
2. Lake Apopka
3. Lake Panasoffkee
[c]Collected at monthly or bimonthly intervals.

TABLE. 3. AVERAGE PERCENTAGE OF DAILY REQUIREMENTS OF NUTRIENT ELEMENTS FOR STEERS PER KG OF DRY AQUATIC PLANTS.[a]

Element	Waterhyacinth	Hydrilla	Naiad	Hornwort	Pondweed	Eelgrass
Ca	85	416	431	362	658	597
P	25	17	13	17	10	11
K	82	54	52	50	28	46
Mg	98	98	47	162	43	77
Na	134	167	209	170	101	147
Fe	170	144	113	101	68	144
Cu	21	63	14	11	5	9
Zn	31	36	10	9	14	18
Mn	133	148	199	589	107	147

[a]Requirements from National Research Council 1970 for 300 kg steer feed to gain 1.10 kg per day.

to eight times higher than the water in which the hydrilla grew but there was no difference in the average Mg level in the two plant species. Forages grown on land usually range from 0.1 to 0.5% Mg (8).

Species differences in Na content were found. Pondweed and naiad that grew in the same location contained 0.71 and 1.46%, respectively. Land forages are almost universally low in Na with regard to the dietary requirements of livestock and range generally from 0.01 to 0.14% (13).

Fe concentration was high in relation to forage crops in the six aquatic plants. The average concentration in pondweed was approximately one-third to one-half that in the other species. Average Fe content in waterhyacinth, hydrilla and eelgrass was 1400 to 1700 mg/kg dry weight. When steer calves were fed rations that contained 1600 ppm Fe as ferrous sulfate, the average daily feed intake and daily gains were significantly depressed (9).

Cu concentrations in waterhyacinth, hornwort, eelgrass and naiad were very similar to that in land forages i.e. 5 to 12 mg/kg (8). Average concentration in pondweed was very low (3 mg/kg). Hydrilla contained 36 mg/kg. Sutton et al. (11) found that naiad and hydrilla contained 1430 and 2650 ppm of Cu, respectively, 1 week after the plants in plastic pools were treated with 1 ppm Cu as copper sulfate.

Zn was found to range in the six aquatic plants in average concentrations from 13 to 50 mg/kg. These values are in the range of most land forages (8).

Average concentrations of Mn in the six species ranged from 114 mg/kg in pondwood to 640 mg/kg in hornwort. Beeson et al. (1) reported a range of concentrations of Mn from 96 to 815 mg/kg in 17 grass species grown in the United States. Healthy pastures may contain less than 100 ppm (13).

Average concentrations of Cr in waterhyacinth, hornwort, pondweed, eelgrass and naiad were approximately 3 mg/kg dry weight and the average value in hydrilla was approximately three times this amount. Cr is a dietary requirement of rats and is associated with carbohydrate metabolism (6).

Table 3 presents the average percentages of the daily requirements of Ca, P, K, Mg, Na, Fe, Cu, Zn and Mn per kg of dried aquatic plants for a 300 kg steer fed to gain 1.10 kg body weight per day (7). The nutrients required for beef cattle are expressed by the National Research Council (NRC) as mg/kg dry matter and do not specify their availability (7). In the present report only the concentrations present in the aquatic plants are presented and they are discussed in relation to the requirements outlined for beef cattle by the NRC. One kg of waterhyacinth on the average contains 85% of the Ca requirement of this type of steer. Three to six times the steer's Ca requirement was present per kg of dry hydrilla, naiad, hornwort, pondweed and eelgrass. Ten to 26% of the P requirement was present per kg of the various aquatic plants. Waterhyacinth contains 82% of the K requirement. Pondweed contains approximately one-fourth and naiad, hornwort, eelgrass and hydrilla half of the K requirement. Waterhyacinth, hydrilla and hornwort contain approximately 100 to 160% of the Mg requirement and naiad, pondweed and eelgrass about half this amount. Na in the aquatic plants contains approximately one to two times the daily need for this element. Pondweed contains 68% of the daily Fe requirement and waterhyacinth, hydrilla, naiad, hornwort and eelgrass approximately one to two time this much. Approximately 5 to 21% of the Cu requirement could be provided by waterhyacinth, naiad, hornwort, pondweed and eelgrass compared to 63% for the hydrilla. Nine and 18% of the Zn daily requirement was present in naiad, hornwort, pondweed and eelgrass and one-third of the requirement in waterhyacinth and hydrilla. Approximately six times the daily Mn requirement was present per kg in hornwort and one to two times the requirement was present in the other aquatic species.

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